UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HTC CORPORATION, HTC AMERICA, INC.

ZTE CORPORATION, and ZTE (USA), INC.

Petitioners

v.

CELLULAR COMMUNICATIONS EQUIPMENT, L.L.C.

Patent Owner.

Case IPR2017-01508

Patent 8,385,966

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VIDEOTAPED ORAL DEPOSITION OF ROBERT AKL, D.Sc.

February 15, 2018

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VIDEOTAPED ORAL DEPOSITION OF ROBERT AKL, D.Sc., produced as a witness and duly sworn, was taken in the above-styled and numbered cause on February 15, 2018, from 9:45 a.m. until 4:04 p.m., before Suzanne Kelly, CSR No. 1260, in and for the State of Texas, reported by stenographic method at the Law Offices of firm image Nelson Bumgardner, P.C., located at 3131 West 7th Street, Suite 300, Fort Worth, Texas, pursuant to Federal Rules of Civil Procedure and the provisions stated on the record, if any.

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P R O C E E D I N G S

THE VIDEOGRAPHER: We're on the record. Today's date is February 15th, 2018. The time 9:45. This is the Videotaped Deposition of Dr. Robert Akl in the case styled, "HTC Corporation, et al, versus Cellular Communications Equipment, L.L.C."

This case is filed with the United States Patent and Trademark Office before the Patent Trial and Appeal Board. This case is Case Number IPR217-01508.

At this time, Counsel, will you please state your appearances for the record?

MR. BUMGARDNER: Barry Bumgardner for Patent Owner. And on the phone is Bijan Jabari, a consultant for the Patent Owner.

MR. NASH: Brian Nash from Pillsbury, Winthrop, Shaw, Pittman here on behalf of Petitioners and the witness.

THE COURT REPORTER: If would raise your right hand, I will administer the witness's oath to you.

Do you solemnly swear or affirm that the testimony which you give in this case will be the truth, the whole truth and nothing but the truth, so help you God?

THE WITNESS: I do.

THE COURT REPORTER: Thank you.

ROBERT AKL, D.Sc.,

having sworn to testify the truth, the whole truth, and nothing but the truth testifies upon his oath as follows:

EXAMINATION

BY MR. BUMGARDNER:

Q. Good morning, Doctor Akl. My name is Barry Bumgardner. I am here on behalf of Cellular Communications Equipment, the Patent Owner in this matter. Can I take it Doctor Akl, you've given many depositions before?

A. Yes.

Q. So, you understand the rules. What I will say is, I typically break about every hour if you'd like a break sooner, just let me know, as long as there is no pending question. That will be fine.

And if I ask you a question today, Doctor Akl, that doesn't make sense for some reason, I'm happy to try and rephrase it and ask it in a different way. So just please let me know if I do that.

What did you do to prepare for today's deposition, Doctor Akl?
A. I reviewed my declaration.
I reviewed the relevant exhibits.
I reviewed the preliminary institutional decision.
I reviewed the initial Patent Owner Response.
And I met with counsel.
Q. And when you say "exhibits," those where exhibits to the Petition filed by Petitioner?
A. Yes.
Q. How much time did you spend reviewing for today's deposition?
A. Total, about ten hours.
Q. How much are you charging Petitioner for your time, Doctor Akl?
A. Six-fifty an hour.
Q. Turning now to the Petition in this matter, when were you first engaged by Petitioner to assist in this matter?
A. Early 2017.
Q. And how much time did you spend preparing your declaration, reviewing the Petition, if you did, leading up to the filing of

the Petition which included your declaration?
A. It depends on how you count because, with respect to this IPR, around 20 hours. But I had submitted two prior IPRs with the same patent and with similar prior art, and I used my notes and, I guess, the prior draft as the initial draft here. So if you count total, the work which resulted in my declaration, it would be probably close to 60 across all three IPRs, 60 hours.
Q. Who were those other IPRs filed on behalf by Doctor Akl?
A. The first one, the Petitioner Kyocera.
The second one, I believe, it was LG.
And those IPRs should be in my CV.
Q. Excuse me. In preparing your declaration for this IPR, did you do any additional searches for prior art that may be relevant to the 966 patent, which is the patent that's the subject of this IPR?
A. No.
Q. Let's turn to certain 3GPP standards that govern what I will -- I'll call it "govern cellular communications" in this country and in

others.

So are you familiar with a group called "3GPP"?

A. Yes.

Q. What is 3GPP?

A. Can I have a copy of my declaration, please?

Q. Can you just testify without that? It's a general question, Doctor Akl.

A. I can, but I would like a copy of my declaration if possible.

Q. I will give you one in a little bit. So what is 3GPP?

A. "3GPP" stands for third generation partnership project.

Q. And what -- what is this project about?

A. It's a group that spun out of ETSI, E-T-S-I, which is a European telecommunications standards setting body. There are a lot of companies that participate and they provide drafts and final versions of the standard that includes LTE, which is long-term evolution, and, previously, the third generation cellular standard, UMTS, or W-CDMA.

Q. Was 3GPP involved as far back as GSM, or

did they come after GSM?
A. I think they came after GSM. It depends at the time frame that you look at. Originally GSM, which is 2G, came out of ETSI, E-T-S-I.
And then, as 2 and a half G evolved and when you look at 3G, that's around the time 3GPP was formed. But you will see some standards that may have identical content with different numbering depending on the document.
Q. And I know I'm asking you to go by memory, Doctor Akl, but do you think 3GPP as a group or organization has been around since 2000?
A. Maybe a little bit earlier. That's -- that's about right. Maybe -- I think sometime in the '90s would be.
Q. And so, it -- would it be fair to say, Doctor Akl, 3GPP is a group, that they promulgate standards by which various entities in the cell phone business can design products?
A. Sure.
Q. And when I say, "entities in the -- in the cellular business," I'm talking about handset makers as well as base station manufacturers.
A. Okay.
Q. So -- so again, just to confirm, if I

want to make handsets that are operable in
cellular networks that have been around, whether
it's 3G or 4G LTE, 3GPP is the group that says:
Here is the way your handset should operate to be
compatible with the various networks in
existence?
A. For a subset of those standards. There
are other standard-setting bodies. So you don't
necessarily have to only be compliant with 3GPP
standards. There is also 3GPP2.
There is IEEE. So there are other
standard-setting bodies that also produce
cellular communication standards.
Q. So what you're saying is: It may not be
enough to be compliant with 3GPP standards; you
may have to comply with other standards as well
to have a network that can operate on
different -- to have a phone that can operate on
different networks?
A. Yes. So, as an example, in the United
States, you have four major national carriers.
With regard to fourth generation cellular
standards, at this point, all four have adopted
LTE.
With regard to second-generation

and third-generation, that was not the case. And you had, for example, in the U.S., you had CDMA or IS-95 for 2G; and you had GSM out of Europe or out of ETSI.

And for example, AT&T and T-Mobile used originally GSM and Sprint and Verizon used CDMA. Similarly, for third-generation, there were two competing technologies.

And for 4G, there were also, a few competing technologies like WiMAX, W-i-M-A-X, that came out of IEEE that I believe initially Sprint adopted. But at this point, everybody -- LTE won.

So -- so we wouldn't just look at 3GPP. There are other standard-setting bodies that contribute cellular standards.

Q. So with respect to the any particular standard, and let's -- let's pick GSM. Would it be fair to say that during the time in the 1990s, most of the world used GSM, say with the exception of the U.S. that had CDMA systems as well and maybe Japan and Korea but for the most part, GSM was a worldwide standard?

MR. NASH: Objection; form.

THE WITNESS: I think this is a

little bit outside of the scope of my declaration. I -- I mean, depending on the source that you look at. Sometimes you see more credit given to GSM, and sometimes you see publications that say there is as much adoption of CDMA worldwide alongside GSM.

So, I wouldn't want to make a generalization like that.

BY MR. BUMGARDNER:

Q. And that's fine, Doctor Akl. I'm not asking you to kind of split up CDMA verses GSM in market share but say with respect to GSM -- let me ask a different question.

Did you travel internationally during the 1990s?

A. Not too much.

Q. Not too much. So I did, and I could take my GSM phone, and it would work here in the United States on T-Mobile's network. It may have been Cingular at the time.

And then I could go to Europe and my same phone would work in Europe, and I could go to Asia, at least certain parts of Asia, my same GSM phone would work.

Are you familiar with kind of that

portability of a phone back in the 1990s?
A. Yes.
Q. And is it fair to say that it was -- that the phone complied with the applicable GSM standards that allowed it to operate in the United States on, say, T-Mobile's network and in Europe on a various European carrier and I could go to Asia and it would also work, that it was because the phone followed a common set of GSM standards that allowed it to operate all over the globe?
MR. NASH: Objection; form.
THE WITNESS: Generally, yes. It would operate on a GSM network. I would agree because of the GSM standard.
BY MR. BUMGARDNER:
Q. And is it fair to say the same is true today with LTE, that there is a common LTE standard that people around the world use that allow phones to work in Europe and in Asia and the United States on LTE networks?
A. Generally, yes. You have to also look at the deployment and the frequency bands. There are different frequency bands. So, the phone would also need to be able to receive specific

frequency bands within the LTE standard.
Q. And then within LTE, too, there are frequency division, multiplex versions of LTE and CDMA versions of LTE, as well, is there not?
A. The LTE standard provides FDM which is frequency-division multiplexing, where the uplink and the downlink have different frequencies versus TDM, which is more common in China, which is time division multiplexing where you use the same frequency on the uplink and the downlink, and you divide them by time.
Q. But assuming I have an LTE phone that's capable of receiving signals at the proper frequency, say in an FDM system, it should work wherever as long as everybody's following the same set of standards? And those standards being the ones promulgated by 3GPP for LTE?
MR. NASH: Objection; form.
THE WITNESS: I think I've already answered that question with the -- as long, also, that you're operating within frequency bands that the phone supports.
BY MR. BUMGARDNER:
Q. Are you familiar with the term "3GPP working group"?

A. Yes.
Q. What is a 3GPP working group?
A. There are different working groups within 3GPP. Some focus on the physical layer. Some focus on the MAC layer and so on. And they have regular meetings and there are proposals that get submitted to those meetings. And then, there are votes that get taken at meetings as consensus is reached on how to proceed with certain aspects of the technology or what decisions to make.
Q. Have you ever personally participated in a 3GPP working group?
A. I have not attended meetings, but I receive e-mails from the 3GPP working groups regularly.
Q. Besides receiving e-mails, have you had any direct participation in a 3GPP group or part of a group?
A. No.
Q. Would you agree or disagree with the statement. Doctor Akl, that the people attending these working group meetings are typically, very experienced engineers in their particular discipline?

MR. NASH: Objection; form.

THE WITNESS: I don't have an opinion on that.

BY MR. BUMGARDNER:

Q. If I am a handset maker, what is the importance of complying with the applicable 3GPP standards, say, for LTE?

A. It depends on the context, and a lot of times there are specific features that you either want to comply with or be interoperable with. So, it's not just a blanket check box. There are a lot of check boxes on a very long list that, a lot of times, the network carrier would require the handset manufactures to either comply with or be interoperable with.

Q. So somebody like Verizon may tell somebody like Apple: Here's a long checklist of 3GPP LTE standards that you need to certify compliance with before I will allow your phone to operate on Verizon's network?

MR. NASH: Objection; form.

THE WITNESS: Again, this is outside the scope of my declaration. But generally, there are some features that may be one network carrier wants to push, either for marketing or for -- they want to advertise it that they have those features, and they would like the handset manufacturers to be compliant or be able to have those features in the phones.

BY MR. BUMGARDNER:

Q. And so, I'm not referring to, sort of -- I mean, I understand there's optional parts of the LTE specification. But, say, the formatting of a MAC layer message, something fundamental, you know, a part of the network?

With respect to the, say, the format of a MAC layer message, would you think that would some -- be something that Verizon would want it's handset carriers to make sure they comply with the applicable standard?

A. That's really outside of the scope of my declaration, and I don't have an opinion on that.

Q. Let's take something that's maybe more closer to this case.

With respect to power control, if there's a 3GPP specification that says, you know, here is the power control algorithm you should use, would you expect Verizon and AT&T and others to require handset manufacturers to comply with that standard?

MR. NASH: Objection; calls for speculation.

THE WITNESS: That is not an opinion that I was asked to provide an analysis or an opinion on in my declaration, so it is outside the scope of the declaration that I'm here answering questions on.

BY MR. BUMGARDNER:

Q. So if it's Patent Owner's position that it's critical for handset manufacturers to comply with applicable 3GPP standards with respect to power control, you don't have any opinion one way or the other to confirm or oppose that view?

MR. NASH: Objection; form.

THE WITNESS: I don't believe I've rendered an opinion on that in my declaration. But, based on what you were asking me earlier, I answered generally that you can comply with the standard, or certain features of the standard. You can be interoperable with certain features of the standard.

And, generally, that's my understanding based on my own experiences of working in the field.

BY MR. BUMGARDNER:
Q. Do you know, Doctor Akl, if a phone -- and when I say, "a phone," a handset is not compliant with an LTE power control standard, that it could cause interference and disrupt an operational LTE network?
A. That is not something I was asked to render an opinion on. And I -- for this IPR, I did not look at any specific products, but it's also my understanding based on my experience in the field that even if the standard provides an algorithm, a -- a manufacturer may implement a different version of the algorithm. And so, there -- there is some leeway in terms of what the standard requires and how products actually implement something specifically.
So it's very difficult to make generalizations and you have to really look at a case-by-case basis and the actual products and how they behave and you go down and look at the source code and what's in the source code before you can generalize. If those products actually do implement exactly what's in the standard or something similar, whether they are compliant with the standard, whether they're interoperable

and so, it's difficult to make generalizations in vacuum.

Q. If a handset operating on a LTE network is transmitting uplink messages at too high a power, is it possible for that handset to cause interference with other handsets in the area and degrade the performances of that LTE network, at least in that local area around the handset?

A. That is outside the scope of my declaration, and that is not something that I rendered opinions on.

Q. So you don't know if a handset is blasting away at maximum power when it shouldn't be, you don't know if that would cause, possibly cause interference with other handsets and possibly degrade their performance in an LTE cell?

MR. NASH: Objection; form

THE WITNESS: I think that's not what I said. I said you're asking me a question that is outside the scope of my declaration.

And I'm not comfortable answering one way or another without looking at specific scenarios. So your question is too general to be able to -- for me to be able to answer accurately in vacuum.

BY MR. BUMGARDNER:

Q. What would you need to know to be able to answer that question?

A. Well, I would need to look at specific numbers in the network and the products and what exactly is happening, and I have not done any of that analysis. So, it would be very difficult for me to answer your question today.

Q. One of the pieces of prior art that you've identified, Doctor Akl, is -- and it's labeled as "Exhibit 1005" to this IPR. It's Technical Standard 36.300.

Do you know if currently, handset manufacturers test for compliance against that standard?

A. That is not something that I have an opinion on today.

Q. Do you know if they tested -- "they" being handset manufacturers -- tested their products for compliance with that standard back at the time this standard was published in 2008?

A. That is not something I have an opinion on today.

Q. In your declaration, Doctor Akl -- and

I'll get it to you in a minute -- you make a statement that the entire path lost is used because there is no fractional portion in the equation. I'm not interested in that specific sentence, but I want to know what -- what is a fractional portion of an equation?

A. Can I get a copy of my declaration if we're going to be discussing that?

Q. I just want to ask -- before I give it to you, I want to ask about: What is a fractional portion of an equation?

A. Right. And --

MR. NASH: Objection; form.

THE WITNESS: And I'm asking for my declaration at this time since you're asking me about something that I specifically address in my declaration. So, I insist.

If you want me to answer your question, I would like my declaration. I've asked for it now multiple times.

BY MR. BUMGARDNER:

Q. Yeah. And I'll give it to you when I'm ready, Doctor Akl.

My question is: Without your declaration, can you tell me what a fractional portion of an equation is?

A. My response is: I would like my declaration before I proceed to answer questions on things that are in declaration.

Q. If I have an equation: A times B times C, what does it mean that there's a fractional portion of that equation?

MR. NASH: Objection; form. Lacks foundation.

THE WITNESS: I am not sure I can answer that question in vacuum, but if we -- you want me to go back to how that term applies in this IPR, I would like a copy of my declaration.

BY MR. BUMGARDNER:

Q. One of the terms at issue in this case. Doctor Akl, is a "power control adjustment state."

Are you familiar with that term?

A. Yes.

Q. That's a central point in this IPR. Isn't it?

MR. NASH: Objection; form.

THE WITNESS: I don't really have an opinion one way or the other on that point.

BY MR. BUMGARDNER:

Q. It's a term used in the claims of the 966 patent. Correct?
A. If you -- I'd like to see the claims to verify that. If you can please hand me the patents.
Q. I'll represent to you it is a term used in the claims.
What is a power control adjustment state?
A. I believe it is something that I have addressed in my declaration. So I would like a copy of my declaration to be able to answer that question.
Q. Can you answer it without looking at your declaration?
A. It is my understanding that this is not a memory test. So since you're asking me something specific, and as you have pointed out is very important to this IPR, I don't want to rely on memory, and I would like my declaration at this time.
Q. So I'm asking the question: Can you describe without your declaration what a power control adjustment state is?
A. I've already answered that question and

my answer is on the record.
Q. Hold on a second, guys.
MR. BUMGARDNER: This is marked as "Exhibit 1002." We'll stay with those same exhibit numbers.
BY MR. BUMGARDNER:
Q. So Doctor Akl, there is your declaration. Can you confirm that that's the declaration that you submitted in this matter?
A. Yes.
Q. So if I could ask you to turn to Page 58 of Exhibit 1002.
Are you there, Doctor Akl?
A. Yes.
Q. You the see the sentence under "Modified Equation 2," it states, "The entire pathloss is used because there is no fractional portion in the equation"?
A. Yes. I see those words.
Q. So what -- what is a -- I ask my question again. What is the fractional portion, or no fractional portion of the equation?
A. (No audible response.)
Q. And while you're looking. Doctor Akl, let me just ask a more general -- I want to ask a

general question of: What is a fractional portion in any equation? As you use the term "fractional portion" in your declaration, 1002, Exhibit 1002.

MR. NASH: Objection; form.

THE WITNESS: So when you have different terms, generally, in an equation and you have a multiplier, or a factor that's being multiplied by those terms, that multiplier or that factor, depending on its value, if it's less than one, it would produce a fractional portion for the components that it's being multiplied by.

BY MR. BUMGARDNER:

Q. So, let's take the equation A times B. If A is .5, would that be a fractional component in the equation A times B?

MR. NASH: Objection; form.

THE WITNESS: You have to look at the context. It's very difficult to generalize. So if B -- because A and B are just variables. So they're names that we assign a meaning to. To the extent that, you know, A is something that has a meaning and it happens to have a value of .5, the answer may be "no."

If the only thing in the equation

that really has a meaning which in that case, in your hypothetical, B, B is some quantity -- or something that has a meaning and A is a scaler, used to multiply B, in that sense, you can think of A as providing a fractional portion or contributing to a fractional portion of B.

So again, it's very difficult to generalize without looking at specific instances and what the meaning that's given to the variables are and then, based on that meaning, you can make a better determination of what constitutes a fractional portion.

Q. So you're saying the -- the variations have to have meaning before you can say there is a fractional portion or not?

MR. NASH: Objection; form. Mischaracterizes testimony.

THE WITNESS: In your incomplete hypothetical, I was trying to build on it to be able to answer your question. The question that you asked me was so vague that it would have been impossible to answer without providing some qualifications.

So, I am merely providing some examples to try to answer your question, which

just said "A times B." So in that context I was trying to answer a -- a vague question.
BY MR. BUMGARDNER:
Q. You find "A times B" to be vague?
MR. NASH: Objection; form.
THE WITNESS: Yes. Without what A is or what B is, or in what context, it is a very vague question.
BY MR. BUMGARDNER:
Q. How can you look at equation -- modified Equation 2 and determine there is no fractional portion in the equation on Page 58 of your declaration marked as "Exhibit 1002"?
A. So we're looking here at the pathloss. And earlier, in my dec, I provide an opinion on what "pathloss" means, and how it is calculated and so I'm looking at the pathloss component of Modified Equation 2. And the pathloss, when we're working in the logarithmic scale is going to be the difference between the transmitted power and the receive power.
So, if you transmit at a certain amount and you end up receiving a lower amount in the logarithmic scale, that difference is the -- would correspond to the pathloss.

Now, if that quantity is multiplied by a variable whose role is to further scale or modify that quantity, then you end up with a fractional pathloss.

If that -- if you also have that variable and the value of that variable is one, so you're multiplying the pathloss by one, you're essentially taking the entire pathloss, and you don't have a fractional portion.

Q. So in your Modified Equation 2, on Page 58 of your declaration, in that -- and that's written in logarithmic form, correct, Doctor Akl?

A. Yes.

Q. So in this Modified Equation 2, these variables you've identified as pathloss are multiplied by a value interference correction. Correct?

A. No.

Q. Can you explain that?

A. Yes. There's -- there is no multiplication by the variable interference_correction. There is an addition between what you've identified as the pathloss and the interference correction.

If you look at that equation, there is a plus sign, not the a multiplication sign between those two terms.

Q. That's because interference correction is a logarithmic value. Correct?

A. In this equation, all the terms -- I'm taking the -- the logarithmic values of -- of the original equation.

Q. And so, if we went back to the original equation as you just referred it, what you've identified as "pathloss" would be multiplied by interference correction?

MR. NASH: Objection; form.

THE WITNESS: Possibly. We would have to -- I mean, there are a lot of different terms in this equation. The pathloss in this equation is just what I've identified for the variable PL, and it's only two terms. But there are several other quantities in this equation.

BY MR. BUMGARDNER:

Q. And that's my question, Doctor Akl. And we can spent as much time as you would like; but in Modified Equation 2 and the non-block rhythmic version of this equation, isn't it the case that the values you have identified as pathloss are

multiplied by interference correction?
A. I would have to go back and look at that equation before I can render an opinion.
Q. Exhibit 1003.
MR. NASH: Thank you, Barry.
BY MR. BUMGARDNER:
Q. Doctor Akl, I've handed you what has been previously marked in this IPR as "Exhibit 1003." It's a patent, Number 8,599,706.
Do you recognize this exhibit, Doctor Akl?
A. Yes.
Q. If I could ask you to turn to Column 9 of this patent. Tell me when you're there.
A. I am there.
Q. Do you see an Equation 2 at about Line 21 of Column 9?
A. Yes.
Q. Do you see the text above it that says, "Equation 1 may be rewritten in logarithm domain using the units of decibel as follows"?
A. Yes. I see those words.
Q. And -- and what follows is Equation 2. Correct?
A. Yes.

Q. And in your declaration on Page 58, your Modified Equation 2 is a modification of Equation 2 in Column 9 of Exhibit 1003. Correct?

A. Yeah.

Q. And so Equation 2, is a version of Equation 1 in Exhibit 1003 shown in Column 8. Correct?

MR. NASH: Objection; form.

THE WITNESS: Can you repeat the question, please?

BY MR. BUMGARDNER:

Q. Certainly. So we have Equation 2 in Column 9 of what I think we're all calling the "Qualcomm reference."

So, do you see that, Doctor Akl?

A. Yes.

Q. And if I refer to this as the "Qualcomm reference," I believe that's how you have referred to it in your declaration. Can we have an understanding that that refers to this Qualcomm 706 patent?

A. Yes.

Q. So we have Equation 2 in Column 9 of the Qualcomm reference and the text in Column 9 says that Equation 1 may be rewritten as Equation 2.

So I'm directing you to Equation 1 in Column 8. I just want you to confirm that, mathematically speaking, Equation 1 and Equation 2 are identical?
A. Yes.
Q. All right. So we have Equation 1, and there, it's not in logarithmic form and we have a series of values that are being multiplied by each other. Correct?
A. Yes.
Q. And so is there value you identified as pathloss shown in Equation 1?
A. Yes.
Q. And my question is: In Equation 1 is the value you've identified as pathloss multiplied by an interference correction value?
A. Going back to my declaration, it also helps provide context in answering your question.
In Paragraph 128 of my declaration, I do refer to paragraphs 51 and 53 where I provide more context in terms of what pathloss means.
And in Paragraph 128, I do refer to Equation 1 in the Qualcomm reference that you're asking me right now on. And it is my opinion

that the pathloss in Equation 1 is the ratio of the power transmitted to the power received, and there are two values in Equation 1 whose ratio would constitute the -- the pathloss.

Those are multiplied by different things in Equation 1.

But the ratio of the power transmitted to the power received, as I've identified in Paragraph 128 and then I go on Paragraph 129 and I carry out the logarithmic analysis which we see in Equation 2 has different -- has the pathloss component multiplied by other variables.

MR. BUMGARDNER: Objection; non-responsive.

BY MR. BUMGARDNER:

Q. My question, Doctor Akl, is: Is the -- the value you have identified as pathloss in Equation 1 and 2 multiplied by a value referred to in Equation 2 as "interference correction"? It's a "yes" or "no" question, is pathloss multiplied by interference correction?

MR. NASH: Objection; form.

THE WITNESS: If you look at the bottom of Column 8, right below Equation 1 that you're asking me on, there are a list of variables and the names of these variables.

Can you identify for me so I can better answer your question which line in Column 8 you're asking me about?

BY MR. BUMGARDNER:

Q. Certainly, so there in Line 55 of Column 8, there's a value capitalized of 0C that's described as the interference from other eNodeBs at the UE.

Do you see that, Doctor Akl?

A. Yes. I see that line in that variable.

Q. Does that variable multiply the value you've identified by pathloss in Equation 1?

A. No. Not directly. It says "added." If we go back to Equation 1, now that I understand which variable you want me to look at, that variable is being added to the Number 1 and it's being added to capital N0, which is the Gaussian noise, which is in Line 54 of Column 8 before. And then it's divided by a different variable.

Q. So maybe that was a bad example, Doctor Akl.

How about, do you recognize the

Greek symbol on Line 62 of Column 8?
A. Yes.
Q. What is that Greek symbol?
A. Delta.
Q. So -- and delta is identified in Line 62 of Column 8 as a correction factor. Correct?
A. Yes.
Q. Does delta on Line 62 of Column 8, multiply the value you've identified as pathloss?
A. Delta is one variable in Equation 1, and it is multiplying the different terms in Equation 1.
Q. Including the terms that you say are pathloss in Equation 1?
A. Yes.
Q. Now, if delta is less than one, does that mean that -- it's a fractional portion of the equation of -- let me ask it again.
If delta is less than one, is that a fractional portion of Equation 1?
A. Yes. That would be an example or an embodiment.
Q. If delta is less than one, would full pathloss compensation be used in Equation 1 because delta is multiplying what you've

identified as pathloss?

MR. NASH: Objection; form.

THE WITNESS: In your specific example, if delta is less than one and it's multiplying the pathloss then you don't have full pathloss. But that would be one example, and one of ordinary skill in the art would understand that delta doesn't necessarily always need to be less than one. And even in the 966 patent and the applicant admitted prior art, there is a corresponding variable alpha that's used there that can take values less than one or can take values equal to one.

So delta less than one would be one example. Delta equal to one would be another example. And in the context of delta being equal to one, you do have full pathloss, and that's how one of ordinary skill in the art would understand the role of delta in Equation 1.

MR. BUMGARDNER: We've been going about an hour, Brian. Do you want to take a break here?

MR. NASH: Sounds good if that's good for you.

THE WITNESS: Yes. Thank you.

THE VIDEOGRAPHER: We're going off the record at 10:42. We're off the record. You can remove your mics.

(Recess taken.)

THE VIDEOGRAPHER: We're back on the record at 10:53.

BY MR. BUMGARDNER:

Q. Doctor Akl, let's -- let's turn to a power control adjustment state. So let me have the Qualcomm reference. You have your declaration. Let me provide you with a copy of the patent in suit, patent at issue.

Do you have that already, Doctor Akl, Exhibit 1001? I don't think you do.

MR. NASH: I don't think so.

THE WITNESS: No.

MR. NASH: Thank you.

BY MR. BUMGARDNER:

Q. Doctor Akl, you now have before you Exhibit 1001 to this IPR proceeding which is U.S. Patent 8,385,966, the patent that is being challenged by Petitioner in this action. You have your declaration as well.

So my question is: What does the term "power control adjustment state" mean to

you, as that term is used in the 966 patent
including Claim 1?
A. Before I answer that question, would I be able to please get a copy of the institutional decision?
Q. I do not have that with me, Doctor Akl. But you opined on it. Doctor Akl, I would give it to you if I had it. I don't have the institution decision before me.
But you say you have studied the patent at issue. Obviously, you've opined about it in your declaration, so with those documents, what is the term "power control adjustment state" mean to you, again, as that term is used in the 966 patent?
A. Looking at the claim in my opinion relating to the first power control adjustment state, one place at Paragraph 130 and 131 in my declaration on pages 58 and 59, I refer to the parameters f of (i), which is f(i) and g of (i) as they are disclosed in the applicant admitted prior art. And specifically, the Standard 36.213 and, also, in Column 4 of the 966 patent, if you look at the bottom of Column 4, around Line 65, through Column 5 around Line 35, you have the

variables, f of (i) being described and f of (i) would be an example of a power control adjustment state.

There is also g of (i) would be another example of a power control adjustment state, depending on which uplink channel you're looking at.

Q. So, and I understand those are examples of power control adjustment states, but my question is broader than that. What -- what is the purpose of a power control adjustment state beyond the specific examples listed in the 966 patent?

A. So in the 966 patent, when they are referring to the "power control adjustment state," they're referring to those terms as they are used in 3GPP TS 36.213, and so looking at Column 4, around Line 29, the 966 patent references that 3GPP standard, and it pulls Equation 1 from the standard and the power control adjustment state is one variable that is described in the standard and in Equation 1 and the 966 adopts that understanding right out of the standard.

Q. But what -- what is the purpose of a

power control adjustment state? That's my question, Doctor Akl.

MR. NASH: Objection; form.

THE WITNESS: So, that term would have its broadest reasonable interpretation. It is a variable that basically just has the word "state." It is an adjustment to the power control, and the reason we use the word "state," because it is dependent on an Index i.

So would be one example where if "i" is equal to zero, that would be your initial state, and "i" can take on different values as you go from one state to another.

But one of ordinary skill in the art would understand that term. I don't believe I provided an explicit construction. It is a term of art. It is used exactly the same way in the 3GPP standard and the 966 patent copies directly out of the standard that term and the equation that uses it.

Q. And the value "i," as part of f of (i) and g of (i), i refers to sub frame number. Correct?

A. Is there somewhere specific you want me to look just to verify before I answer?

Q. One second, Doctor Akl, I'll point you to.
If you look at Column 4, Line 61, it makes reference in PUSCH of i or sub frame i?
A. Yes. I see those words. I also see them on Line 56.
Q. So, is it your understanding that f of (i), the value "i" in f of (i) and g of (i), "i" refers to a particular sub frame?
A. i is an index, and in -- in this case, you're indexing over the different sub frames.
Q. If you look in the 966 patent in Column 6, the paragraph that starts on Line 27, there's a discussion about f of (i) and different sub frames.
Do you see that, Doctor Akl?
A. Yes, I see. I'm at Column 6. The paragraph that starts at Line 26.
Q. So, you see it's -- I'll direct you to Line 23, the sentence that reads, "When the UE first sends data on the P-U-S-C-H," all caps, "there is no previous sub frame and so i equals zero."
Do you see that, Doctor Akl?
A. Yes.

Q. So do you see that is contemplating the scenario when the UE first starts sending data on the P-U-S-C-H, it's the first sub frame so there's no previous sub frame, so i equals zero denoting the first sub frame or there is no previous sub frame?

A. Correct.

Q. So do we agree that when we use the term "f of (0)," that's referring to the power control adjustment state for the first sub frame?

A. Sure. I can agree with that, and that is, I believe, what the 966 and the -- what the prior art referred to as "Message 3" because that's when you are initiating your transmission of data.

Q. So you mentioned Message 3. So, the sequence is Message 1 would be the UE sending a random access preamble to an eNodeB to obtain access to whatever network services are available to connect to the network. Correct?

MR. NASH: Objection; form.

THE WITNESS: We can look at Figure 1-B in the 966 and Figure 1-B is prior art, and it does label "Message 1" the random access preamble. And we can go to the corresponding text.

BY MR. BUMGARDNER:

Q. And so, Message 2 would be the response from the eNodeB back to the UE. It's a response to the random access preamble. Correct?

A. Yes.

Q. And in that response, it may have allocations of resources that the UE can then use to send up what is labeled in Figure 1-B, the schedule transmission, I think what we're calling is Message 3. Correct?

A. That was a long question because you had a lot of subparts to it.

Q. Sure.

A. The random access response is Message 2 from the eNodeB to the UE, and there's a lot of information in that random access response. And in my declaration, I describe some of those parameters in Message 2 and then the UE would transmit Message 3, which is the scheduled transmission.

Q. So let's -- let me direct your attention now to Claim 1 of the 966 patent?

A. (Witness complies.)

Q. Are you there, Doctor Akl?

A. Yes.
Q. Do you see the first claim element that starts with "Using a processor to initialize."
A. Yes.
Q. In that -- in the claim element there states, it's a method claim, so a method step of using a processor to initialize for i equals zero, a first power control adjustment state g(i) -- I'm going to skip a little bit" "and a second power state of f of (i).
Do you see that?
A. Yes. I see those words.
Q. So would you agree, Doctor Akl, that Claim 1 requires two power control adjustment states, one for g(i) and one for f of (i)?
MR. NASH: Objection; form.
THE WITNESS: Even though two variables are used for two power control adjustment states, the two states are actually equal, and f of (i) and g of (i), when i is equal to zero will have the same value, and the dependent claims also make that very clear, and so does the specification.
Q. So, I understand. I appreciate that. But my question is sort of -- is more fundamental

that: Do you agree that Claim 1, the scope of Claim 1 requires a first power control adjustment state and a second power control adjustment state?

MR. NASH: Objection; form. Asked and answered.

THE WITNESS: Yes. I see those words, and I expanded previously on the record how the two states relate to each other.

BY MR. BUMGARDNER:

Q. So Claim 1 in -- you opine on this, requires setting f of (0) to be part of an equation listed on Column 13, Line 10.

I won't repeat the equation but do you see the equation there on Column 13, Line 10?

A. Yes, I do.

Q. This is of the 966 patent?

A. Correct. We are in Column 13, Line 10 of Claim 1.

Q. I believe in your opinion you state that P -- is that a zero or a letter "O" there on the first variable in the equation of -- in Column 13, Line 10?

A. We can go with either.

Q. How about zero?
A. That's fine.
Q. Okay. So the value that starts with P0, I believe you state in your declaration that because that can be equal to zero, the equation in Column 13, Line 10, can basically collapse to f of (0) equals delta Ppc+ delta C_rampup.
A. Correct. And I go through an analysis why that is so. And at a high level, looking at Claim 4, which depends on Claim 3, which depends on Claim 1, it explicitly provides an embodiment where that -- that variable that starts with P_0 has the value of zero.
Q. So, my question now is, Doctor Akl, for f of (0), as described in the 966 patent, can you confirm that that is a different equation than what is described in Exhibit 1004 of the 3GPP specifications which, as you noted, is also reproduced largely in Column 5, the 966 patent.
So, said a lot of words. Let me ask the question: I want you to confirm that f of (0) as described in Claim 1 of the 966 patent is different than f of (0) as described in the 3GPP specifications of Exhibit 1004.
MR. NASH: Objection; form.

THE WITNESS: Can I get a copy of 36.213?

BY MR. BUMGARDNER:

Q. Certainly. I thought you had one. So I'm handing you what's been marked in this IPR as "Exhibit 1004." The title of this document is "3GPP TS 36.213."

A. Is there a specific section that you want me to look at in 36.213 to be able to answer the question that you asked me?

Q. Sure, Doctor Akl. If you could turn to -- it's marked as "1004-9." It's Page 9 of the document.

A. I am there.

Q. It's the third bullet point down, and it says "f of (0) equals zero."

A. I see those words.

Q. So the standard says f of (0) is equal to zero. Correct?

A. I wouldn't phrase it that way. I would phrase it. I would answer that question by -- I disagree in part. The standard isn't just one document. The standard is multiple documents. So in this specific example limited to 36.213, on Page 9 it gives you an example where f of (0) is equal to zero.

Now, it is my opinion that when you combine 36.213 with other documents from the standard, one of ordinary skill in the art would understand that the standard also discloses different examples where f of (0) can be different from zero and would be equal to what's disclosed in the 966.

It is also my opinion that when 36.213 is combined with the Qualcomm reference, one of ordinary skill in the art would understand that the combination discloses an f of (0) that is different from zero.

Q. So you have your opinion in front of you, Doctor Akl. Can you list the other 3GPP standards that give an alternate value of f of (0)?

A. So in the context of -- of my analysis, starting on Page 46, I am providing an analysis why the combination of 36.213 and Qualcomm would disclose a value of f of (0) that would be identical to what's in the 966.

In that opinion, I also disclose, starting on Paragraph 107 from Page 49 why one of ordinary skill in the art will come up with equation for A in the 966 by looking at admitted prior art and 36.213.

Q. So I understand that, Doctor Akl. We'll get to your opinions later.

I believe you said earlier that when I was asking if 36.213 disclosed f of (0) equals zero, you said something, well, that particular document does, but there is other standards documents that I have other values to f of (0).

So I want to limit my question to other 3GPP standards documents that you rely on for your opinion. I don't think there's any other document -- any other standards documents that address f of (0) but I want you to confirm that.

So, if there's other standards documents that are at issue in this IPR that disclose a different value of f of (0), can you please list them?

A. I think you're mischaracterizing my testimony slightly. So let me answer that question and be clear on the record.

I believe your question stated the standard. And to me, the word "standard," or the standard document is not limited to 36.213. That is one document in the standard. And we were looking at one bullet point on Page 9, and that does list f of (0) being equal to zero.

But when I was doing my analysis, in terms of how one of ordinary skill in the art would understand what the initial value of f of (0) can be, looking not just at 36.213, but looking at additional admitted prior art, one of ordinary skill in the art would come up with ultimately Equation 4-A, which is Equation 4-A out of the 966 patent, which also appears in the claims.

Q. Are there any other standards documents that you're relying on that show f of (0) equal to something other than zero? And if there are, please list them.

A. So I rely on applicant's admitted prior art, including TS 36.213. And I walk through, from Paragraph 107 through Paragraph 118, why one of ordinary skill in the art, looking at the standard and the different documents in the standard beginning applicant admitted prior art would come up with Equation 4-A, of which f of (i) is part of.

So, my task isn't specifically to show f of (0). My task is to look at the claims of the 966 and would one of ordinary skill in the art have found those claims to be obvious.

So in the process of doing that, I provide two opinions that are consistent in terms of the one that we're describing, the first one that I offer is the combination of 36.213 with Qualcomm.

And then without looking at Qualcomm, the second opinion is looking at the standards and applicant's admitted prior art, Equation 4-A is disclosed.

Q. Again, Doctor Akl, I don't think your opinion or report mentions any other 3GPP standards that disclose f of (0). So, I want to get an answer to this before we move on because you've said there's maybe other standards, parts of the standards that talk about f of (0).

The question still remains: Are there other 3GPP standards documents that you are relying on that show f of (0) equal to some other value other than zero?

MR. NASH: Objection; form. Asked and answered.

THE WITNESS: So in Paragraphs 107 through 118, I rely on TS 36.213.

I also rely on 36.321, which is also applicant admitted prior art. And the 966 references 3GPP Standard 36.321.

I also rely on another 3GPP standard later, but at least with respect to this specific limitation I believe these are the two that I rely on unless I missed something on pages 49 through 53.

BY MR. BUMGARDNER:

Q. Is there anywhere in your opinion where you rely on TS 36.321 to show the value f of (0)?

A. So as part of my opinion in this section, starting in Paragraph 113, I do state that why one of ordinary skill in the art would be motivated to look at 36.321 and why it is applicant's admitted prior art.

And then in Paragraph 114, I rely, for example, on Section 5.1.3 of TS 36.321 that describes what happens during the random access procedure.

And I continue citing and I refer to previous parts of my declaration at the end of 114, and I rely on two proposals for what one of ordinary skill in the art would have understood. But then continuing in Paragraph 115, I continue relying on Section 5.1.3 and -- in 36.321, to do the analysis why the 3GPP standard on its own and combined with the knowledge of one of ordinarily skill in the art and applicant's admitted prior art discloses Equation 4-A.

Q. Same question, Doctor Akl: Do -- are there any 3GPP standards about which you're aware of that disclose a value of f of (0) that's something other than zero?

A. So it is the combination of the different documents in the 3GPP standard combined with the knowledge of one of ordinary skill in the art and admitted applicant prior art that does disclose a value of f of (0) that would be -- that would correspond to the 966 and specifically Equation 4-A.

Q. Doctor Akl, are there any 3GPP documents besides Exhibit 1004 that describe zero is equal to something other than zero?

MR. NASH: Objection; asked and answered.

THE WITNESS: So you've asked me that question multiple times and I've answered that question to the best of my ability. And my answer is on the record.

BY MR. BUMGARDNER:

Q. With all due represent, Doctor Akl, you have not answered that question. And if we need to get on a call with the Board to make you answer that question, we can. It's a simple question: Are there other documents besides Exhibit 4 that disclose a value of f of (0) to be something other than zero?

MR. NASH: Objection; asked and answered and argumentative.

And if you want, we can take a break and get the Board on the phone. But you've asked him to answer. He's answered. He's provided a bunch of context for that answer by pointing to his declaration. So, the answer's on the record.

MR. BUMGARDNER: The answer is not on the record. It's: List the documents you're relying on. He identified in the first question I asked him that there's other standards documents that identify f of (0).

BY MR. BUMGARDNER:

Q. If there's not, there's not your

opinion, Doctor Akl. But I want you to confirm that because if there are, then there are some other documents on there, I want to know about them.

So, it's a simple question, are there other documents, standard or otherwise, that say f of (0) is something other than zero?

That's all. I just want know if there's other documents you're relying on. If there is not, then we can move on.

MR. NASH: He's pointed you to the answer on that.

MR. BUMGARDNER: He has not. He's -- he's talked about his opinions, the combinations. He mentioned there's other standards documents, and if you want to say there's not, that you're just relying on Exhibit 4, then that's fine. We'll move on.

MR. NASH: And now, you're mischaracterizing his testimony because he didn't say he is just relying on Exhibit 2004. He has also provided context about the standard that is at .321.

So I don't think you need to mischaracterize his testimony if you're going to

be arguing with him about what he said.
BY MR. BUMGARDNER:
Q. Doctor Akl, does Technical Standard 36.321 disclose a value of f of (0)?
MR. NASH: Objection; asked and answered.
THE WITNESS: The combination of 36.321, with 36.213, an applicant admitted prior art, disclose the Equation 4-A in the 966 patent which includes f of (0).
BY MR. BUMGARDNER:
Q. Does TS 36.321 disclose any value of power control adjustments?
MR. NASH: Objection; asked and answered.
THE WITNESS: I'm not doing an anticipation argument on one piece of prior art alone. And so, it's -- it would be incorrect to me to be able to answer a question "yes" or "no" because this is not a single reference.
This analysis is done from the point of view of one of ordinary skill in the art and why one of ordinary skill in the art would have been motivated to combine two parts of the standard, which I have already provided that

motivation, and looking at both parts of the standard, do they teach a limitation in the 966 patent?
That is the analysis and that is the only way I can answer your question.
MR. BUMGARDNER: If I could have this -- I don't know how we want to mark this, Paper Number 1 is the Petition in this matter. Paper Number 1.
THE COURT REPORTER: Okay.
(Paper Number 1 is marked.)
BY MR. BUMGARDNER:
Q. Doctor Akl, I've handed you what's been marked as "Paper Number 1," which is the Petition in this matter. If I could ask you to turn to the third page that starts with "List of Exhibits."
A. I'm there.
Q. So, we see a number of 3GPP documents. Some are technical standards. Some are draft proposals.
Do you see that, Doctor Akl?
A. Yes.
Q. So, my question is: Do any of those documents besides Exhibit 4 -- or excuse

me -- Exhibit 1004 -- disclose a value or disclose that f of (0) something equal to other than zero?

And if you want to, Doctor Akl, I'll print all these out and you can have them and we can sit here on the record for however long it takes, and you can point me to the pages in those. I don't think there is. I don't -- you can read your declaration. You don't rely on anything other than that.

So I want you to confirm that. But if you want me to print these out and have you look at them, we can do that. So, it's up to you, Doctor Akl?

MR. NASH: Objection; form.

THE WITNESS: You've asked me that question now multiple times and I believe I've answered that question multiple times. I'm going to take another stab at answering the question. And just like I've answered previously, looking at the task that I was asked to do, I am not using hindsight. I'm not looking for a specific term or a piece of the puzzle. I'm trying to find if that piece of the puzzle is in different documents.

That is not how you do the type of analysis that I'm asked to do. So, I can't answer your question as a "yes" or "no" because that is not my task.

My task was: Did I -- to put myself in the shoes of one of ordinary skill in the art and look at the standard and I looked at TS 36.213.

I looked at 36.300.

I looked at 36.321.

And would one of ordinary skill in the art, looking at the 3GPP standards, as a whole, why would they have they be motivated. It's one standard but that's one example. Why they would be motivated to look at the different documents and would the different documents disclose and teach one of ordinary skill in the art the limitations in the 966?

It's not a recipe that I follow and I find buzz words in different documents. That's not -- that would be using hindsight and that is not my task. So, I can't answer maybe to your satisfaction the question because that is not a task that I did, and that would be an improper way to do an analysis.

But what I can say is buy not using hindsight, would one of ordinary skill be motivated to look at the different sections of the standard? And would they come to the understanding that is what is disclosed in the 966 patent is obvious?

And specifically, Equation 4-A and the f of (0) having the value that the 966 tells you needs to be for the initial stay.

The answer to that question is yes, and those are the sections that I have pointed to multiple times, including the table and the chart that I've also added to the end of my declaration that goes through again and references the standards.

So that is what I did, and that is the best way I can answer your question.

Q. So in Exhibit 1004, we've -- we're on Page 9. I think we agree that that describes a value for f of (0) equals zero. Correct?

A. It introduces the concepts of power control adjustment states, and it provides an example where if you don't know the value of f of (0), you can initialize it to zero. That would be one example of how to initialize an unknown value.

But one of ordinary skill can look at different embodiments and examples in the standard to know that you can initialize the power control adjustment states to different values based on what you know.

You cannot initialize it to something you don't know, and part of my analysis goes through why one of ordinary skill in the art looking at 36.213 along with 36.321 and the applicant admitted prior art, it does disclose an initial value that is different than zero.

Q. So I want you to take Exhibit 1004, Doctor Akl, and point me to any other pages. I want you to go read the first page to the last page and point me to any other pages that describe a value of f of (0) being equal to something other than zero. And then we'll start with Exhibit 1005 when you finish with that.

MR. NASH: Objection; form.

THE WITNESS: I can definitely do what you asked me to do. But that would not be a proper analysis that I would be doing. So, I can walk through that exercise, but that is different than what I was asked to do.

MR. BUMGARDNER: Objection; non-responsive.

BY MR. BUMGARDNER:

Q. Please identify, Doctor Akl, the pages in Exhibit 1004 besides Page 9 that describe a value of f of (0) that is equal to something other than zero?

MR. NASH: Objection; asked and answered. Form.

(Pause in proceedings.)

THE WITNESS: Okay. I'm done with my initial assignment.

BY MR. BUMGARDNER:

Q. All right. What are the pages in Exhibit 1004 besides Page 9 that show a value of f of (0) to something other than zero?

A. So when you were to look at f of (0), you have to look at not just those specific words, but you have to look at f of (i), and then when you said "i equals to zero," you end up with f of (0).

So, the variable, f of (i), appears in multiple places starting, for example, on Page 8 in the equation right under Section 5.1.1.1.

And then, on Page 9, there are two different examples of how f of (i) can be determined.

One example represents accumulation, which is the first bullet point we were looking at under which there is disclosure for f of (0) being equal to zero.

The second way f of (i) can be determined would be as a current absolute value. And halfway down Page 9, it describes different ways that f of (i) would be determined and f of (0) would be one way where you said "i equals to zero."

And then, at the -- right above Section 5.1.2, the standard describes the different types for determining f of (i).

Then, when we go to Section 10 -- sorry -- Page 10, Section 5.1.3.1, the variable f of (i) appears again, and there is a description of it at the bottom of Page 10. Those are the examples that I found looking specifically at the variable "f."

Q. On Page 10, does it describe how to compute f of (0)?

A. No. It refers you back to

Section 5.1.1.1.

MR. BUMGARDNER: Y'all want to take a break here? We need to change the tape.

MR. NASH: Sure.

THE VIDEOGRAPHER: Going off the record at 11:49. We are off the record. You can remove your mics.

(Luncheon recess taken.)

THE VIDEOGRAPHER: This is Disk Number 2 of the deposition. We are back on the record at 12:55.

BY MR. BUMGARDNER:

Q. Doctor Akl, I will hand you what's been previously marked as "Exhibit 1005" of this IPR proceeding.

A. Thank you.

Q. So my question, Doctor Akl, is, I'd like you to identify any pages in this document that discuss setting a value f of (i) or g of (i), as those terms are used in the 966 patent.

A. I don't think this is the complete document. This document starts at Page 44.

Q. So, good call, Doctor Akl. I printed off, only, I thought the pages that you referred to in your declaration. If you would like, I can print the whole document off. And you can take a look at that.

But, you know, I guess I'd first ask: Do you refer to other pages besides the ones included in what I have marked as "1005"?

A. Actually for the section that we were discussing at least with regard to Limitation B of Claim 1, and specifically the discussion on Pages 46 through 53, I don't think I even referenced 36.300 on those pages.

Q. So it's -- okay. If I printed the wrong pages, then that's on me.

All right. Why don't you hand that back to me, Doctor Akl? Or you can keep it, and let the record show what was marked as "Exhibit 1005," was not a complete copy.

So let me hand you what was marked as "Exhibit 1006," is this -- or what has been marked as "1006" in this IPR.

MR. NASH: Sorry.

MR. BUMGARDNER: Bless you.

BY MR. BUMGARDNER:

Q. And ask if you can tell me any pages in Exhibit 1006 that discuss setting a value of f of (i) or g of (i) as those terms are used in the 966 patent.

A. I'm ready.

Q. Are there any pages in 1006 that discuss f of (i)?

A. So, I'm looking at 3GPP TS 36.321. And the relevant sections are under Section 5, Section 5.1, which is random access procedure on Page 11 through the top of Page 13.

Section 5.11 is the random access procedure initialization.

Section 5.12, random access resource selection.

Section 5.13, random access preamble transmission.

And then 5.14, random access response reception.

So starting with Section 5.1.1, there is -- there are multiple bullets that describe the different parameters some that I have cited in my declaration with regard to the POWER_RAMP_STEP and preamble initial power similarly in Section 5.13, there are equations for the random access procedure that I have also cited.

For example, on Page 51 in my

declaration, I cite to Section 5.1.3.
The variable "f" does not appear. But one of ordinary skill would still look at this reference because it does describe random access preamble transmissions.
Q. And we'll get to a complete copy of Exhibit 1005 in a moment. Let's turn now, Doctor Akl, to your declaration. And let me get a page for you.
Let's say Page 39, Paragraph 85. Are you there, Doctor Akl?
A. Yes.
Q. Do you see in the third-to-the-last line on Page 39, you make reference to unknown UE specific parameters.
Do you see that?
A. Yes.
Q. What do you mean as "unknown" in this Paragraph 85? What makes these parameters unknown?
A. So the -- these specific parameters f of (0) or g of (0) and p of (0)_UE_PUSCH or P_0_UE_PUCCH.
Those are parameters that have not been defined yet for a specific UE. So those

values need to be initialized to some value before they can be used.

One example would be to initialize those values to zero, and the applicant admitted prior art discloses that example where the p of (0) variables and the f of (0) or g of (0) variables are disclosed, are -- are initialized to zero in the prior art.

In difference embodiments of the 966, they continue to initialize p of (0) for the uplink shared channel and the control shared channel to zero, also, while f of (0) or g of (0) may be initialized to something that is non-zero.

But you have to determine or make a decision what you want to initialize them to before you can use them. And so, before you do those parameters or the values of those parameters unknown.

Q. If I could ask you to turn to Page -- excuse me -- Paragraph 113, Page 51 of your report. You again, used the term "unknown" in Paragraph 113. And there in the first sentence, I believe, you're discussing that the parameters P sub zero and f of (0) appear in

Equation 1.

Do you see that?

A. Yes.

Q. And so, that's Equation 1 of the 966 patent. Correct?

A. Yes, Equation 1 in the 966 patent as it appears in Column 4 is identical to the equation and is copied from 3GPP TS 36.213.

So, it is an equation that is in the prior art. It is admitted prior art. And I have first reproduced that equation in Paragraph 107, in Paragraph 107 on Page 49.

So, it's two pages before, and provided substitutions to get to the Equation 1 that appears on Page 50 of my declaration right before the paragraph that you asked me about.

Q. So if -- if the technical standard 36.213, that's what we've been referring to as "Exhibit 1004." Correct?

A. Yes.

Q. So can we turn to Exhibit 1004 and Page 8 of that exhibit?

A. I am there.

Q. So can you confirm that the equation immediately under 5.1.1.1 is the same equation

listed in the 966 patent as Equation 1?
A. It is. And it appears exactly in 107 of Page 49 of my declaration.
Q. So in this equation in Exhibit 1004, uses the term "P_0_UE_PUSCH." Correct?
And I note that's in the third bullet point down in 5.1.1.1.
A. P_0_UE_PUSCH, is part of P_0_PUSCH.
Q. Okay. So good point, Doctor Akl. So, the Equation 1 in the 966 patent and the equation listed on Page 8 Exhibit 1004 used the term P_0 PUSCH(j.) Is that correct?
A. Yes. That equation was reproduced, also, as is in Paragraph 107 of my declaration.
And then in Paragraph 108 is where I specifically describe the term that you're asking me about, the P sub 0_PUSCH and how that relates to P sub 0_UE_PUSCH.
Q. So I just want to be clear. It isn't, I don't think, a controversial question.
But the value in Paragraph 113 of your report, P sub 0_UE_PUSCH, that parameter is the same parameter discussed on Page 8 of Exhibit 1004 by the same name?
A. Yes. P_0_UE_PUSCH is at four-bit

UE-specific component that is configured by the RRC for the different indices, and I also provide a range of values and the standard gives us a range of values that it can take, and that's also described in Paragraph 108 of my declaration where I list the range of values it can take along with what that term represents.

Q. So just for abbreviation, I'm going to refer to that term as P_0_ -- scratch that. I'll refer to it by its full name.

So, you just said, Doctor Akl, that P_0_UE_PUSCH is configured by the RRC. Correct?

A. Yes.

Q. And in fact, the standard gives a range that this parameter can take. Correct?

A. Yes.

Q. So please explain how you can contend that that -- the value of that term is unknown when the standard describes how that parameter is configured and, in fact, the different range that parameter can take.

A. So it's undefined until you specify a specific value. And so, my testimony is accurate and correct in stating it is a UE-specific component.

And until I give you an exact value for it, you don't know what value to use. You are provided with a range and, in fact, the value will also depend on the index. So you need to initialize for j equals to zero.

The first time that you would use it, what value you would need to use, and the 966 states that you -- you could use the value of zero for it and that's in the specification. It's also in Claim 4 of the 966.

And going back to Paragraph 108, you do see that zero is one value that is also provided in the standard as an option. It's the one in the middle between minus one and one.

But -- the UE needs to know what value to use from this range, and until it is instructed or decides what value to use, that value would be unknown.

Q. Well, of course it's unknown until it's given a value. I believe you said it's undefined until a value is given to it. And that seems circular to me.

But can we agree, Doctor Akl, that the standard describes exactly how this value is configured and how it contains a value as part of

determining the power on the physical uplink shared channel?
MR. NASH: Objection; form.
THE WITNESS: I believe I've already answered that question, that the standard is describing the general scenario where the variable is a function of j; and we are looking at the initial value where j is equal to zero, and I don't believe there is a dispute that for j equal to zero, we're going to use the value of zero as the initial value for this variable.
BY MR. BUMGARDNER:
Q. What I think there is a dispute, Doctor Akl, is that this is an unknown parameter when the specification describes exactly how you configure the value assigned to that parameter and it would -- it would have a value before the UE transmits on the physical uplink shared channel.
So my question would be: Does -- does the power determination formula on Page 8 of the standard that's Exhibit 1004, is that functional. Does it work?
MR. NASH: Objection; form.
THE WITNESS: I think your -- your

question has multiple parts, and it's difficult to answer "yes" or "no" to the whole question, because it's really more than one question --

BY MR. BUMGARDNER:

Q. Sure.

A. -- in one.

Q. I'll break it up if you would like: Can a UE that is determining what power to transmit a message on the physical uplink shared channel -- can it implement the algorithm listed in 5.1.1, or is this algorithm defective such that the power to transmit on the physical uplink shared channel cannot be determined because of unknown parameters?

MR. NASH: Objection; form.

THE WITNESS: The standard -- there are two things we need to realize. The first is: What we're looking at is not the value for j equals to zero. That is only one specific case.

The bullet point is denoted for any value of j. And when j is equal to zero, that's the initial value, and that's the specific case.

The standard doesn't necessarily give you an algorithm how you determine that value. It's merely stating the range that are -- that -- the range of values that the variable can take. And until a -- a value is assigned, the statement that I have made previously is correct, that that variable which is UE-specific, its value is unknown until a value is -- is assigned.

And I'm still describing the general term of that variable which is a function of j, and even looking at the standard, you see that the standard starts out with a general equation in terms of f of (i) that we've described previously and variables in terms of j.

And then, you have to provide additional information or the UE needs to determine what to initialize those values when i is equal to zero or j is equal to zero, and that's where, for example, we turn to Column 9 that provides additional information specifically with regard to an example where i is equal to zero.

And we have to do the same for j is equal to zero. And I don't think there is a -- I mean, one example would be for j equal to zero. The variable is initialized to zero. That is consistent with the standard because that is a value in the range. And that's what the 966 patent contemplates and claims in Claim 4.

BY MR. BUMGARDNER:

Q. Would you agree the standard provides a mechanism to assign a value to P_0_UE_PUSCH?

MR. NASH: Objection; form.

THE WITNESS: Whatever the standard states, that's also in the 966. I don't think the 966 patent is disputing what's in the standard.

In fact, it's replicated in Column 4 of the 966. I'm still not sure whether we are discussing or we have a disagreement because the equation that is in 36.213 is Equation 1 in the 966 and the different variables that we are discussing are described in detail in the 966 and that is all part of applicant's admitted prior art.

Q. Would you also agree, then, that the parameter P0_UE_PUSCH is also unknown -- strike that.

Let's talk about f of (0) that you describe in Paragraph 113. You also state that that is unknown.

Do you see that, Doctor Akl?

A. Yes.

Q. So explain how f of (0) as that term is used in the Equation 1 which we discussed, is also the same equation, 1004. How the value of f of (0) is unknown when the standard specifically states that f of (0) is equal to zero?

A. So this is a value that is unknown, and when you don't know a value, you can -- especially a value that is -- is iterative in the sense that its value is going to change as a function of an index. You need to know what to initialize it to.

And so, that initial value is unknown and one way -- one example to proceed with initialization is to set it equal to zero.

So, the fact that the standard in 36.213 on -- in Column 9 provides an example to overcome the fact that it is unknown and you need to initialize it to something and the standard describes initializing it to zero as an example so you can proceed and use a value and build on f of (i), doesn't contradict. In fact, it supports the opinions that I have in my declaration.

Q. Is the value zero an unknown value?

A. Your question is too vague to answer in vacuum but if I take your question and I apply it to the issues that we're looking at here, f of (0) is not known. You need to initialize it. And when you don't know something, you can look at different ways to initialize it. One example is to initialize it to zero.

You can also, the prior art also discloses to one of ordinary skill in the art, that you can initialize it to other values, which exactly would correspond to what the 966 teach.

So, the answer is "yes." It's -- it's -- just because you give something a value of zero doesn't remove the unknown component. It's still not known to the UE. And you -- you initialize it to zero, and then that value is going to change over time. As the index increases, the value of f is going to change.

Q. Does -- is there anywhere in Exhibit 1004 that characterizes f of (0) as being unknown?

MR. NASH: Objection; form.

THE WITNESS: We look at things

from the point of view of one of ordinary skill in the art.

So one of ordinary skill in the art would start out with the equation, the general equation, on Page 8. And the general equation on Page 8 provides those variables as a function of their respective indices, i and j for the different variables.

So one of ordinary skill would know that those values may change as a function of the index.

Looking at Column 9, the -- the standard, itself, informs one of ordinary skill in the art that there are two ways to determine f.

Q. Did you mean Page 9, Doctor Akl?

A. Yes, sir.

Q. All right. Please continue.

A. On Page 9, one of ordinary skill in the art looking at the standard would understand that the standard teaches and discloses two ways of how f can be determined and the first bullet point represents a accumulation equation while the same f in the second bullet point represents current absolute value.

So even the standard is providing to one of ordinary skill, different options for calculating f.

One of ordinary skill in the art would also understand that because this is a function and when that function, as in the -- in the accumulation case depends on a previous value of the index, we're looking at the bullet point f of (i) is equal to f of (i) minus one where the "i minus one" are in parentheses.

You see that a current value of f of (i) depends on a previous value of f of (i) and the process is iterative.

So when you have an iterative process, you need to define initial conditions. That is all within the knowledge of one of ordinary skill in the art would understand that.

And the standard provides an example where it states that you may initialize f of (0) to zero and the other constant to four.

So, what I have stated in my declaration is consistent with the knowledge of one of ordinary skill in the art when they read pages 8 and 9 of Exhibit 1004, what that teaches them.

Q. Is there any evidence in this proceeding that documents one of ordinary skill in the art would see it deficient to initialize f of (0) to zero?

MR. NASH: Objection; form.

THE WITNESS: Yes.

BY MR. BUMGARDNER:

Q. What?

A. So, looking at the discussion and the analysis that I did for Element B starting with the combination of why one of ordinary skill in the art looking at the 3GGP standard --

Q. Can you tell me what page you're on, Doctor Akl?

A. Yes. I'm starting on Page 46 of my declaration.

Q. Okay. Please continue.

A. On Page 46, I provide an analysis why or how one of ordinary skill in the art would -- would -- why equation for A in the 966 would have been obvious to one of ordinary skill in the art.

And why you would start with, for example, 3GPP 36.213 because it is admitted prior art and it is in the 966, but it is prior art, and it describes one example where you initialize an unknown value to zero.

One of ordinary skill in the art would look at the Qualcomm reference because one, Qualcomm is a major contributor through the standards, it's a major player, and you would look at the disclosures that are provided by patents by Qualcomm.

Specifically, looking at the Qualcomm reference, it is -- it is compliant with the standard. It improves on the standard. It provides better random access signalling and transmission. And so, there would be motivation to combine the two references to yield an equation that gives you better transmission for random access procedure.

MR. BUMGARDNER: Objection; non-responsive.

BY MR. BUMGARDNER:

Q. Is there any document in this proceeding, Doctor Akl, that specifically criticizes initializing f of (0) to zero?

MR. NASH: Objection; form.

THE WITNESS: The -- I don't know if you need a specific criticism of something to be able to put yourself in the shoes of one of ordinary skill in the art to find motivation why you want to improve something. So -- so, I'm not sure if I understand your question correctly.

My -- from my analysis and from my guidance in terms of what I need to show, it's my understanding that I need to see: Would one of ordinary skill in the art be motivated to combine two references?

Would one of ordinary skill in the art be motivated to improve on something?

And that motivation exists because, generally, one of ordinary skill in the art is always looking on improving a current system.

This is why we have so many different versions of the standard, each providing small improvements in order to make the transmissions more efficient, to make the communication better, and, looking more specifically at the random access procedure, there is always motivation to improve on all the different variables and parameters to make the transmit power more efficient, whether that's the open loop or the closed loop.

And so, that motivation already

exists in the mind of ordinary skill in the art looking at how and why do I want to improve any specific aspect.

So f of (0) being equal to zero is one example where you just initialize it to zero, and looking at the knowledge of one of ordinary skill in the art and the motivation to combine 36.213 with Qualcomm, which is describing the same problem, which is addressing the same issues of random access signalling and transmission, which discloses equations in Columns 8, 9, and 10 that improve on the -- the signalling so -- so that motivation already exists.

And that is part of the analysis, and I have spent a lot of paragraphs in my declaration explaining the motivation why you would combine those different pieces.

Q. So if you look at the bottom of Page 59 of your declaration, the last sentence -- and I think it touches on what you were just saying, such a combination would be obvious in creating a more efficient random access signalling.

Do you see that, Doctor Akl?

A. Yes.

Q. So what you're saying is the solution presented in the patent is better than what's described in the standard and better than what's described in Qualcomm?

MR. NASH: Objection; form.

THE WITNESS: No. I -- I disagree.

BY MR. BUMGARDNER:

Q. Well, what -- what's more efficient that you're describing at the bottom of Page 59?

A. So the -- the patent, the 966 is proposing a solution.

It's -- it's looking at 36.213, and there is -- there is in the minds of the inventor a problem that they're trying to solve, and specifically, they are looking at improving the initial transmit power. The question becomes: Is what's disclosed in the claims is what's taught?

Is the invention obvious to one of ordinary skill in the art?

Is what the 966 claiming already in the prior art?

If it is new, then it's not in the prior art, and it is an improvement, but it is a new improvement.

If it is in the prior art, then

that improvement is in the prior art. It may still be an improvement over one document. I am not proposing an anticipation argument. But the combination of 36.213 with Qualcomm discloses and teaches one of ordinary skill in the art what is in the 966.

And so, the claims of the 966 are obvious to one of ordinary skill in the art.

Q. Well, I'm asking about what is more efficient. At the bottom of Page 59, you say a combination is more -- creates a more efficient random access signal. So what is the combination? Is that Qualcomm in Exhibit 1004?

A. Yes. This is one of example. In Paragraph 131, I am describing why one of ordinary skill in the art would look at and be motivated to combine Qualcomm with 36.213 and, and -- and that combination would make the 966 claims obvious.

Q. All right. So the combination of Qualcomm in the standards is more efficient than either the standard standing by itself, the standard being Exhibit 1004, or a Qualcomm standing by itself?

MR. NASH: Objection; form.

THE WITNESS: I'm not sure I specifically rendered an opinion on that point.

Again, my analysis is from the point of view of the combination so I look at the combination from the point of view of one of ordinary skill in the art. Would the combination teach one of ordinary skill in the art what is claimed by the 966? Would the combination render what is claimed by the 966 obvious.

The answer to that question is "yes." Then I also have to show motivation. Why would one of ordinary skill be motivated to combine two references? And that is what I'm showing here is that the combination would have been obvious because it creates a more efficient random access signalling that is also compliant with the LTE specifications.

Q. But so the -- the combination you mentioned in -- in the last sentence of Page 59 of your report, you see that says, "such a combination," so let's just break it down. What is this combination you're referring to?

A. This is a combination to what I'm disclosing, what I'm describing in Paragraph 131, which is the applicant's admitted prior art with

Qualcomm.

Q. Okay. So that's the combination.

A. Because if you go to the previous sentence, it says the teachings of Qualcomm combined with the teachings of 36.213 allow UE to efficiently transmit the random access preamble for system access while maintaining compatibility with the LTE standard, such as TS 32.

Q. So -- and then you say that combination is -- "Such a combination therefore would be obvious to a POSITA in creating a more efficient random access signal.

This combination -- my question: This is more efficient than what?

MR. NASH: Objection; form.

THE WITNESS: I'm not sure I understand the question.

BY MR. BUMGARDNER:

Q. Do you see the last sentence of Page 59?

A. Yes.

Q. You use the term "a more efficient random access signalling." Do you see that, Doctor Akl?

A. Yes.

Q. You don't just say, "an efficient"? You say a "more efficient."
Do you see that?
A. Yes.
Q. So it's -- would you say you're comparing this to something? You say it's more. More efficient than what? More efficient than -- that's what I want to know. What is it more efficient than?
A. So when -- when I say "more efficient," I'm referring to previous versions. You're always trying to -- or one of ordinary skill is always trying to improve on what is done at a specific point in time.
And I think that's, you know, that's what drives innovation in general. So we look at where we were with 1G.
We look at 2G.
We look at 3G.
We look at LTE.
And it's not -- I mean, I don't know if I thought in my mind I'm making such a distinction using the word "more," or without putting the word "more." I think both sentences to me convey the same thing.

There would have been motivation to combine. The combination is one of ordinary skill would have combined them because the combination produces an efficient random access signalling.

I agree I used the word "more." But it's -- it's -- I don't necessarily think I'm using it to compare to something else. It's more, no pun intended, to -- to highlight the benefit of the combination, and the benefit of the combination is an efficient random access signalling and so, one of ordinary skill in the art would have been motivated to combine.

Q. So, one, I believe, you would say, and correct me if I am wrong, Doctor Akl, that, so you have a 3GPP standard that says "f of (0) equals zero" and then you have the 966 patent and that says "f of (0)" should be initialized to something other than zero.

Is that fair or not?

MR. NASH: Objection; form.

BY MR. BUMGARDNER:

Q. Do you agree with me on that or not?

MR. NASH: Same objection.

THE WITNESS: I don't think

the -- I disagree with that characterization because it's -- it's too broad. And when you're saying the -- the standard, I don't believe the standard, even the standard on its own discloses only f of (0) equal to zero.

And in fact, we spent a lot of time describing, and in my declaration I go into an analysis why just using the standard and the different modules in the standard, one of ordinary skill in the art would have understood that even the standard on its own discloses other embodiments other than f of (0) equals zero.

And if the applicant admitted prior art and the standard would render the claims of the 966 obvious -- there are certain limitations that I've described -- without even Qualcomm.

So, I don't agree with your characterization in your question.

Q. Describe to me, Doctor Akl, what the difference is in the teachings in the 966 patent and Exhibit 1004 with respect to initializing f of (0).

MR. NASH: Objection; form.

THE WITNESS: My analysis isn't anticipation. So again, what you're asking me to do in a sense is to -- is to limit my analysis. Because my -- I did not provide one reference, which is 36.213, and I did not come forward with an anticipation argument saying 36.213 discloses and teaches one of ordinary skill everything in the 966.

That is not my opinion today. My opinion is: Looking at the applicant's admitted prior art of which 36.213 is -- is one reference and combining that with Qualcomm, the combination discloses everything in the 966.

And I did walk through the differences and the similarities of the references to the 966, why the combination renders the claims of the 966 obvious, why one of ordinary skill in the art would have been motivated to carry out this combination.

MR. NASH: Barry, when you get to a point, can I -- can we break?

MR. BUMGARDNER: Sure. We can do it right now.

MR. NASH: I didn't want to interrupt your flow but...

THE VIDEOGRAPHER: We're going off the record at 1:53. We are off the record. You can remove your mics.

(Recess taken.)

THE VIDEOGRAPHER: We are back on the record at 2:02.

BY MR. BUMGARDNER:

Q. Doctor Akl, with respect to Exhibit 1004, can you describe the differences between that reference and Claim 1 of the 966 patent?

A. So as I -- I was doing my analysis, specifically looking at the prior art references and the applicant's admitted prior art and why one of ordinary skill in the art, looking at those references why that renders the claims of the 966 obvious, starting at least on Page 44 of my declaration through the end of the declaration, I -- as I am describing the different references including 36.213, I do the similarities and the differences so if you want to point me somewhere specific, I can elaborate on that opinion.

Q. With respect to, let's say, the power control adjustment state as described in the 1004 exhibit in Claim 1 of the 966 patent, what, if any, differences are there with respect to the power control adjustment state?

MR. NASH: Objection; form.

THE WITNESS: My analysis at least for the limitation that contains power control adjustment states starts on Page 46. And goes to Page 53 where, then, I go into the depends on limitation, and I continue on.

There are also charts at the end of my declaration where I provide examples where the references disclose what's thought in the 966, so.

Q. Well, can you look at those, Doctor Akl, whether it's the claim chart or Claim 1 or in somewhere else in the body of your opinion? And I'd like for you to describe what, if any differences you found, between the power control adjustment state as disclosed in Exhibit 1004 and the power control adjustment state described in Claim 1 of the 966 patent.

A. I -- I would be happy to answer that question, but as I'm going through my paragraphs, I would like to point out on the record that in -- in Paragraph 112. I do explain part of why I was saying that the UE-specific parameters are unknown, because the 966, itself, in Column 10 describes that the other parameters are known and refers to the P zero parameter and the F zero parameter as unknown.

So again, my declaration is not committed to memory. And sometimes, you ask me a question without referring me to a specific section.

And then I try to answer that question.

But then when I start reading it line by line, I realize that there are even better answers within the declaration. So, it's -- it's very difficult to sometimes answer questions without knowing -- without being referred to specific paragraphs.

Q. Well, let -- let me just follow up on that point. Does the 966 patent describe computing f of (0) in a different form than Exhibit 1004. The different method?

MR. NASH: Objection; form.

THE WITNESS: That is not a "yes" or "no" question. And the reason that's not a "yes" or "no" question, because I don't have an analysis in vacuum that just looks at the 1004 exhibit.

It is a combination analysis, and I look at things from the point of view of one of ordinary skill in the art. How they would have understood that combination and how they would have understood the applicant admitted prior art.

So in the process, I -- I do specifically address the similarities and differences of the references, and I think we've -- I've answered on the record multiple times that 36.213 describes an example where f of (0) is equal to zero.

But at the same time, one of ordinary skill in the art would -- the understanding of one of ordinary skill in the art is not limited to just that one single embodiment.

Looking at the combination of the different parts of the standard and looking at Qualcomm and looking at applicant's admitted prior art, it is still my opinion that one of ordinary skill in the art would understand that the combination discloses and renders obvious what is claimed in the 966.

Q. So back -- back to my original question, Doctor Akl, and that is, I'd like to know what, if any differences, exist between the power control adjustment state as described in Exhibit 1004 and the power control adjustment state as described in Claim 1 of the 966 patent.

A. Right, and I think that I've answered that, and I've answered that a couple times. The one example that 36.213 describes is setting f of (0) equal to zero.

But looking at one of ordinary skill in the art and what they would understand looking at the combination and the opinion that I'm rendering in this declaration in terms of using the different versions of the standards together and combining it with Qualcomm and what -- and combining it with the applicant's admitted prior art, that combination renders the claims of the 966 obvious.

Q. Doctor Akl, I'm just very clear that what you think this combination renders the 966 patent's claims obvious, my question is limited, though, to the Exhibit 1004 and the claims of the 966 patent.

And I want to know what the differences are between computing the power control adjustment state between those two documents.

So you mentioned that the standard in one example computes f of (0) is equal to zero. Is that a difference between what is described in Claim 1 of the 966 patent? That one example?

A. I think if you can be more specific with your questions because I think sometimes you refer to the exhibit specifically as "1004," and then you generalize and you refer to the standard, and I'm -- I'm not comfortable with that generalization because I think that's inaccurate and vague because the standard isn't limited to Exhibit 1004.

And so, I'm, you know, half your question would have Exhibit 1004, and then a different part of your question would generalize to the standard.

The standard is not just Exhibit 36.213. The standard is not just Exhibit 1004. So, the standard is made up of a lot of different modules. And there are three modules we have discussed today 36.213, 36.321, and 36.300.

So, I think maybe I can better

answer questions if your questions are more specific and we don't go back and forth so that the record is clear what specific part of the standard I am providing a very narrow answer on.

Q. With respect to Exhibit 1004, is one difference between the power control adjustment state that they described in Exhibit 1004, in Claim 1 of the 966 patent, that the standard expressed in 1004 describes setting at the zero equal to zero?

A. And I think I've answered that. I've answered that question multiple times.

One example in 36.213, is an embodiment. I mean it's not a patent but I'm using the word "embodiment" to mean "example."

One example in 36.213, f of (0) is initialized to zero. But there are other descriptions in 36.213, and the way the terms are described, how one of ordinary skill in the art would understand those terms and what they would take from the teachings of 36.213 and how they would combine that with the teachings of other sections of the standard and with Qualcomm, that's the focus of my analysis. This is not an anticipation argument. This is a combination argument.

Q. Have you heard of a case, Supreme Court case, called "Graham versus John Deere"? Just curious if you've ever heard of that?

A. I don't recall. Sometimes, I'm -- I get legal principles explained to me from counsel, but they may not refer to the specific case. So, I may know some of the details without knowing specifically where they came from.

Q. I understand, Doctor Akl. You're not an attorney, are you?

A. No. I am not.

Q. One of the -- it's a Supreme Court case dealing with obviousness. In one of the requirements the Supreme Court sets out in that case, I'll just represent to you, is that any differences between the prior art and claims at issue must be ascertained.

Have you ever heard that phrased that way before in conducting an obvious -- obviousness analysis?

A. Yes. I think part of the analysis is you look at the different pieces of prior art and you provide an opinion, what's similar, what's different, why would the combination, you know, why would the combination -- why would one of ordinary skill be motivated to combine and would the combination disclose or teach to one of ordinary skill the claims of a specific patent; or would they render the claims of a specific patent obvious?

So, I believe, generally I do understand that legal principle.

And in my declaration, I have gone through, and as I discussed the different references, I do discuss how the references are similar and different, but I focus, also, on their combination, and unless you point me somewhere specific, I don't want to exclude or miss something that is already in my declaration. This is a fairly long declaration. It's probably one of the longer declarations that I have written. And it's not committed to memory.

So, I'm trying to find and make sure my answer is as accurate as possible on the record while still being within what I wrote in my declaration.

Q. So for the record, Doctor Akl, you spent 60 hours working on this matter when you were preparing or assisting Kyocera and LG prepare

their IRPs. Correct?
A. Yes. And I think that was -- one second. The LG IPR is L21 in my CV on Page 6. That's from 2015.
And the Kyocera was also in 2015. So, that was three years ago where -- when I was initially retained, to my recollection.
Q. And then you spent about 20 hours of preparing this declaration and working on the IPR we're discussing here today. Correct?
A. Yes. That was last year, I believe, the declaration was signed in May.
Q. And then, you spent 10 hours getting ready for this deposition. Correct?
A. Yes. I reviewed the different prior art references in my declaration and the relevant exhibits, including the institutional decision and the preliminary response.
Q. And you have your declaration in front of you, right, Doctor Akl?
A. Yes.
Q. And you have the 966 patent in front of you. Correct?
A. Yes.
Q. And you have Exhibit 1004 which is 3GPP

TS 36.213. Correct?

A. Yes.

Q. All right. My question is: What are the differences 2010 what's described in 3GPP TS 36.213 that is Exhibit 1004 and Claim 1 of the 966 patent?

A. And I've answered that multiple times.

In my declaration, I provide an overview of the different references individually. And then I walk through the combination analysis and as I'm doing that, I'm providing an opinion how they're similar, how they're different to the 966 and why one of ordinary skill in the art would have been motivated to combine them and again, I'm not using hindsight in the analysis.

You read the 966 and then you set it aside but then you have the claims in terms of that you do the analysis while one of ordinary skill in the art would have been motivated and would that motivation yield and teach and render the claims of, in this case, the 966, would that make them obvious?

So that analysis is in my declaration --

Q. And -- go ahead. I'm sorry.
A. But my point is, it's over multiple pages, and -- and I've -- I've pointed to some examples in it, but I don't want to limit my answer to just the examples that I pointed to because I don't have my declaration committed to memory, and I would be more than happy if you point me somewhere specific to expand on the opinion in my declaration and make sure I make that opinion clear to you if you have questions on any specific section.
Q. So can you point me to -- you said in your opinion you discussed how they're -- I wrote that down in my notes.
So can you point me in your declaration to the part that -- where you discuss the differences between Exhibit 1004 and Claim 1 of the 966 patent?
A. I would have to go through -- do you want me to look through it page by page?
Q. Yes.
A. Okay.
(Pause while witness peruses a document.)
THE WITNESS: Would it be okay as I

go through to find examples so we don't wait until the very end?

BY MR. BUMGARDNER:

Q. Sure. Sure.

A. Okay. So starting with the introductory part, in Paragraph 33, I do state or introduce 36.213 and when it was available and also state that it was cited in the 966 provisional.

Q. Do the sections you just referenced, Doctor Akl, discuss any differences between Exhibit 1004 and Claim 1 of the 966 patent?

A. No. At this point, I'm merely providing the date of 36.213 and -- and pointing to the fact that it is applicant's admitted prior art.

Q. And -- and Doctor Akl, again, just -- I know that 36.213 is mentioned throughout your report. I'm specifically looking for the sections that discuss differences between what is described in Claim 1 of the 966 patent and 36.213.

A. I understand. I just want to make sure since I am being very thorough that I don't miss a citation.

Q. Okay.

A. In Paragraph 39, I do compare 36.213 to the 966. Here, I am describing the preamble transmission that's identified in LTE as "Message 1" and the claim first message of claims 2 and 11.

So Paragraph 39 would be an example comparing 36.213 to the 966 patent.

Q. Do you note any differences in Paragraph 39 between Claim 1 of the 966 patent and 36.213?

A. I believe 39 is more focused on the similarities between them.

Q. Okay.

A. Or Paragraph 39.

Paragraph 42 is another comparison to -- of 36.213 to the 966 and here, I am showing that the difference in the terminology is -- is slightly different but the meaning to one of ordinary skill in the art is the same in terms of the power, ramp, step, and that's how the 36.321 uses that term and the 966 uses delta P ramp-up.

Q. But again, that's a similarity -- not a difference, not a substantive difference anyway. Correct?

A. It's --

MR. NASH: Objection; form.

THE WITNESS: It's a difference in

terminology and how one of ordinary skill would understand the difference in terminology would refer to the same concept. So, it just depends on your perspective.

Paragraph 78, I do claim to what the 966 states differences are between 36.213 and what -- what the 966 claims -- to be -- to be different. So there is a comparison at least from the point of view of the 966 patent 236.213.

Q. Do you agree with that comparison contained in the 966 patent?

MR. NASH: Objection; form.

THE WITNESS: I can't provide one answer to that question because it's not a "yes" or "no" answer. Looking at the discussion that I see in Paragraph 78, I do state what the patent claims to be difference. I go on to explain how Equation 1 in the 966 and the parameters relate to 36.213 and I do go on to explain how the disclosure in 36.213 for the P zero parameters that we described to you earlier can be broken up in to subcomponents.

So -- so it's not a "yes" or "no." I'm providing an opinion in terms of the similarities and the differences as the 966 claims and my opinion with regard to how one of ordinary skill in the art would understand 36.213.

Q. So let's just break that down, Mr. Akl -- or, excuse me, Doctor Akl.

The first sentence of Page 78 quotes the 966 patent, states, "However, TS 36.213 does not specify how the UE-specific parameters of the PUSCH and PUCCH power control formulas are initialized."

Do you see that, Doctor Akl?

A. Yes.

Q. Do you agree with that or not?

A. Again, this is not a "yes" or "no" answer and I can explain why. So, it depends on how you define "initialized," and how you limit that word. The patent is stating -- and this is Column 4, Line 25 through 27, that TS 36.213 does not specify how the UE-specific parameters of the PUSCH and the PUCCH power control formulas are initialized.

So, when we go and look at those terms, they are broken down further and there are some components that the standard describes a range of values and we described that earlier.

But whether that discloses an algorithm and exact initialization is -- is part of the discussion that we had earlier.

So again, I don't necessarily 100 percent agree or disagree, and it's difficult to generalize because it depends on your view of initialization. There are examples where some values are initialized to zero, but you may want to initialize them to something other than zero.

So, again, it depends on the context. If -- if something is assigned a value of zero, because you don't know what to assign it, does that fit the inventors definition of "initialized"?

Because it seems here the patent is claiming there is no disclosure at all to any initializations, but as we talked about earlier, there are examples where things are initialized to zero.

So again, I don't -- again, it's debatable from the point of view on the perspective of -- of how much initialization is required and do you want to initialize something to non-zeros?

And this is why, you know, this is

not a -- a short declaration. It's I have to go through and look at all the details, look at what's taught explicitly, look at what the -- what one of ordinary skill in the art would understand the disclosures are and -- and how those terms, what those terms would mean and then how they would be combined and whether they're motivation to combine and that's why this is a -- a declaration that's, you know, 100 and -- you know, over 100 pages.

So even a simple statement like that, I don't think there is a clear "yes" or "no" answer.

Q. Okay. Let's change gears, Doctor Akl.

So going back to the Page 59 of your declaration.

A. I'm there.

Q. Back to that last sentence, so, we talked about more efficient. Let's talk about the com -- combination of being compliant with the LTE specifications.

So, we established the combination is Qualcomm and TS 36.213: Can you explain how that combination is compliant with the LTE specification?

MR. NASH: Objection; form.

THE WITNESS: Yes. The -- the term "compliant" is fairly broad and there is different ways to show that something is compliant.

One way to show that something is compliant is to run tests on a product. And to look at the end result and does the final value match what you would expect if you ran a simulation on what's in, for example, the standard.

So -- so you may not necessarily implement things exactly as in the standard step by step. But you may be able to get a final answer that the standard would understand and be able to use correctly that would -- that could make you compliant or that would be within the definition of being compliant.

So in -- in this case what -- what I'm describing is the -- the -- it is my opinion that the standard provides different examples of how you could initialize, and it's my opinion that one of ordinary skill in the art looking not just at Exhibit 1004 but looking as a standard and I'm using the term "standard" to refer to the different versions in the standard together.

And it is my opinion and I expand that opinion why the applicant admitted prior art and the different versions of the standard do disclose and render obvious what's in the 966, and for the same reasons, because the standard alone with the knowledge of one of ordinary skill in the art discloses and renders obvious what's in the 966.

The fact that you can also reach the same conclusion when you look at the combination of Qualcomm with 36.213 yields me to say that that result is also compliant with the standard because, as I pointed out, using the different documents in the standard you do -- it would have been obvious to come up with equation for A in the 966.

So because of that, the fact that you can come up with -- and by "you," I mean one of ordinary skill in the art -- can come up with equation for A just looking at the versions of the standard and looking at the versions of the standard with Qualcomm, this combination is compliant with the standard.

And one of ordinary skill in the

art would have been motivated to do that analysis, to do that combination because it yields efficient random access signalling.

So there is motivation to combine. The results are predictable. There is not undue experimentation, and you -- you get a result that provides efficient random access signalling, and, therefore, it is my opinion that this combination renders the claim of the 966 obvious.

MR. BUMGARDNER: Objection; non-responsive.

BY MR. BUMGARDNER:

Q. The -- you speak of a combination of TS 36.213 and the Qualcomm patent, the 706 patent. You state the combination is compliant with the LTE specifications.

Did you do any tests to determine that that combination is compliant with the LTE specifications?

A. It was not necessarily to do any tests because I tried to explain to you the reasoning why I'm stating it's compliant.

The fact that you reach the same result using the standard alone and you reach the same result -- and by "result," I mean, there is

disclosure or equation for A would be obvious.
Equation for A in the 966 is obvious. This is an example. Equation 4-A of the 966 is obvious by just looking at the applicant's admitted prior art which includes the standard.
And Equation 4-A is obvious by combining the Qualcomm reference with 36.213. That is sufficient to be able to state that the combination would be compliant with the standard because the standard on its own provides different embodiments of how you could initialize.
And -- and that's a lot of the analysis that I've gone through in this declaration, using the standard on its own, you can -- this is the applicant's admitted prior art and the standards that are disclosed, in the applicant's admitted prior art, that gives you an equation for f of (0) and g of (0) that's the same in the 966.
Q. If I could turn you to Column 10 of the 966 patent, there is an equation on lines about 23 through 25.
A. Yes. I'm there.

Q. And would you agree this equation describes the power a UE is to transmit on the physical uplink shared channel when i is 0?
A. Yes.
Q. So this is what the 966 patent says, set your power to when transmitting on the first sub frame?
A. Yes.
Q. And we've discussed 36.213 on Page 8, there's a similar -- well, I won't say "similar" -- there is another formula that describes setting the power of a handset to transmit on the physical uplinked shared channel as well.
Do you see that, Doctor Akl?
A. Yes.
Q. Do you know if the transmitting and the power described in the 966 patent in Column 10, if that would get you the same power as described in Exhibit 1004 on Page 8 for the first cell phone?
A. The -- the answer to the question -- I'm going to try to answer your question.
My analysis is not to look at the specifications. So I didn't specifically look at

Column 10 to see, is the equation in Column 10 obvious, but I can go one step further and say, there are equations in the claims and the, as I'm going through and looking at the different claims there is for Claim 5 an equation that is the power for Message 3.

The power for Message 3 would correspond to the power when you initialize transmission because Message 3 is the first initial transmission where if you recall, Message 1 is the preamble.

Now, looking at the analysis that I did, looking at -- you -- you can start with the equation in 36.213 on Page 8 and the combination of the applicant admitted prior art and Qualcomm, and I walk through how that -- why one of ordinary skill would have been motivated to do that combination, but when you do the math and it's actually not complicated. It's a lot of notation, but really, the analysis in my declaration from a mathematical point of view, it's fairly basic calculus once you get past the notation. The notation is actually the hardest part, but the math, itself, is fairly simple. We are doing simple calculus.

That does yield -- that map that I have shown and the analysis that I have shown renders the equations in the claims obvious.

And so, indirectly to the extent that the equation that you're pointing to in Column 10 matches up to one of the equations in the claims, then the answer is "yes."

That the -- you can do the math. You can start with 36.213, and the combination of 213 with the -- with the Qualcomm and the math as I have outlined it would get you the same equation.

MR. BUMGARDNER: Objection; non-responsive.

BY MR. BUMGARDNER:

Q. My question, Doctor Akl, is, if I compute power using the equation on Page 8 of 36.213, I compute the power for the first sub frame, i equal zero, do I get the same power figure as if I used the equation either in Claim 5 or the one we've been discussing in Column 10? Is it -- do you get the same number, or do you get a different number?

A. Again, I believe, I've answered that question. I didn't -- my -- my task wasn't to take one equation, plug in "i equals zero" and see if they match or not.

Q. And that's fine, Doctor Akl. If you don't have an opinion on it, then that's okay. If you haven't done that analysis, then fine.

So have you done that analysis as part of your declaration?

A. I don't think I've rendered an opinion on -- that would -- that specifically addresses looking at the equation on Page 8 in vacuum, plugging in i equals to zero if that gives you the same power as the equation in Column 10.

Before we break, can I just add something to the previous question that you asked me?

Q. Certainly.

A. So on Page 74 of my declaration because I believe your question was combining both the equation in Column 10 and Claim 5.

So at least for Claim 5, I have provided an opinion looking at why Qualcomm and Qualcomm 386 and TS 36.213, why that combination would render the equation or Claim 5, and the equation in Claim 5 obvious. And that analysis starts on Page 74 and goes through 83 along, also, with the charts at the end of my declaration.

MR. BUMGARDNER: Okay. Can we take a break here?

THE VIDEOGRAPHER: We're going off the record at 2:55.

(Recess taken.)

THE VIDEOGRAPHER: This is Disk Number 3 of the deposition. We are back on the record at 3:06.

BY MR. BUMGARDNER:

Q. So, Doctor Akl, with respect to the equation lists in Claim 5 of the 966 patent, if it did give you a different power value for i equal to zero, then the equation in 36.231 on Page 8, so I run -- I have i of 0, everything else is the same. I get a different value from Claim 5 equation than I do from the -- the equation on Page 8 of Exhibit 1004. So, I get a different value.

Would you then say that the equation in Claim 5 or a system operating using the equation in Claim 5 is not compatible or not compliant with the standard since it gives me a different result?

A. That is not an analysis that I have done so I don't have an opinion on that.
Q. If I could ask you to turn to Page 80 of your declaration, and it's specifically, Paragraph 179.
So would it -- would it be fair to say that starting in Paragraph 179, you kind of have -- you start a new obviousness analysis with respect to the equation in Claim 5?
So you've asked me to kind of direct you to some paragraphs. So your analysis of Claim 5 starts in Paragraph 166. And you go through -- through several pages, and then it seems like you wrap up one analysis in Paragraph 178 and start a new analysis in Paragraph 179. So is that -- is that accurate?
MR. NASH: Objection; form.
THE WITNESS: I'm going to take a second just to --
BY MR. BUMGARDNER:
Q. Sure.
A. -- review my declaration before I answer.
(Pause while witness reviews a document.)

THE WITNESS: Okay. What is your question again, please?
BY MR. BUMGARDNER:
Q. The question is just kind of to get this conversation started a little bit, it looks like in Paragraph 179, you begin a new obviousness analysis, new as compared to what you concluded in Paragraph 178 as to how Equation 5 of the 966 patent -- excuse me -- how you get to Equation 5 of the 966 patent.
A. So, the -- again, this is not a "yes" or "no" question. I have one analysis for Claims 5 and 14. And that's Section E of my report.
That analysis -- in a sense, is split in to two parts because using Qualcomm and TS 36.213 and Qualcomm 386, there are two ways that you can get the same result or two ways looking at the same prior art one of ordinary skill in the art can -- would find Claim 5 and Claim 14 of the 966 patent to be obvious.
So it's not two separate grounds. It's the one ground. But just like we saw earlier, where I -- for the power control adjustment state, where in the same section, I provide an analysis where you would look at

Qualcomm in combination with TS 36.213 or you would just look at 36.213 along with other sections of the standard and an applicant's admitted prior art, both of them, both analysis yield -- or would convey to one of ordinary skill that that limitation in Claim 1 was obvious.

So here again, it is one section. It is one ground, but it is an analysis that's approached in two different -- from two different perspectives is how I would phrase it.

Q. Okay. So in Paragraph 180, you're starting with Equation 3, and that's, I believe, Equation 3 from the 966 patent?

A. Yes. The equation on the top of Page 81 is Equation 3 from the 966 that is on Column 4, lines 20 through 25.

Q. And then you have Equation 1. That's also Equation 1 from the 966 patent which I think, as we've discussed, is the same equation found on Page 8 of TS 36.213. Correct?

A. Yes. That is correct.

Q. And so, going to -- so just so I can follow your analysis, the first thing you do is you rearrange Equation 3, and this is in Paragraph 181, such that pathloss is equal -- you

set pathloss equal to a number of power parameters. Correct?
A. Yes.
Q. And then you substitute pathlosses computed there in to Equation 1 and that's done in Paragraph 182. Correct?
A. Yes.
Q. Let's see. And then, on -- turning the page to Page 82, you take an f of (i) value from 36.213 and also insert that into Equation 1.
Is that what is happening there?
A. So I do substitute f of (i) in to Equation 1 and then I rearrange and simplify the terms to get the equation right above Paragraph 184.
Q. And so that f of (i) value comes from the standard 36.213 on Page 9 where that's the f of (i) calculation for a current absolute value. Is that correct?
And I think you discuss that in Paragraph 183.
A. Yes.
Q. So I don't want to repeat the whole Equation 1 that's immediately above Paragraph 184, but it has a power preamble in there.

Does it not Mr. -- or Doctor Akl?
A. Yes. There is a parameter, P_preamble.
Q. And that P_preamble is the same P_preamble discussed on Page 81 at the top of the page in Equation 3?
A. Yes. It's the same variable.
Q. Okay. And so, you --
SOUND FROM PHONE: Hello. You have been conducing a meeting for a long period of time. If you need to continue meeting, press 1.
BY MR. BUMGARDNER:
Q. So, going back to Page 81, you made a substitution into Equation 1, and then you made another substitution on Page 82 for f of (i). Is that correct?
A. Correct. f of (i) is also disclosed like -- like I said, on Page 9 and of 36.213.
Q. But I guess the main point is, you can substitute in, if you know one parameter and it's made up of constituent parameters, mathematically acceptable to substitute one parameter in if it's, say, the sum of two other parameters.
A. Yes.
MR. BUMGARDNER: May I have this marked as "Exhibit 1"?

(Deposition Exhibit Number 1 is marked.)

BY MR. BUMGARDNER:

Q. Doctor Akl, I am handing you what's been marked as "Exhibit 1."

My question, Doctor Akl, is: If I substitute the three power values that make up preamble in Equation 3 on the top of Page 81 which is P sub target plus PL plus delta P_rampup, if I substitute those in for the preamble, the P_preamble in Equation 1 immediately above 184, is the equation I've presented to you in Exhibit 1, an accurate representation of what your Equation 1 immediately above Paragraph 184 would look like?

MR. NASH: Objection; form.

THE WITNESS: (No audible response.)

BY MR. BUMGARDNER:

Q. Again, all I've done is substitute in certain parameters for P_preamble.

THE COURT REPORTER: I'm sorry? P?

MR. BUMGARDNER: _preamble.

THE WITNESS: I think so.

BY MR. BUMGARDNER:

Q. Now, do you notice in the equation on

Exhibit 1 that I have a P sub target value and a negative P sub target value?
A. Yes.
Q. And do you also notice that I have a positive pathloss value? Excuse me. And that I also have a positive delta P sub rampup value and a negative P sub rampup value?
A. Yes.
Q. And we are operating for the equation listed in Exhibit 1 in the logarithmic domain. Correct?
A. Yes.
Q. And if I add a positive P target value to a negative P target value, I will get zero. Correct?
A. Yes.
Q. And if I add a positive delta P sub rampup value to a negative delta P sub rampup value, I will get zero. Correct?
A. Yes.
MR. BUMGARDNER: Mark this as "Exhibit 2," please.
MR. NASH: This one is Exhibit 1.
MR. BUMGARDNER: Did I give you two copies?

THE COURT REPORTER: You did.
MR. BUMGARDNER: Sorry about that.
MR. NASH: No problem.
(Deposition Exhibit Number 2 is marked.)
BY MR. BUMGARDNER:
Q. So. Doctor Akl, I am handing you what's been marked as "Exhibit 2."
And Exhibit 2, I'd like you to confirm that that is an accurate simplification of the equation on Exhibit 1 where the P target values have been added together and reduced to zero as well as the delta P sub rampup values that have been added together resulting in zero such that they no longer appear in the equation.
A. Yes.
Q. So, starting with the equation found on Page 82 of your report, that's immediately above Paragraph 184. You would agree that what's shown in Exhibit 2, the equation, is mathematically identical to the Equation 1 immediately above Paragraph 184 with the appropriate substitutions?
MR. NASH: Objection; form.
THE WITNESS: I've done substitutions, and you've done kind of

substitutions back to reach this step. So at least at this point, I want to see where this is going or if we get to a point where we end up with something that may or may not -- I guess I should say right now, we've -- we've substituted, and we've kind of re-substituted back. And I'm -- and it's difficult for me to render, I guess, an opinion on the fly as I'm going through just one equation at a time.

But I'm -- I'm entertaining the -- I mean, I believe this is correct, but I -- I kind of want to make sure that I do get a chance to spend an adequate number of time on the math that you are giving me if I need to in the end.

So that's -- but right now, I see -- or at least I see what you're doing. But I haven't really thought about from a -- whether that substitutions make sense in the end or not. But we'll see where this heads.

Q. You don't know where I'm going, do you, Doctor Akl?

A. Well, these are equations that are not in my report, so -- so I'm -- I want to be able to answer accurately, but it's also difficult to render an opinion on the fly, but it's outside of my declaration.

Q. But I understand; but sitting here right now, looking at Exhibit 2 and having been explained that all I did was substitute the three different values for the -- the sum of the three power values for preamble in Equation 3, the top of Page 81, I substituted that in and then simplified the equation.

You can't, sitting here right now, identify any math errors I made in doing that substitution and simplification. Can you?

A. I mean I don't really have an opinion because I haven't spent a lot of time looking at it. But I'm interested in keep going to see where this leads.

Q. So, well, where it's going to lead is, so we have Exhibit 2 that I've simplified and made some substitutions now comparing that to Equation 5, which is also the equation in Claim 5, well, yes, it's -- so we have Equation 5 at the bottom of Page 82 in your report.

Do you see that, Doctor Akl?

A. Which page in my report?

Q. Page 82, it's Equation 5 immediately

above Paragraph 185. And I believe that that equation is identical to the equation in Claim 5, the 966 patent.

A. Correct.

Q. So now, I want to compare the equation in Exhibit 2 to Equation 5 in your report at the bottom of Page 82.

And so would you agree with me that in Exhibit 2, the equation, there is no power preamble value in a -- in the equation in Exhibit 2?

A. Not directly because the P -- the power of the preamble is part of the pathloss.

So as a result of the substitutions that you made, we now have the pathloss parameter in lieu of the P preamble parameter, which was Equation 3 on Page 81 in my declaration.

Q. But -- right. The P_preamble is made up of a P sub target value, a pathloss value and a delta P sub rampup value. Correct?

A. Yes.

Q. And so the P_target and delta P sub rampup values are no longer there, so isn't it accurate to say that the P sub preamble value that was in your Equation 1 is no longer there in

Exhibit 2?

A. I'm not sure I understand the question or the -- the logic in -- in what your -- what you're stating?

Q. Well, there is no logic. So, the question I'll ask with respect to Exhibit 2: Is there power sub preamble value in the equation in Exhibit 2 or any combination of parameters that equal P sub preamble?

MR. NASH: Objection; asked and answered.

THE WITNESS: Indirectly, yes. The power preamble is part of the pathloss parameter that you have in Equation 2.

So if you go back to my declaration, on Page 81 and Equation 3, with the arrow proceeding it right above Paragraph 182, the pathloss parameter that you have in your Exhibit 2 depends on the power preamble.

BY MR. BUMGARDNER:

Q. In Paragraph 184, you state a POSA would simplify the equation immediately above Paragraph 184 by creating a new parameter power_offset.

Do you see that?

A. Yes. I see those words.

Q. Do you have any documentation anywhere to support your position that a POSA would simplify the above equation by defining a power offset from the preamble in the form you described in Paragraph 184?

A. Yes. I'm referring to Equation 4 of Qualcomm, which teaches the transmit power of Message 3, how it can be calculated and how one of ordinary skill in the art would simplify the above equation and what the power offset variable would be.

Q. If you could turn to the Qualcomm reference, Exhibit 1003, and specifically Column 10 in Equation 4.

So, I'd like to ask you about the PUSCH_RACH power offset parameter.

Do you see that, Doctor Akl?

A. Yes.

Q. And I note down about lines 18 and 19 of Column 10 of Exhibit 1003, it states, "This power offset is a power offset between the physical uplink shared channel PUSCH and RACH."

Do you see that?

A. Yes.

Q. That -- that sentence there mentions the power offset between two channels. It doesn't refer to messages on those two channels. Does it?

A. I'm not sure I understand your question.

Q. So, the question is -- so I'll ask it a different way. It's a power offset between what?

It says that the Qualcomm patch says, "Between a physical uplink shared channel and a random access channel."

So does it make sense to you to say there's a power offset between two channels? Do channels have power, a difference in power?

A. So one of ordinary skill in the art would understand what this is stating that the power offset is the difference between what you use to transmit on the PUSCH and what the UE used to transmit on the RACH.

So if you recall, the RACH, that's the random access channel, and that's what the -- what Message 1 would go out on. So, when a reference is referring to the power offset between our ACH, it's referring to the power of Message 1 that was transmitted on RACH.

Similarly, when it's defining the power offset and one component being the PUSCH, it would be referring to the power used to transmit on the PUSCH and an example would be Message 3.

Q. In this Qualcomm patent that's Exhibit 1003, does it use the term "power control adjustment state"?

I will try to speed things up, Doctor Akl. I don't believe it does, but I'd like for you to confirm that.

A. And I do recall rendering an opinion on that specifically. I don't remember which paragraph, but I remember a couple paragraphs where I've addressed that in my declaration. I don't know if you have a paragraph number in mind.

Q. I'll see if I can get you one. Just give me a second, Doctor Akl. If you find it before I do, that's fine.

A. That's fine. We are working in parallel. That's good.

Q. How about Paragraph Number 9?

A. I am there.

Q. You state there, "The Qualcomm reference does not expressly show these power control adjustment states using the same terminology."

THE COURT REPORTER: I'm sorry. "Using the same"?

MR. BUMGARDNER: Terminology.

THE WITNESS: Correct. I used those words. I see that sentence. I also add a person of ordinary skill in the art, however, would understand that Qualcomm teaches these states and/or would look at lease to TS 36.213 in regards to the two claimed power control adjustment states.

And I go on and continue with my opinion.

Q. So explain to me how Qualcomm teaches power control adjustment state apart from TS 36.213?

A. I'm not sure I understand the question because as I've pointed out and I've answered multiple times today, I'm not bringing forth an anticipation argument for any single reference, so Qualcomm is not anticipatory ground on its own. It is the combination of Qualcomm with TS 36.213 as understood by -- as that combination is understood by one of ordinary skill in the art. Those teachings would render the claims of the 966 patent obvious.

So it's difficult for me, because I -- my analysis is on the combination to isolate a reference in vacuum and be able to render an opinion to what is not, or is there in vacuum because it is the combination that discloses the elements of the 966.

Q. The sentence states, "A POSITA, P-O-S-I-T-A, however, would understand that Qualcomm teaches these states."

Do you see that, Doctor Akl?

A. Yes, and the sentence continues, "and/or would look at lease to TS 36.213 in regards to the two claimed power control adjustment states."

Q. So, but it says -- if it doesn't mean this, let me know. It says "a POSA understands that Qualcomm teaches these states." Should that be rewritten to say, "Qualcomm, in combination with TS 36.213, teaches these states"?

A. I think the sentence is clear as it is. It does say: Qualcomm teaches these states and/or a person of ordinary skill in the art would look at -- would understand that Qualcomm teaches these states and/or would look at lease to TS 36.213.

So in the same sentence, I am

stating that at least the combination would have been obvious.

Q. So is it your position that Qualcomm, by itself, does not teach these states as the combination of Qualcomm and TS 36.213 that teaches the states?

MR. NASH: Objection; form.

THE WITNESS: I think you are mischaracterizing what I said. The -- the sentence that I stated is the Qualcomm reference does not expressly show the spiral control adjustment states using the same terminology.

But different -- but the -- we've talked about a lot what the qualifications of one of ordinary skill in the art are:

The difference prior art references;

What the knowledge of one of ordinary skill in the art would encompass;

And the analysis is from the point of view of one of ordinary skill in the art.

So even though the Qualcomm reference does not expressly show these power control adjustment states, it is my opinion that a person of ordinary skill in the art -- with the knowledge of ordinary skill in the art -- this is from the point of view of one of ordinary skill in the art, would understand that the Qualcomm reference does teach these states looking at the disclosure in Qualcomm. And to the extent it doesn't, the combination definitely does. So -- of Qualcomm with 36.213.

Q. So you said a person of ordinary skill in the art would understand that the Qualcomm reference does teach these states? Did you say that, Doctor Akl?

A. You're --

MR. NASH: Objection; form.

THE WITNESS: -- taking a phrase that's part of a longer sentence and, yes, I said those words.

BY MR. BUMGARDNER:

Q. Okay. So I want to know: Where in Qualcomm does it teach these states, as you refer to them, on Page 59 of your declaration?

A. I've also stated, and I think my opinion is very clear on the record that the Qualcomm reference does not expressly show these power control adjustment states. So when you ask me to expressly show you something, it's not going to be there, because Qualcomm does not expressly show these power control adjustment states.

But a person of ordinary skill in the art would understand. So here we are looking at the understanding of one of ordinary skill in the art. And there is a lot of analysis and opinion why I can make this statement based on the qualifications of one of ordinary skill in the art.

Based on the different prior art that I have cited, there is a long introduction at the beginning, what is part of the knowledge of one of ordinary skill in the art. And I can put myself in the shoes of one of ordinary skill in the art and be able to make a statement like this.

Q. So, again, Doctor Akl, I'm asking you -- if you can't do it, that's fine -- for you to explain or point me to the portions of the Qualcomm reference that a person of ordinary skill in the art would look be at and understand to teach the power control adjustment states.

A. I believe I've already answered that question, and it would be the same answer. So my response is already on the record.

Q. So I -- well, we can differ about whether you've answered the question. So I'm asking -- just last chance -- if you can point me to Qualcomm or not. I'm asking for you to direct me to the portions of the Qualcomm reference, Exhibit 1003 in this IPR, that a person of ordinary skill would review and understand/teach the power adjustment states that you state very clearly on Page 59 in your declaration.

A. So if we look at Qualcomm, and specifically, Columns 8, 9, and 10, so, Column 8, around Equation 1, we are looking at the transmit power of the random access preamble. And this would correspond to Message 1 that we've talked about previously on the random access channel.

Equation 2 in Column 9 is a rewrite in the log domain of Equation 1. So we're still looking at the transmit power on the random access preamble. And Qualcomm discloses having to do multiple retransmissions, and that's the variable small m. And that's why you would have a rampup, because you would need to adjust for multiple transmissions for the -- multiple retransmissions for the random access if there is no response; and that's consistent with Equation

3 in Column 9.

Looking at Column 10, Qualcomm is now describing the first uplink message, and that would correspond to Message 3 in the 966. And the first uplink message would also -- that would also correspond to the equation in 36.213 on Page 8 where we previously talked about the transmit power. The equation on Page 8 is more general because it is a function of i.

But when little i equals to zero, that would give you Message 3. And that is what Equation 4, in Qualcomm is, discussing. It's describing on the PUSCH the amount of power that would be required. And it describes the different parameters.

So these equations aren't looked at in vacuum. We are not looking at variables and specifically just what is disclosed. We are looking at those equations from the point of view of one ordinary skill in the art. So one of ordinary skill in the art would not approach an equation like Equation 4 in vacuum.

One of ordinary skill in the art who has a Bachelor's degree and a few years of experience and understands the G3PP standard and understands what's in the standard and how you look at the content of Message 3, how you would need to initialize, that knowledge is part of how one of ordinary skill in the art would look at Equation 4.

And so the opinion that I've rendered in Paragraph 131 is supported by the documents, the prior art and the analysis that I've done.

Q. If I could direct you to Page 53 of your declaration, Doctor Akl.

A. I'm there.

Q. The first sentence states that you received information for delta P_rampup before the preamble transmission.

Do you see that?

A. Yes. I see those words.

Q. And so are you saying that the delta P_rampup is received by the UE before it transmits its preamble?

A. I define the delta P_rampup right above Paragraph 116 on the previous page. And it is the P_rampup applied for preamble retransmissions.

To give you an example, it may clarify what the delta P_rampup means. Suppose you're across the street and, you know, me and you are standing on opposite sides of the street, and I want to call your name. And if I may just use your first name, and I look at the street, I look at how busy the street is, and I, in my mind, I have an idea of what level I need to use based on how many cars, what value is and I scream, varied.

And that's me using open loop, making an estimate of what the -- how my voice is going to attenuate. And you don't hear me. I don't get a response from you.

And so then, I raise my voice, and I scream "Barry" again. That's the "rampup" component.

And if you hear me this time, you respond. If you don't, I try again; and I increase my voice again with an additional rampup component.

So this increase, because of retransmissions, is what the delta P_rampup component is because of the lack of a response for the preamble message. So, it is a value that the UE has to the preamble power because of a lack of response to try to get the attention of the base station.

Q. So all right. I am a little confused, but I just go back to 118. Is the dealt a P_rampup determined in transmission or is that value stated before preamble transmission is stated in Paragraph 118?

A. Let me -- Let me elaborate more. Initially, there is no -- your -- the UE is doing retransmissions. It has not received a response yet from the base station.

So, the UE is using its best estimate, and that's what we call "the open loop" for the pathloss. It assumes the power target needs to be, what it's initial transmit power and the rampup component, it's adding because of retransmissions.

Now, once that message is received and a response, this is where you hear me from across the street and you say, "hey," and now, I have a better idea what it took for me to communicate with you. And for example, you know, you can say, you don't need to scream. I can hear you.

That corresponds to the delta PPC component. So Message 2 coming from the UE to the -- sorry. Message 2 coming from the eNodeB, from the base station to the UE, will contain a power control command.

And at that point, the UE has a better understanding of what -- because of now we call it closed loop power control because it has received a correction. That's what the first sentence in 118 is describing.

After you've received the random access response which is in Message 2, the UE has received the power control command delta PC and has a better understanding what rampup because it may have used multiple delta P rampups in the process to get that message to.

MR. BUMGARDNER: Objection. Non-response responsive.

BY MR. BUMGARDNER:

Q. My question, Doctor Akl, has to do with the delta P_rampup value mentioned in the first line of Paragraph 118. It says the UE receives information for that value before the preamble transmission.

You see that. Right?

A. Yes, I see that sentence.

Q. So is the value delta P_rampup I mean the paragraph states that value, the information for that value or that parameter is received before the preamble transmission. And I am asking: Is that right, or is there a mistake in this declaration?

A. I think I understand your question now. No. This is not a mistake. The sentence states the UE receives information for delta P_rampups. So, I'm not saying the value of delta P_rampup. But, for example, you could have how much you increase the delta P_rampup from one message to another method.

The step value, that information can be adjusted and may be received before a UE even does a random access response as part of what the network informs the UE so -- so in my analogy when I said, you know, I state -- state your name and say it a little louder and a little louder and I am increasing that, my voice. The amount that you increase, that information, not the value but the amount you may increase, that may come, that information comes to the UE before we even start the process.

So, the UE may have -- different UEs may have different rampup steps. But the lack of a response is what causes the delta rampup to be added and to consistently increase within -- within certain ranges.

So that's what the -- so the UE receiving information for delta P_rampup is what happens as part of the -- before any communication takes place. These are the parameters that get set up in the phone early.

Q. That might come to the phone over a broadcast channel or something like that in a message information block?

A. That's not part of -- at least how this value comes is really not part of this litigation. It doesn't affect a -- the if you look at the 966 patent, specifically when we look at Figure 1-B, we start with the random access preamble, which is Message 1, where the phone already knows, or the UE already knows, if it doesn't receive a response, what the rampup is going to be. It's the random access response Message 2 that contains the power control command.

MR. BUMGARDNER: No further questions.

MR. NASH: I don't have any

questions for the witness, but I appreciate him being here today.

THE VIDEOGRAPHER: We're going off the record at 4:04. We are off the record. You can remove your mics.

(Deposition concluded at 4:04 p.m.)

CERTIFICATE OF DEPONENT

I have read the foregoing transcript of my deposition and except for any corrections or changes noted on the errata sheet, I hereby subscribe to the transcript as an accurate record of the statements made by me.

_________________________

ROBERT AKL, D.Sc.

SUBSCRIBED AND SWORN before and to me this ____ day of ________________, 20___.

___________________________

NOTARY PUBLIC

My Commission expires:

# ERRATA SHEET

VERITEXT LEGAL SOLUTIONS
330 OLD COUNTRY ROAD
MINEOLA, NEW YORK 10001
516-608-2400

NAME OF CASE: HTC CORP. VS. CELLULAR COMMUNICATIONS
DATE OF DEPOSITION: FEBRUARY 15, 2018
NAME OF DEPONENT: ROBERT AKL, D.Sc.

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______________________
ROBERT AKL, D.Sc.

SUBSCRIBED AND SWORN TO BEFORE ME
THIS___DAY OF ____________, 20__.

______________________ ______________________
(NOTARY PUBLIC) MY COMMISSION EXPIRES:

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD
HTC CORPORATION, HTC AMERICA, INC.
ZTE CORPORATION, and ZTE (USA), INC.
Petitioners
v.
CELLULAR COMMUNICATIONS EQUIPMENT, L.L.C.
Patent Owner.
Case IPR2017-01508
Patent 8,385,966

REPORTER'S CERTIFICATION
VIDEOTAPED ORAL DEPOSITION OF
ROBERT AKL, D.Sc.
February 15, 2018

I, Suzanne Kelly, Certified Shorthand Reporter in and for the State of Texas hereby certify to the following:

That the witness, ROBERT AKL, D.Sc., was duly sworn by the officer and that the transcript of the videotaped oral deposition is a true record of the testimony given by the witness;

That the deposition transcript was submitted on the _____ day of __________, 2018, to the witness for examination, signature and return to Suzanne Kelly by the _____ day of __________, 2018;

That the amount of time used by each party at the deposition is as follows:

Mr. Bumgardner: Four hours and 42 minutes used;

That pursuant to the information given to the deposition officer at the time said testimony was taken, the following includes counsel for all parties of record:

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I further certify that I am neither counsel for, related to, nor employed by any of the parties or attorneys in the action in which this proceeding was taken, and further that I am not financially or otherwise interested in the outcome of the action.

In witness whereof, I have this date subscribed my name on this 19th day of February, 2018.

Suzanne Kelly, CSR, RDR, CRR
Certification No. 1260
Expiration Date: 12-31-18
Firm Registration No. 571

**g**

Modified Equation [1]: $P_{PUSCH}(i) = \min\{P_{MAX}, P_{target} + PL + \Delta P_{rampup} + P_{O\_PUSCH} \quad (j) - P_{target} - \Delta P_{rampup} + \Delta_{TPC} + 10\log_{10}\big(M_{PUSCH}(i)\big) + \Delta_{TF}(TF(i))\}$

Simplified Modified Equation [1]: $P_{PUSCH}(i) = \min\{P_{MAX}, PL + P_{O\_PUSCH}\quad(j) + \Delta_{TPC} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$

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Deponent Akl
Date 2-15-18 Rptr. SK
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Paper No. 1

IN THE

**UNITED STATES PATENT AND TRADEMARK OFFICE**

**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

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HTC CORPORATION, HTC AMERICA, Inc.
ZTE CORPORATION, and ZTE (USA), Inc., Petitioners,

v.

CELLULAR COMMUNICATIONS EQUIPMENT LLC,

Patent Owner

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U.S. Patent No. 8,385,966
Issued: February 26, 2013
Inventor(s): Jari Lindholm; Juha S.Korhonen

Title: METHOD, APPARATUS AND COMPUTER PROGRAM FOR POWER CONTROL RELATED TO RANDOM ACCESS PROCEDURES

*Inter Partes* Review No. ______

**PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 8,385,966 PURSUANT TO 35 U.S.C. §§ 311-319 AND 37 C.F.R. § 42**

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Patent Trial and Appeal Board
P.O. Box 1450
Alexandria, VA 22313-1450

## TABLE OF CONTENTS

## LIST OF EXHIBITS

| Exhibit No. | Exhibit |
|---|---|
| Ex.1001 | U.S. Patent No. 8,385,966 ("'966 patent") |
| Ex.1002 | Declaration of Dr. Robert Akl |
| Ex.1003 | U.S. Patent No. 8,599,706 ("Qualcomm") |
| Ex.1004 | 3GPP TS 36.213 v8.2.0 (2008-03) ("TS 36.213") |
| Ex.1005 | 3GPP TS 36.300 v8.4.0 (2008-04) ("TS 36.300") |
| Ex.1006 | 3GPP TS 36.321 v8.0.0 (2007-12) ("TS 36.321") |
| Ex.1007 | U.S. Patent Publication No. 2010/0093386 ("Qualcomm-386") |
| Ex.1008 | 3GPP Draft Proposal "Transmission Power Control in E-UTRA Uplink" ("R1-070870") .by NTT DoCoMo (Feb. 2007) |
| Ex.1009 | 3GPP Draft Proposal "Uplink power control procedures and Text Proposal for E-UTRA" ("R1-074704") by InterDigital Communications, LLC (November. 2007) |
| Ex.1010 | 3GPP Draft Proposal "Reply to RAN2 LS on RACH Power Control Optimisation Use Case" ("R1-080612") by Jung A. Lee of Alcatel Lucent (January. 2008) |
| Ex.1011 | 3GPP Draft Proposal "Uplink power control procedures and Text Proposal for E-UTRA" ("R1-080879") by Ericsson (February, 2008) |
| Ex.1012 | 3GPP Specifications Home, http://www.3gpp.org/specifications/specifications (accessed 2017-04-19) |
| Ex.1013 | Prosecution History of U.S. Patent No. 8,385,966 ("'966 file history") |
| Ex.1014 | Provisional Application of U.S. Patent No. 8,385,966 ("'966 provisional") |

# I. INTRODUCTION

Petitioner HTC Corporation and ZTE (USA), Inc. requests institution of *Inter Partes* Review, and cancellation of Claims 1-17 (the "Challenged Claims"), of U.S. Patent No. 8,385,966 ("the '966 Patent") (Ex. 1001).

# II. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(a)(1)

## A. Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)

The real-parties-in-interest for this Petition are HTC Corporation, HTC America, Inc., ZTE Corporation and ZTE (USA), Inc.

## B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

The following would affect, or be affected by, a decision in this proceeding: (1) Cellular Communications Equipment LLC v. HTC Corporation et al, No. 6:16-cv-00475-RWS- KNM (E.D. Tex.) and (2) Cellular Communications Equipment LLC v. ZTE Corporation et al, No. 6:16-cv-00476-RWS-KNM (E.D. Tex.).

## C. Lead and Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Petitioners provides the following designation of counsel.

| **Lead Counsel:** | **Back-Up Counsel** |
|---|---|
| Steven A. Moore (Reg. No. 55,462)<br>PILLSBURY WINTHROP SHAW PITTMAN LLP<br>Postal and Hand Delivery Address<br>501 West Broadway, Suite 1100<br>San Diego, CA 92101<br>Telephone: 619-544-3112<br>Facsimile: 619-236-1995<br>Email: steve.moore@pillsburylaw.com | Brian Nash (Reg. No. 58,105)<br>PILLSBURY WINTHROP SHAW PITTMAN LLP<br>Post and Hand Delivery Address<br>401 Congress Avenue, Suite 1700<br>Austin, TX 78701<br>Telephone: 512.580.9629<br>Facsimile: 512.580.9601<br>Email: brian.nash@pillsburylaw.com |

| | |
|---|---|
| **Back-Up Counsel**<br>Cheng (Jack) Ko (Reg. No. 54,227)<br>PILLSBURY WINTHROP SHAW PITTMAN LLP<br>Postal and Hand Delivery Address<br>501 West Broadway, Suite 1100<br>San Diego, CA 92101<br>Telephone: 619-544-5000<br>Facsimile: 619-236-1995<br>Email: jack.ko@pillsburylaw.com | |

### D. Service Information Under 37 C.F.R. § 42.8(b)(4)

Service of any documents via hand-delivery may be made at the postal mailing address of the respective lead or back-up counsel designated above with courtesy email copies to the email addresses and docket_ip@pillsburylaw.com

## III. PAYMENT OF FEES UNDER 37 C.F.R. § 42.103

The undersigned authorizes the Office to charge Deposit Account No. 033975 for the fee set forth in 37 C.F.R. § 42.15(a) for this Petition for *Inter Partes* Review and any additional fees in connection with this Petition.

## IV. GROUNDS FOR STANDING (37 C.F.R. § 42.104(a))

Petitioner certifies that the '966 patent is available for *Inter Partes* Review, and that Petitioner is not barred or estopped from requesting *Inter Partes* Review challenging the claims of the '966 patent on the grounds identified herein.

## V. STATEMENT OF MATERIAL FACTS

The earliest potential effective filing date of the claims of the '966 patent is May 5, 2008. (*See* Ex. 1001). U.S. Patent No. 8,599,706 ("Qualcomm," Ex. 1003) is at least § 102(e) prior art to the claims of the '966 patent because it was filed on June 5, 2009, as a National Stage Application to PCT/US2007/080319, filed October 3, 2007. U.S. Patent Application No. 12/443,783 was filed on July 2, 2009, as a National Stage Application to PCT/US07/83239, filed October 31, 2007, and published as U.S. Patent Publication 2010/0093386 ("Qualcomm-386," Ex. 1005). Qualcomm-386 is at least § 102(e) prior art to the claims of the '966 patent.

**Applicant's Admitted Prior Art ("AAPA")**: The AAPA of the '966 patent includes at least FIGs. 1A, 1B, 1C (which are labelled "Prior Art") and descriptions related to those figures. The AAPA also includes 3GPP LTE specifications referenced in the '966 patent, including TS 36.213 (Ex. 1004), TS 36.300 (Ex. 1005), TS 36.321 (Ex. 1006) and disclosure related to those specifications; e.g., 1:24 – 3:6 and 4:21– 6:49 of the '966 patent. (Ex. 1002, ¶¶33-35, 76). A patent applicant's prior art admissions are prior art for purposes of *Inter Partes* Review. *See, e.g., Intri-Plex Tech., Inc. v. Mmi Holdings Saint-Gobain Performance Plastics Rencol Ltd.*, IPR2014-00309 (Paper 83).

## VI. STATEMENT OF PRECISE RELIEF REQUESTED

The Petitioner respectfully requests the Board initiate an *Inter Partes* Review and cancel Claims 1-17 of the '966 patent as unpatentable pursuant to 35 U.S.C.§ 311(b) based on the following three grounds of unpatentability that are discussed in detail herein (including relevant claim constructions). These grounds are:

**Ground A**: Qualcomm and TS 36.213 render obvious Claims 1, 3, 4, 9, 10, 12, and 13 under 35 U.S.C. § 103.

**Ground B**: Qualcomm, TS 36.213, and TS 36.300 render obvious Claims 2 and 11 under 35 U.S.C. § 103.

**Ground C**: Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386 render obvious Claims 5-8 and 14-17 under 35 U.S.C. § 103.

Petitioner evaluates the scope and content of the prior art and, any differences between the prior art and the claims, and the level of skill of a person of ordinary skill in the art in accordance with *Graham v. John Deere Co.*, 383 U.S. 1 (1966) and *KSR Int'l C. v. Teleflex, Inc.*, 550 U.S. 398, 417 (2007) ("a court must ask whether the improvement is more than the predictable use of prior art elements according to their established functions").

A detailed explanation of why the Challenged Claims are invalid is provided below, including grounds stated in the supporting declaration by Professor Akl ("Akl Dec."; (Ex. 1002)).

## VII. THRESHOLD REQUIREMENT FOR *INTER PARTES* REVIEW

A petition for *Inter Partes* Review must demonstrate "a reasonable likelihood that the petitioner would prevail with respect to at least one of the claims challenged in the petition." (35 U.S.C. § 314(a)). The Petition meets this threshold. The prior art teaches each of the elements of Claims 1-17 of the '966 patent as explained below in the proposed grounds of unpatentability. Also, the Petition establishes reasons and motivations to combine prior art for each ground under 35 U.S.C. § 103(a).

## VIII. STATEMENT OF REASONS FOR RELIEF REQUESTED

### A. Introduction to the Technology of the '966 Patent

The '966 patent describes "techniques for power control on different uplink messages sent from a communication device." (1:19-20). The '966 patent relates to determining the transmit power on uplink messages sent from a user equipment. Specifically, the '966 patent indicates "the problem solved by those embodiments is how the power control formulas for PUSCH [physical uplink shared channel] and PUCCH [physical uplink control channel] are taken in use during or after the

Random Access procedure." (4:16-19). A brief overview of the state of the art and the random access procedure is provided by Dr. Robert Akl. (Ex. 1002, ¶¶27-75).

Figures 1B and 1C of the '966 patent—labeled "Prior Art"—show random access procedures and include sending various messages between user equipment (UE) and a base station called an evolved Node B (eNB). (Ex. 1002, ¶¶36-45). As shown in FIG. 1B, the contention-based random access procedure includes four messages.

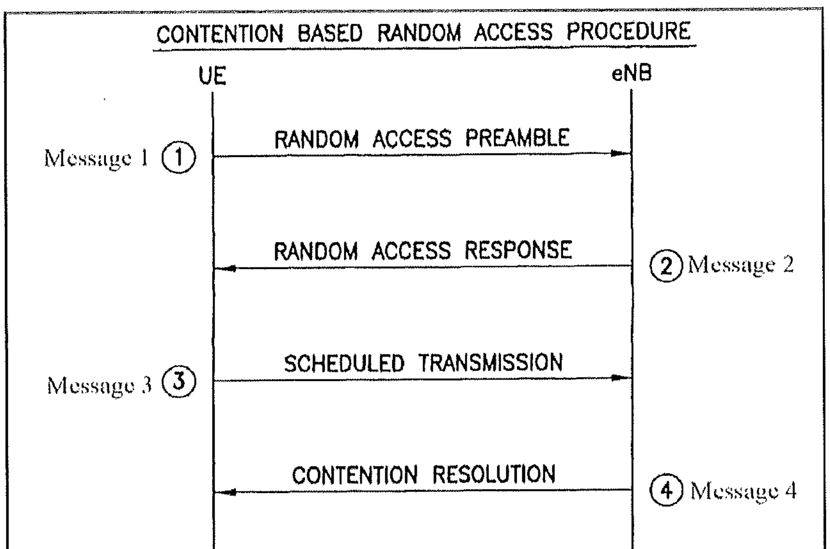

FIG.1B
PRIOR ART

(FIG. 1B of the '966 Patent)

The UE communicates the first message ("Message 1"), which is a "random access preamble," to the eNB. (Ex. 1002, ¶39). The UE uses open loop power control to determine the transmit power of the random access preamble. (*See* Ex.1001, Equation [3], 6:20-24; Ex.1002, ¶39). If the UE does not receive a response to its transmitted preamble, the UE can retransmit the preamble with increased power. The '966 patent refers to the increased power as a "ramp-up" value. (6:25-26; Ex.1002, ¶42).

The eNB responds with a random access response ("Message 2") once it receives the random access preamble. (Ex. 1002, ¶40). The claimed "second message" of Claims 2 and 11 of the '966 patent corresponds to Message 2, which is the random access response. (*Id.*). After receiving the random access response, the UE can respond with a first scheduled transmission on the uplink shared channel; this first transmission after receiving the random access response is called "Message 3." (Ex. 1002 ¶43). Message 3 serves as the first message sent after the successful transmission of the random access preamble. (*Id.*). The'966 patent refers to the transmit power of Message 3 as an "initial transmit power." (*Id.*).

The AAPA of the '966 patent also describes this random process procedure: "the UE transmits a random access preamble and expects a response from the eNB in the form of a so-called Message 2 (e.g., Random Access Response at FIGS. 1B and 1C). Message 2 is transmitted on a DL [downlink] shared channel DL-SCH (PDSCH, the PDCCH) and allocates resources on an UL-SCH (PUSCH). *** The Message 2 contains UL [uplink] allocations for the transmissions of a Message 3 in the UL (e.g., step 3 of the Contention Based Random Access Procedure at FIG. 1B)." (Ex. 1001, 2:27-38).

The '966 patent points to the LTE technical specification 3GPP TS 36.213v.8.2.0 ("TS 36.213"; Ex. 1004) as dictating the transmission of "Message 3" in the LTE communication system using the PUSCH power control formula, taking into account the power control command received from the eNB in Message 2. (Ex.1001, 4:21-25; Ex. 1002 ¶77). Importantly, the '966 patent states: "However, this [technical specification] does not specify how the UE specific parameters of the PUSCH and PUCCH power control formulas are initialized." (Ex.1001, 4:25-27; Ex. 1002 ¶¶78-80). Thus, the '966 patent attempts to teach the "initialization" of power control formulas for PUSCH and PUCCH. (Ex. 1002, ¶81). To teach how the formulas are "initialized," the '966 patent purports:

> According to an embodiment of the invention, the UE receives a power control command (e.g., $\Delta P_{PC}$) in the preamble response from the eNB, which is Message 2. The UE then initiates the PC formula for PUSCH and PUCCH, or compensates open loop error, according to the following equations:
>
> $$P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup} \qquad [4a]$$
>
> $$P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup} \qquad [4b]$$

(Ex.1001, 6:58-67). $\Delta P_{PC}$ is a "power control command" that is included in Message 2. (Ex.1001, Claim 1; *see also* 7:5-13). ΔPrampup is "the power ramp-up applied for preamble retransmissions." (Ex.1001, 6:25-26). The '966 patent admits that the values $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can be set to zero. (Ex.1001, 4:40-50; 5:48-53; 7:16-19). Thus, the purported invention of the '966 patent teaches that the power control formulas, claimed as power control adjustment states, can both be initialized to $\Delta P_{PC} + \Delta P_{rampup}$. (Ex.1001, 7:19-21).

As discussed further below, both $\Delta P_{PC}$ and $\Delta P_{rampup}$ parameters were well known to a person of ordinary skill in the art ("POSITA") by the time of the '966 patent. (Ex. 1002 ¶¶80-84). The UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the random access response, which is Message 2. (Ex. 1002 ¶¶85). Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. (*Id.*). Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. (*Id.*).

The power control equations disclosed in the '966 patent were all known prior to the invention of the '966 patent. (Ex. 1002 ¶¶86-89). As discussed below, Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) teach all of the claimed features of the independent claims, including calculating a transmit power of Message 3 that depends on $\Delta P_{PC}$ +

$\Delta P_{rampup}$, as well as preamble power, power control command, and power offset. (*Id.*).

### B. LEVEL OF ORDINARY SKILL IN THE ART

Petitioner asserts a POSITA as of the time of the '966 patent would have been aware of power control of mobile terminals in cellular systems. (Ex. 1002, ¶19). Such a POSITA would have had a B.S. degree in computer science, computer engineering, electrical engineering, or a related field, and around 2 years of experience in the design or development of transmitter power control in wireless communication systems, or the equivalent. Also, such a POSITA would have been familiar with various working group proposals presented in the 3GPP meetings related to uplink power control and 3GPP specifications, including 3GPP TS 36.213, 3GPP TS 36.300, and 3GPP TS 36.321. (Ex. 1002 ¶¶21-22).

### C. Construction of the Claims

A claim in *Inter Partes* Review receives the "broadest reasonable construction in light of the specification." (*See*, 37 C.F.R. § 42.100(b)). For the purposes of this proceeding, claim terms are presumed to take on their broadest reasonable meaning. As stated in the case *In re ICON Health and Fitness, Inc.* at 496 F.3d 1374, 1379 (Fed. Cir. 2007): "the PTO must give claims their broadest reasonable construction consistent with the specification. Therefore, we look to the specification to see if it provides a definition for claim terms, but otherwise apply a broad interpretation." In addition to this presumption, Petitioner provides a more detailed explanation of the broadest reasonable meaning of certain claim terms.

### 1. "Full path loss compensation" (Claims 1, 9, and 10)

In the context of the '966 patent, the terms "path loss", "pathloss", and "PL" are used interchangeably and they all refer to the downlink path loss estimate calculated by the UE. (Ex. 1002, ¶125). Specifically, the '966 patent states "PL is the downlink pathloss estimate calculated in the UE" (Ex. 1001, 4:53) and "PL is the path loss that UE estimates from DL." (Ex. 1001, 6:24).

The phrase "full path loss compensation" refers to using an entire estimated path loss, which is in contrast to fractional path loss compensation that uses only a portion of the estimated path loss. (Ex.1001, 8:7-17 and 11:25-31). The power formulas of the '966 patent indicate full path loss compensation by setting α to 1 (Ex.1001, 8:21-25). Thus, "full path loss compensation" as used in the claims of the '966 patent should be interpreted to mean using the entire estimate path loss. (Ex. 1002, ¶¶125-126).

### 2. "Initial transmit power" (Claims 1, 5, 8-10, 14, and 17)

The '966 patent refers to "Message 3" as the "first or initial message sent on PUSCH." (Ex. 1001, 11:15-17). The phrase "initial transmit power" should mean the transmit power of the message after a successful transmission of a random access preamble; i.e., the transmit power of Message 3. (Ex. 1001, 11:15-19; Claim 5; Ex. 1002, ¶¶86-87).

### 3. "Depends on" (Claims 1, 9, and 10)

In the context of the '966 patent, the phrase "depends on" includes both direct dependency and indirect dependency. (Ex. 1002, ¶¶119-123). For example, the initial transmit power can depend directly on a parameter or depend indirectly on a parameter. (Ex. 1001, claims 1 and 5; Ex. 1002 ¶¶120-122). This reading of "depends on" is consistent with the claims and the specification of the '966 patent. (*Id.*).

### 4. "Fractional path loss compensation" (Claims 7 and 16)

The phrase "fractional path loss computation" as used in the claims of the '966 patent should be interpreted to mean a path loss computation based on a fraction of the estimated path loss. Ex. 1002, ¶44. $\alpha$ in Equation [1] and Claims 6 and 15 represents the fractional component. (Ex.1001, Fig. 4, 410; 4:31-33; and 11:39-44). In the context of the '966 patent, "fractional path loss compensation" is also referred to as "fractional power control." (Ex.1001, 2:39-49; Ex. 1002, ¶44).

Petitioner notes that claim construction in *Inter Partes* Review is broader than in litigation. Nothing in this Petition should be taken as an assertion regarding how the claims should be construed in litigation, whether the claims constitute patentable subject matter under 35 U.S.C. § 101, or whether the claims satisfy the definiteness, enablement, or written description requirements of 35 U.S.C. § 112.

### D. PRIOR ART

#### 5. U.S. Patent 8,599,706 (Qualcomm)

U.S. Patent No. 8,599,706 ("Qualcomm"; Ex. 1003) was filed on June 5, 2009, as a National Stage Application to PCT/US2007/080319, filed October 3, 2007. The PCT application claimed the benefit of Provisional Application No. 60/828,058, filed on October 3, 2006. Accordingly, Qualcomm qualifies as a printed publication and prior art to the '966 patent. In addition, PCT/US2007/080319 published as WO2008/042967 on April 10, 2008, has substantially the same disclosure as Qualcomm.

#### 6. 3GPP TS 36.213 v8.2.0 (TS 36.213)

The 3rd Generation Partnership Project (3GPP) website made 3GPP TS 36.213 v8.2.0 ("TS 36.213"; Ex. 1004) available before the invention of the '966 patent. (Ex. 1002, ¶33). The 3GPP brings together partners to produce specifications on 3GPP technologies, such as LTE. (Ex. 1002, ¶31-32). Accordingly, one of skill in the art interested in LTE would turn to the resources and/or specifications that are available on the 3GPP website. (*Id.*). TS 36.213, therefore, was both publicly available and also sufficiently accessible to the public that are interested in LTE prior to the invention of the '966 patent. (*Id.*).

The '966 patent acknowledges that TS 36.213 was available prior to the invention of the '966 patent. (Ex.1001, 4:20-30). Portions of TS 36.213 were attached as an exhibit to the '966 patent's provisional application. (*Id.*). The '966 patent admits that Equation [1] and its description are from section 5.1.1.1 of TS 36.213. (Ex.1001, 4:20-30). Accordingly, TS 36.213 is part of AAPA and qualifies as a printed publication and prior art to the '966 patent. (Ex. 1002, ¶33).

**7. 3GPP TS 36.300 v8.4.0 (TS 36.300)**

3GPP TS 36.300 v8.4.0 ("TS 36.300"; Ex. 1005) was published before March, 2008 and publicly available before the invention of the '966 patent. (Ex. 1002, ¶34). The '966 patent admits that TS 36.300 was available prior to the invention of the '966 patent. (Ex.1001, 2:18-26). Portions of TS 36.300 were attached as an exhibit to the '966 patent's provisional application. (*Id.*). Accordingly, TS 36.300 is part of AAPA and qualifies as a printed publication and prior art to the '966 patent.

**8. U.S. Patent Publication 2010/0093386 (Qualcomm-386)**

U.S. Patent Application No. 12/443,783 was filed on July 2, 2009, as a National Stage Application to PCT/US07/83239, filed October 31, 2007. The PCT application claimed the benefit of Provisional Application No. 60/855,903, filed on

October 31, 2006. U.S. Patent Application No. 12/443,783 published as U.S. Patent Publication 2010/0093386 ("Qualcomm-386"; Ex. 1007). Accordingly, the Qualcomm-386 qualifies as a printed publication and prior art to the '966 patent.

### E. Claim-By-Claim Explanation of Grounds for Unpatentability

#### Ground A. Qualcomm (Ex. 1003) and TS 36.213 (Ex. 1004) Render Obvious, Under 35 U.S.C. § 103, Claims 1, 3, 4, 9, 10, 12, and 13.

Claims 1, 3, 4, 9, 10, 12, and 13 of the '966 patent are unpatentable under 35 U.S.C. § 103(a) over Qualcomm and 3GPP TS 36.213 v8.2.0 (TS 36.213). *See* Ex. 1002, Appendix B.

Claims 1, 9, and 10 include features which are taught in Qualcomm and TS 36.213 (which is AAPA of the '966 patent). Claims 1, 9, and 10 claim different invention types (method, computer readable memory, and an apparatus), but contain nearly identical features. These claims require initializing f(0) and g(0); calculating an initial transmit power; and sending the third message with the initial transmit power. As detailed below, Qualcomm and TS 36.213 (which is AAPA) teach all the features of these claims. (Ex. 1002 ¶¶ 98-135; App. B.) Regarding the preambles of Claims 1, 9, and 10, Qualcomm discloses "The steps of a method or algorithm described in connection with the disclosure herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two." (Ex. 1003, 14:37-40).

1. "***compute/computing an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0) … wherein the second power control adjustment state f(i) for i=0 is initialized as [Equation 4a]***"

Qualcomm teaches calculating the "initial transmit power", which is the transmit power for Message 3, in the form of PUSCH_power. (Ex. 1003, 10:1-19 ("PUSCH_power is the transmit power of the message sent on the PUSCH" and it is "the transmit power of the first uplink message sent after successful transmission of the random access preamble")). Qualcomm teaches that PUSCH transmit power depends on both the preamble power of the first message sent on a random access channel and the power control adjustment state f(0). For example, Qualcomm discloses "FIG. 10 shows a design of a process 1000 for transmitting a message for system access. A random access preamble may be sent for system access (block 1012). A random access response with a PC correction may be received (block

1014). The transmit power of a message may be determined **based on the PC correction** and possibly other parameters (block 1016). For example, the transmit power of the message may be determined further **based on the transmit power of the random access preamble**, a power offset between a first channel used to send the random access preamble and a second channel used to send the message, etc. The message may be sent with the determined transmit power (block 1018)." (Ex. 1003, 13:34-45; emphasis added).

**a. "*the initial transmit power depends on a preamble power of a first message sent on an access channel*"**

Qualcomm's Equation (4) discloses a formula for calculating the transmit power for Message 3 (PUSCH_power): "PUSCH_power = RACH_power + PC_correction + PUSCH_RACH_power_offset." (Ex. 1003, 10:1-19).

The parameter RACH_power "is the transmit power of the successful transmission of the random access preamble on the RACH [random access channel]." (Ex. 1003, 10:12-13). The initial transmit power (PUSCH_power), therefore, depends on the preamble power of the first message, *i.e.,* the transmit power of the random access preamble (RACH_power).

**b. "*the initial transmit power depends on ... power control adjustment state f(0) … wherein the second power control adjustment state f(i) for i=0 is initialized as [Equation 4a]*"**

Equation [4a] of the '966 patent recites "$P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup}$", but Equation [4a] can be rewritten as $f(0) = \Delta P_{PC} + \Delta P_{rampup}$. (Ex. 1002, ¶81). Qualcomm discloses that initial transmit power (PUSCH_power) depends on both $\Delta P_{PC}$ and $\Delta P_{rampup}$. (Ex. 1002 ¶¶ 102-106; 119-124). For example, TX_power (the transmit power for the random access preamble, or RACH_power; 8:37-9:36) is defined in units of decibels in Equation (2) of Qualcomm. As shown below, TX_power (or RACH_power) depends on the power_ramp_up parameter.

Equation (2): **TX_power = RACH_power** = -RX_power + interference_correction + offset_power + added_correction + **power_ramp_up**.

The power_ramp_up parameter describes the increase in the UE's transmit power for subsequent transmissions of the random access preamble. (Ex. 1003, 9:45-49). It is used to increase the transmit power of a subsequent random access preamble that is sent when the UE does not receive a response from the eNB from an earlier sent random access preamble. (Ex. 1002, ¶103). The power_ramp_up parameter is the same as "a ramp-up power for preamble transmissions," *i.e.*, $\Delta P_{rampup}$ of claims 1, 9, and 10 of the '966 patent. (*Id.*).

Further, the PUSCH_power described in Equation (4) of Qualcomm can be rewritten by substituting the parameter RACH_power with Qualcomm's Equation (2), which describes the transmit power of the preamble. As shown below, after this substitution, the modified Equation (4) of Qualcomm shows that PUSCH_power depends on power_ramp_up + PC_correction (Ex. 1002, ¶104):

**Equation (4) of Qualcomm:** PUSCH_power = RACH_power + PC_correction + PUSCH_RACH_power_offset.

**Equation (2) of Qualcomm:** TX_power = RACH_power = -RX_power + interference_correction + offset_power + added_correction + power_ramp_up.

**Substituting Equation (2) into Equation (4) to obtain:**

Modified Equation (4): **PUSCH_power** = -RX_power + interference_correction + offset_power + added_correction + **power_ramp_up + PC_correction** + PUSCH_RACH_power_offset.

**Rearranging Modified Equation (4) to obtain:**

Modified Equation (4): **PUSCH_power = power_ramp_up + PC_correction** - RX_power + interference_correction + offset_power + added_correction + PUSCH_RACH_power_offset.

Qualcomm describes that PC_correction "indicates an amount of increase or decrease in transmit power" and it "is the PC correction received in the random access response" (Ex. 1003, 10:20-21; 10:16-17). The random access response (which is Message 2) is the response sent by the eNB after receiving the random access preamble. (Ex. 1002, ¶105). In the '966 patent the UE receives a power control command, $\Delta P_{PC}$, in the preamble response from the eNB, which is Message 2. (Ex. 1001, 6:58-60.) $\Delta P_{PC}$ indicates if the UE should increase or decrease its transmit power. (Ex. 1002, ¶105). Thus, PC_correction is "a power control command indicated in a second message that is received in response to sending the first message," *i.e.*, $\Delta P_{PC}$ of claims 1, 9, and 10 of the '966 patent. (*Id.*). Accordingly, the initial transmit power (PUSCH_power) described in Qualcomm also depends on f(0), *i.e.* $\Delta P_{PC} + \Delta P_{rampup}$.

As discussed above, PUSCH_power as described in Qualcomm depends on both the preamble power, *i.e.,* RACH_power, and f(0), *i.e.,* $\Delta P_{PC} + \Delta P_{rampup}$ or PC_correction + power_ramp_up. The power_ramp_up parameter is part of both the preamble power and f(0). In this manner, the initial transmit power (PUSCH_power) of Qualcomm depends directly on a preamble power and depends indirectly on the power_ramp_up parameter. (Ex. 1002 ¶¶ 119-124).

In addition, it would have been obvious for a POSITA to come up with Equation [4a] based on AAPA of the '966 patent. (Ex. 1002 ¶¶ 107-118). For example, TS 36.213 discloses an equation for PUSCH transmit power, which is Equation [1] of the '966 patent. (Ex. 1001, 4:28-5:35; Ex. 1004, §5.1.1.1). A POSITA would understand Equation [1] is dependent on UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(i). (Ex. 1002 ¶¶108-111). And the '966 patent admits that except for the UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), other parameters of Equation

[1] are known. (Ex. 1001 10:11-20). Thus, a POSITA would have been motivated to use other parameters relevant to the Random Access Procedure in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to initialize Equation [1]. (Ex. 1002 ¶¶113-118).

For example, the UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access Response, which is Message 2. (Ex. 1002, ¶118). Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. (*Id.*) Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. (*Id.*) Accordingly, Equation [4a] of the '966 patent simply uses two parameters, $\Delta P_{PC}$ and $\Delta P_{rampup}$, known to the UE in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to initialize Equation [1]. (*Id.*).

#### c. "*compute/computing an initial transmit power for the uplink shared channel using full path loss compensation*"

As noted above, the term "full path loss compensation" means that the entire estimated path loss or PL (as opposed to a fractional portion of estimated PL) is used in the power control calculation. (Ex. 1002 ¶¶125-126). The initial transmit power (PUSCH_power) in Equation (4) of Qualcomm uses full path loss compensation because it uses the entire estimated value of "PL" in the power control formula. (Ex. 1002, ¶127). The preamble power described in Qualcomm is based on the entire estimated path loss. (*Id.*). First, the preamble power is calculated using an open loop method. (Ex. 1003, 8:37-39*).* The '966 patent admits that preamble power is calculated using full path loss compensation in an open loop method. (Ex. 1001, 2:39-40; 6:60-62; 7:3-4). In contrast, a closed loop method implies that the power is determined based on a feedback parameter; e.g., a power correction value. (Ex. 1002, ¶127).

Path loss (PL) is the difference or ratio between transmit power and the receive power of a signal. (Ex. 1002, ¶¶51-53). And in the context of the '966 patent, "path loss" or "PL" refers to the downlink path loss estimate calculated by the UE. (Ex. 1002, ¶128). The parameter PL does not expressly appear in Qualcomm Equation (1), but its components, *i.e.* transmit power of a reference signal ($P_{TX}^{eNB}$) and the received power of the reference signal ($P_{RX}^{UE}$), are disclosed. (*Id.*) According to Equation (1) of Qualcomm, $P_{TX}^{eNB}$ "is the transmit power of the reference signal from the recipient eNB" and $P_{RX}^{UE}$ "is the received power at the UE for time-frequency slots used for a reference signal (*e.g.*, a pilot signal) from the recipient eNB." (Ex. 1003, 8:49-51; 8:58-59). Thus, the path loss for the downlink reference signal can be calculated at the UE as PL = $P_{TX}^{eNB}$ /

$P_{RX}^{UE}$, or the difference of the power values in the logarithm domain. (Ex. 1002, ¶128).

The preamble power of Qualcomm's Equation (2) includes both the transmit power of the reference signal ($P_{TX}^{eNB}$) and the received power of the reference signal ($P_{RX}^{UE}$). (Ex. 1003, 9:20-35, 8:58-59, 8:49-51). The parameter RX_power is $P_{RX}^{UE}$ written in the logarithm domain; and the parameter offset_power parameter includes $P_{TX}^{eNB}$ in the logarithm domain. (Ex. 1002, ¶129). Accordingly, rewriting Equation (2) of Qualcomm with the RX_power and offset_power values expanded and rearranging the terms (*Id.*):

**Modifiled Equation (2)**: TX_power = $[10\log_{10}(\mathbf{P_{TX}^{eNB}}) - 10\log_{10}(\mathbf{P_{RX}^{UE}})]$ + interference_correction + $10\log_{10}(SNR_{target})$ + $10\log_{10}(N_0+I_{oc}^{eNB})$ + added_correction + power_ramp_up.

The path loss in Modified Equation (2) is PL = $[10\log_{10}(P_{TX}^{eNB}) - 10\log_{10}(P_{RX}^{UE})]$. (*Id.*) The entire estimated path loss is used ($\alpha = 1$) because there is no fractional portion in the equation, so the preamble power uses full path loss compensation. (*Id.*) Because the transmit power of Message 3, which is Equation (4) in Qualcomm, uses the preamble power, the transmit power of Message 3 is also calculated using full path loss compensation. (*Id.*)

**2. "*initialize/initializing for i = 0 a first power control adjustment state g(i) for an uplink control channel and a second power control***

***adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error***"

Claims 1, 9, and 10 recite initializing a first power control adjustment state g(0), but do not define the formula g(0) or the general formula g(i). Dependent claims 3 and 12 though do provide an example of g(0) in the form of $P_{0\_UE\_PUCCH}$ + g(0) = $\Delta P_{PC} + \Delta P_{rampup}$. The AAPA of the '966 patent also provide that $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can be equal to 0. (Ex. 1002, ¶¶152-153). Accordingly, initializing for i = 0 a first power control adjustment state g(i) and a second power control adjustment state f(i) leads to g(0) = f(0) = $\Delta P_{PC} + \Delta P_{rampup}$. (Ex. 1002, ¶130).

The parameters f(i) and g(i) are disclosed in the AAPA and TS 36.213 as "power control adjustment state." (Ex. 1001, 4:65-5:35, 6:1-17; TS 36.213, §5.1.1.1, §5.1.2.1). The parameter f(i) is the power control adjustment state relevant to messages sent on the uplink shared channel; the parameter g(i) is the power control adjustment state relevant to messages sent on the uplink control channel. (Ex. 1002, ¶131). As described above, when calculating the transmit power of Message 3, the value f(0) is calculated. Because f(0) and g(0) can be the exact same formula and were both disclosed in TS 36.213, calculating f(0) also calculates g(0). Accordingly, Qualcomm discloses initializing for i = 0 a first power control adjustment state g(i) and a second power control adjustment state f(i) as f(0) = g(0) = $\Delta P_{PC} + \Delta P_{rampup}$. (Ex. 1002, ¶¶ 102-118; 137-150).

The Qualcomm reference does not expressly show these power control adjustment states using the same terminology. A POSITA, however, would understand that Qualcomm teaches these states and/or would look at least to TS 36.213 regarding the two claimed power control adjustment states. (Ex.1002, ¶131). As the claims only require that g(0) is initialized and that f(0) can be equal to g(0), Qualcomm teaches initializing both f(0) and g(0). (*Id.*) TS 36.213 makes explicit what a POSITA would have known, *i.e.*, that f(i) exists for use in calculating power for a shared channel and that g(i) exists for use in calculating power for a control channel. (TS 36.213, §5.1.1.1, §5.1.2.1; Ex. 1002, ¶131). The teachings of Qualcomm combined with the teachings of TS 36.213 allow UE to "efficiently transmit the random access preamble and signaling for system access," while maintaining compatibility with the LTE standards such as TS 36.213. (Ex. 1003, 1:45-47). Such a combination, therefore, would be obvious to a POSITA in creating a more efficient random access signaling that is compliant with the LTE specifications. (Ex. 1002, ¶131).

As described in the '966 patent, the open loop power control error is "the sum of the UE specific power control constants ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and the power control initial states (f(0) and g(0)) ... taking into account the preamble power ramp-up." (Ex. 1001, 7:1-5). Specifically, $\Delta P_{PC}$ reflects the open loop power control error. (Ex. 1002, ¶82). The PC_correction of Qualcomm may be based on a received signal quality of the random access preamble at the eNB, thus reflecting an open loop power control error. (Ex. 1003, 13:46-47.) Therefore, calculating a transmit power or any formula that includes $\Delta P_{PC}$ or PC_correction reflects an "open loop power control error." (Ex. 1002, ¶106).

**3. *"sending from a transmitter a third message on the uplink shared channel at the initial transmit power"/"outputting the initial transmit power for transmission of a third message on the uplink shared channel"/"compile a third message to be sent on the uplink shared channel at the initial transmit power"***

Qualcomm discloses calculating a "transmit power of the first uplink message sent after successful transmission of the random access preamble…" (Ex. 1003, 10:1-3). Equation (4) of Qualcomm defines the variable PUSCH_power as "the transmit power of the message sent on the PUSCH." (Ex. 1003, 10:14-15). PUSCH is a physical uplink shared channel. (Ex. 1003, Table 1; 4:24-25). Qualcomm, therefore, teaches sending a third message on an uplink shared channel at the calculated transmit power, as claimed. (Ex. 1002, ¶133).

As described in Qualcomm, the invention can be implemented using various technologies such as software, computer-readable media, processors, methods, etc. (Ex. 1003, 14:6-10; 37-44; 52-60). Accordingly, the transmit power calculation for

Message 3 described in Qualcomm could be implemented as a method, computer-readable medium, or an apparatus. (Ex. 1002, ¶134).

Qualcomm describes that its disclosed inventions can be used in an LTE system. (Ex. 1003, 3:3-14). Further, Qualcomm relies on LTE terminology and examples in describing the disclosed inventions. (Ex. 1003, 3:10-14). In reviewing Qualcomm, a POSITA would also be familiar with or reference the LTE specifications available on the 3GPP website. (Ex. 1002 ¶135). The LTE specifications define how equipment, such as user equipment, operates to be compatible with LTE. Accordingly, a POSITA reading about the random access procedure described in Qualcomm that can be used in an LTE system would naturally be familiar with and look to LTE specifications, such as 3GPP TS 36.213 and TS 36.300. (*Id.*) Combining teachings from Qualcomm and TS 36.213 would achieve rational and expected results, user equipment that is compliant with and can successfully operate in an LTE system. (*Id.*).

Based on the above, Qualcomm and TS 36.213 disclose, suggest, or teach the features of independent Claims 1, 9, and 10. *See also* Ex. 1002, Appendix B. Specifically, Qualcomm provides the claim features added to the independent claims during prosecution to overcome the prior art rejections, namely addition of the equation: P0_UE_PUSCH +f(0)=ΔPPC +ΔPrampup. (Ex. 1002 ¶136). Equation (4) of Qualcomm defines a transmit power for Message 3 that depends on a preamble transmit power, a PC correction (which is ΔPPC in the claimed equation as defined in the claim) and a power_ramp_up value (which is ΔPrampup in the claimed equation). (*Id.*). Thus, Qualcomm and TS 36.213 disclose, suggest, or teach the claimed features of Claims 1, 9, and 10, including the same equation added by Patent Owner during prosecution to overcome prior art rejections.

**9. Qualcomm and TS 36.213 render dependent claims 3 and 12 obvious.**

Although different in scope, Claims 3 and 12 include similar features. Specifically, they include a formula to initialize the "first power control adjustment state g(i) for i=0" as: P0_UE_PUCCH +g(0)=ΔPPC +ΔPrampup. As described above, the claim term P0_UE_PUCCH can be zero. (Ex.1001, 5:48-53, 7:16-18; Ex. 1002, ¶153).). Accordingly, Claim 3 is broad enough to recite the formula for g(i) as g(0)=ΔPPC +ΔPrampup. As noted above, other than initializing, the claims never refer to or use g(0). Further, the definitions of f(0) and g(0) are broad enough such that f(0) = g(0). (Ex. 1002, ¶¶152-153). Accordingly, calculating f(0) as $\Delta P_{PC} + \Delta P_{rampup}$ also teaches calculating the initial state of g(0) as $\Delta P_{PC} + \Delta P_{rampup}$. (Ex. 1002, ¶138).

As described in detail above related to the "initial transmit power depends on … power control adjustment state f(0)" limitation of Claim 1, Qualcomm, teaches calculating the formula ΔPPC + ΔPrampup, which is the same as initializing g(0). (Ex. 1002, ¶¶102-105). The calculation of RACH Power in Qualcomm includes summing a power control correction with a preamble rampup value. (*Id.*).

Claim 12 is an apparatus claim that includes the same features as Claim 3. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 3 and 12 are obvious in view of Qualcomm and TS 36.213. *See also* Ex. 1002, Appendix B.

In addition, it would have been obvious to a POSITA to come up with Equation [4b] based on AAPA of the '966 patent. (Ex. 1002, ¶¶ 139-150). For example, TS 36.213 discloses an equation for PUSCH transmit power, which is Equation [2] of the '966 patent. (Ex. 1001, 5:39-40; Ex. 1004, §5.1.2.1). A POSITA would understand Equation [2] is dependent on UE specific parameters, $P_{0\_UE\_PUCCH}$ and g(i). (Ex. 1002 ¶¶139-141). And the '966 patent admits that except for the UE specific parameters, $P_{0\_UE\_PUCCH}$ and g(i), other parameters of Equation [2] are known. (Ex. 1001 10:11-20). Thus, a POSITA would have been motivated to use other parameters relevant to the Random Access Procedure in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH}$ and g(0), to initialize Equation [2]. (Ex. 1002, ¶¶142-149).

For example, the UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access Response, which is Message 2. (Ex. 1002, ¶150). Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. (*Id.*) Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. (*Id.*) Accordingly, Equation [4b] of the '966 patent simply uses two parameters, $\Delta P_{PC}$ and $\Delta P_{rampup}$, known to the UE in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to initialize Equation [2]. (*Id.*).

**10. Qualcomm and TS 36.213 render independent claims 4 and 13 obvious.**

Although different in scope, Claims 4 and 13 include similar features. Specifically, they indicate that P0_UE_PUSCH = P0_UE_PUCCH = 0 when computing initial values at i=0 of power control states for shared and control channels. As discussed above in regard to Claims 1, 3, 9, 10, and 12, Qualcomm describes equations for computing initial values without using P0_UE_PUSCH or P0_UE_PUSCH, *i.e.*, P0_UE_PUSCH = P0_UE_PUCCH =0. (Ex. 1002, ¶89).

Claim 1 provides that f(0) depends on $P_{0\_UE\_PUSCH}$ and claim 3 provides that g(0) depends on $P_{0\_UE\_PUCCH}$. The '966 patent admits that both of these values can be 0. (Ex. 1001, 7:16-18). Equation [1] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.1.1, discloses $P_{0\_UE\_PUSCH}$ (j) is a 4-bit UE specific component configured by RRC for j=0 and 1 in the range of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, **0**, 1, 2, 3, 4, 5, 6, 7] dB. (Ex. 1001, 4:40-50; Ex. 1002, ¶152).

Equation [2] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.2.1, discloses $P_{0\_UE\_PUCCH}(j)$ is a UE specific component configured by RRC in the range of [-8, 7] dB with 1 dB resolution; *i.e.*, a range of [-8, -7, -6, -5, -4, -3, -2, -1, **0**, 1, 2, 3, 4, 5, 6, 7] dB. (Ex. 1001, 5:48-53; Ex. 1002, ¶153). Accordingly, the recited features of claims 4 and 13 are disclosed in the AAPA; specifically, TS 36.213 §5.1.1.1 and §5.1.2.1.

Claim 13 is an apparatus claim that includes the same features as Claim 4. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 4 and 13 are obvious in view of Qualcomm and TS 36.213. *See also* Ex. 1002, Appendix B.

### Ground B. Qualcomm (Ex. 1003), TS 36.213 (Ex. 1004), and TS 36.300 (Ex. 1005) Render Obvious, Under 35 U.S.C. § 103, Claims 2 and 11.

#### 1. Qualcomm, TS 36.213, and TS 36.300 render dependent claims 2 and 11 obvious.

Claim 2 of the '966 patent depends from independent Claim 1 and Claim 11 depends from independent Claim 10. Although different in scope, Claim 2 and Claim 11 include similar features. Specifically, they further limit Claims 1 and 10 to: compute the "preamble power using full path loss compensation," "sending the first message," computing "an updated transmit power for the uplink shared channel using fractional power control," and transmitting "a subsequent message on the uplink shared channel using the updated transmit power."

##### *a. "wherein the first message comprises a random access request message"*

Claims 2 and 11 recite the first message is a random access request message. Qualcomm teaches the first message as a random access preamble. (Ex. 1003, 8:38-40). This is also how the AAPA and TS 36.300 refer to the first message sent from the user equipment in a contention based random access procedure. (Ex. 1001, Figure 1B and 4:1-4; Ex. 1005, Fig. 10.1.5-1; Ex. 1002, ¶156).

***b. "computing the preamble power using full path loss compensation"***

Claims 2 and 11 further recite that the preamble power is computed using full path loss compensation. Here, preamble power refers to the random access preamble power used to transmit the RACH preamble. (Ex. 1001, claim 1; Ex. 1002, ¶157). The '966 patent admits that existing random access procedure discloses this limitation. (Ex. 1001, 2:39-40 "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula."). In addition, Qualcomm teaches calculating the preamble transmit power using the full path loss compensation, *i.e.*, the difference between the transmit power of a reference signal and the receive power at the user equipment of the reference signal. (Ex. 1002 ¶¶125-129). Because the entire estimated path loss of the reference signal is used to calculate the preamble power, the preamble power is computed using full path loss compensation. (Ex. 1002 ¶157).

***c. "sending from the transmitter on the access channel the first message and in response receiving at a receiver a second message that comprises an allocation of resources on which the third message is sent"***

Claims 2 and 11 also recite transmitting the first message on an access channel and in response receiving the second message that includes an allocation of resources that are used to transmit Message 3. The random access preamble of Qualcomm is sent on a random access channel (RACH). (Ex. 1003, 4:19-20 and 13:16-20). Qualcomm describes that an eNB responds to receiving a random access preamble by sending a random access response. (Ex. 1003, 6:16-18). This message can include "UL [uplink] resources" that "indicate resources granted to the UE for uplink transmission." (Ex. 1003, 6:26-27; *See also* TS 36.300, 10.1.5.1, p. 49 (initial UL grant)). Message 3 is an uplink transmission and these UL resources would be used to transmit Message 3. (TS 36.300, 10.1.5.1, p. 49 (transport blocks depends on the UL grant conveyed in step 2); Ex. 1002 ¶159). The uplink resources mentioned in Qualcomm are the same as those from TS 36.300. (Ex. 1002 ¶159). They are both received by the UE in a random access response message sent by an eNB that has successfully received a random access preamble from the UE. (*Id.*). While Qualcomm mentions that the uplink resources are "for uplink transmission," TS 36.300 specifically notes that one such uplink transmission is the transmission of Message 3. (TS 36.300, 10.1.5.1, p. 49; Ex. 1002 ¶159).

In addition, the AAPA discloses this limitation: "the UE transmits a **random access preamble** and expects a response from the eNB in the form of a so-called **Message 2** (e.g., Random Access Response at FIGS. 1B and 1C). Message 2 is transmitted on a DL [downlink] shared channel DL-SCH (PDSCH, the PDCCH) and **allocates resources** on an UL-SCH (PUSCH). The **resource allocation of Message 2** is addressed with an identity RA-RNTI that is associated with the frequency and time resources of a PRACH, but is common for different preamble sequences. The Message 2 contains **UL [uplink] allocations for the transmissions of a Message 3** in the UL (e.g., step 3 of the Contention Based Random Access Procedure at FIG. 1B)." (Ex. 1001, 2:27-38; emphasis added.)

***d. "after sending the third message, the method further comprises using the processor to compute an updated transmit power for the uplink shared channel using fractional power control and sending from the transmitter a subsequent message on the uplink shared channel using the updated transmit power"***

Claims 2 and 11 also recite that an updated transmit power for the uplink shared channel using fractional power control is computed and that a message after Message 3 is sent on the uplink shared channel using the updated transmit power. These limitations of Claims 2 and 11 are simply a verbal description of the TS 36.213 PUSCH transmit power function. (TS 36.213, 5.1.1.1, p. 8; Ex. 1002 ¶161). This function, also part of the AAPA of the '966 patent, is $P_{PUSCH}(i) = \min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{0\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(i))(TF(i)) + f(i)\}$ [dBm].

The term α, which can be a value less than 1, represents the fractional power control element. (Ex. 1002 ¶162). Fractional power control as used in the '966 patent is when some amount less than the entire estimated path loss is used. (Ex. 1001, 7:54-57 and 8:50-53; Ex. 1002 ¶162). The '966 patent admits that Equation [1], *i.e.,* the $P_{PUSCH}$ equation from TS 36.213, can use "fractional" path loss rather than "full path loss." (Ex. 1001, 7:47-53). The fractional component described in the prior art $P_{PUSCH}$ equation is $\alpha$. (Ex. 1002 ¶162). As α can be less than 1, $\alpha \cdot PL$ represents calculating the power for messages that are transmitted subsequent to Message 3 on the shared uplink channel, PUSCH, with a fractional power control. (*Id.*).

The $P_{PUSCH}$ equation in TS 36.213 describes the power used to transmit message on a shared uplink channel, PUSCH. (TS 36.213, 5.1.1.1; Ex. 1002, ¶163). Qualcomm, however, describes an enhancement to TS 36.213 where the transmit power of Message 3 is based on the preamble power, a power control correction, and a power offset, similar to Equation [5] of the '966 patent. (*Id.*) Qualcomm, however, is silent on the transmission power for messages sent after Message 3. (*Id.*) A POSITA would recognize, based at least on Qualcomm's disclosure, that the PUSCH formula as described in TS 36.213, would be used to calculate the transmit power for messages sent after Message 3. (*Id.*)

The techniques described in Qualcomm can be used in a 3GPP LTE system. (Ex. 1003, 3:3-10; Ex. 1002, ¶163). Further, Qualcomm relies on system access in LTE to explain the disclosed embodiments. (Ex. 1003, 3:12-14; Ex.1002, ¶163). Accordingly, specifications related to LTE would be highly relevant to anyone implementing the embodiments disclosed in Qualcomm. (Ex.1002, ¶163).

For example, to determine transmit power for uplink messages subsequently sent after Message 3 in an LTE system, a POSITA would turn to the 3GPP LTE documentation; specifically, a POSITA would reference the TS 36.213 and TS 36.300 specifications that describe the physical layer procedures and the power used to transmit messages over the physical layer. (Ex. 1002, ¶164). Using TS 36.213 to calculate the transmission power for messages sent after Message 3 would ensure that the UE operated consistently with TS 36.213. (Ex. 1002, ¶164). Further, TS 36.300 simply makes explicit what is implied in Qualcomm. The uplink resources that are granted to the user equipment as described in Qualcomm are used in transmitting Message 3. (Ex. 1005, p. 49; Ex. 1003, 6:26-27; Ex. 1002, ¶164). Qualcomm and TS 36.300 are consistent in that the uplink resources are received by the user equipment in a random access response. (*Id.*). While Qualcomm only notes that the uplink resources are "for uplink transmission," TS 36.300 makes explicit that the uplink resources are used in transmitting Message 3. (*Id.*).

Qualcomm describes that its disclosed inventions can be used in an LTE system. (Ex. 1003, 3:3-10; Ex. 1002, ¶165). Further, Qualcomm relies on LTE terminology and examples in describing the disclosed inventions. (Ex. 1003, 3:10-14). Because Qualcomm is silent on how to calculate the transmit power for messages after Message 3, a POSITA would have to look to other sources for calculating the transmit power for subsequent messages. (Ex. 1002, ¶165). A POSITA would naturally turn to the 3GPP specifications for an LTE system. Combining the transmit power calculation of Message 3 with the transmit power for subsequent messages described in the LTE specifications would be obvious to a POSITA. (*Id.*) The teachings of Qualcomm combined with the teachings of TS 36.213 and TS 36.300 allow user equipment to "efficiently transmit the random access preamble and signaling for system access," while maintaining compatibility with the LTE standards such as TS 36.213 and TS 36.300. (Ex. 1003, 1:45-47; Ex. 1002, ¶165). Such a combination, therefore, would be obvious to a POSITA in creating a more efficient random access signaling that is compliant with the LTE specifications. (Ex. 1002, ¶165).

In addition, the AAPA discloses that "RACH preambles are transmitted by the UEs using a **full path-loss compensation PC** formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. *** However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." (Ex. 1001, 2:39-49; emphasis added.)

Claim 11 is an apparatus claim that includes the same features as Claim 2. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 2 and 11 are obvious in view of Qualcomm, TS 36.213, and TS 36.300. *See also* Ex. 1002, Appendix B.

**Ground C. Qualcomm (Ex. 1003), TS 36.213 (Ex. 1004), TS 36.300 (Ex. 1005) and the Qualcomm-386 (Ex. 1007) Render Obvious, Under 35 U.S.C. § 103, Claims 5-8 and 14-17.**

**1. Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386 render dependent claims 5 and 14 obvious.**

Although different in scope, Claims 5 and 14 include similar features. Claims 5 and 14 recite a specific function, *i.e.,* Equation [5] for calculating the transmit power for Message 3 (Ex. 1001, 8:15-17):

**Equation [5]:** $P_{Msg3} = \min\{P_{max}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$.

**"$P_{max}$"**

$P_{max}$ refers to "the maximum allowed power that depends on the UE power class." (Ex. 1001, 4:35-36). The idea of ensuring that the Message 3 transmit power does not exceed $P_{max}$ is well known in the telecommunications world. (Ex. 1002, ¶167). As one example, TS 36.213 includes a similar check to ensure that the transmit power cannot exceed $P_{max}$. (Ex. 1001, Equation [1]; Ex. 1004, §5.1.1.1).

**"$\Delta_{TF}$(TF(i))"**

The AAPA and TS 36.213 power control formula disclose the parameters 10 log10($M_{PUSCH}$(i)) and $\Delta_{TF}$(TF(i)). (Ex. 1001, Equation [1]; Ex. 1004, §5.1.1.1). As noted by TS 36.213 and acknowledged by the '966 patent, $\Delta_{TF}$(TF(i)) can be equal to zero. (Ex. 1001, 4:54-56). This effectively removes $\Delta_{TF}$(TF(i)) from the Equation [5] of the '966 patent. The claimed formula, therefore, can be rewritten as

**Modified Equation [5]**: $P_{Msg3} = \min\{P_{max}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log_{10}(M_{PUSCH}(i))\}$.

As detailed below, the disclosures of Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386 teach the claimed $P_{Msg3}$ formula in Equation [5] of the '966 patent.

**"$P_{preamble}$"**

Equation (4) of Qualcomm teaches the transmit power of Message 3 (PUSCH_power) is calculated based on RACH_power parameter, which is transmit power of a successfully received random access preamble. (Ex. 1003, 10:12-13; Ex. 1002, ¶170). This RACH_power parameter is the same as the claimed $P_{preamble}$. (Ex. 1001, 6:18-21; Ex. 1002, ¶170).

**"$\Delta_{PC\_Msg3}$"**

The '966 patent Equation [5] includes parameter $\Delta_{PC\_Msg3}$, which "is the power control command included in the preamble response (*e.g.*, Message 2)." (Ex. 1001, 8:32-35). Similarly, the parameter PC_correction used in Qualcomm's Equation (4) "is the PC correction received in the random access response." (Ex. 1003, 10:16-17; Ex. 1002, ¶170). Accordingly, the PC_correction parameter of Qualcomm is the same as the $\Delta_{PC\_Msg3}$ parameter. (Ex. 1002, ¶170).

**"$\Delta_{0,preamble\_Msg3}$"**

The '966 patent Equation [5] includes parameter $\Delta_{0,preambie\_Msg3}$ which is "an offset from the preamble power" (claim 5) and "corresponds to a typical power offset between a Message 3 and the preamble whose power corresponds to the detection threshold." (Ex. 1001, 8:26-28). The parameter PUSCH_RACH_power_offset used in Qualcomm's Equation (4) "is a power offset between the PUSCH and RACH." (Ex. 1003, 10:18-19). The random access preamble is sent on a random access channel (RACH). (Ex. 1003, 4:19-20; 4:3841; and 6:14-15). PUSCH is a physical uplink shared channel and is used to transmit Message 3. (Ex. 1003, 4:24-25, 10:14-15). Thus, PUSCH_RACH_power_offset as used in Qualcomm corresponds to a power offset between a message sent on a PUSCH, *e.g.,* Message 3, and a power used to transmit a successful random access preamble. (Ex. 1002, ¶172). Accordingly, the parameter

PUSCH_RACH_power_offset in Qualcomm is the same as the claimed parameter $\Delta_{0,preamble\_Msg3}$. (*Id.*).

**"$10\log_{10}(M_{PUSCH}(i))$"**

Equation (4) from Qualcomm does not expressly include the $10\log_{10}(M_{PUSCH}(i))$ expression. The $10\log_{10}(M_{PUSCH}(i))$ expression, however, is still present in Equation (4) as part of the PC_correction parameter.

As noted above, the AAPA and TS 36.213 power control formula disclose the parameters $10\log10(M_{PUSCH}(i))$. (Ex. 1001, Equation [1]; Ex. 1004, §5.1.1.1). The expression $10\log_{10}(M_{PUSCH}(i))$ describes the "size of the PUSCH resource assignment expressed in number of resources blocks valid for subframe *i*." (Ex. 1001, 4:37-39). This means that the transmit power is determined based on the number of resources that the user equipment will use to transmit data. (Ex. 1002, ¶174). A POSITA would recognize that transmit power goes up as the number of resources is increased. (*Id.*) Accordingly, transmit power calculations in LTE will take into account the number of resources that the UE will use to transmit data. (*Id.*) One way the transmit resources can be used in power calculations is by the UE incorporating these resources in its power calculations. (*Id.*) This is how PUSCH power calculations are done in TS 36.213. (Ex. 1004, §5.1.1.1, p. 8). Alternatively, the eNB determines the resources to grant to the user equipment and sends the uplink grant to the user equipment in a random access response. (Ex. 1005, §10.1.5.1, p. 49; Ex. 1002, ¶174). The eNB, therefore, knows the uplink resources that the user equipment will use to transmit data to the eNB.

In the random access response, the eNB can also modify the transmit power used by the UE to transmit a message through various mechanisms, such as the power control correction value. *(See* Ex. 1003, 10:16-17; Ex. 1002, ¶175). The eNB can take into account the uplink resources granted to the user equipment in determining the power control correction value. (*See*, Ex. 1007, ¶¶[0057]-[0067]; Ex. 1002, ¶175). Incorporating the uplink resources in the calculation of the power control correction value has the same effect as the user equipment adjusting its transmit power based on the granted uplink resources. (Ex. 1002, ¶175). That effect is the transmit power of messages sent on the PUSCH is adjusted based on the uplink resources granted to the user equipment. (*Id.*) Thus, calculating, at the eNB, the transmit power adjustment due to the granted resources yields the predictable results of the user equipment's transmit power being adjusted due to the granted resources. (*Id.*) The eNB knows of the resources granted to the UE and the eNB transmits a power control correction value to the UE. (*Id.*) It is simply a design choice as to where the granted resources are used to adjust the transmit power. (*Id.*)

Qualcomm-386, whose inventors are the same as the Qualcomm reference, describes such a system where the eNB's power control adjustment can take into account the uplink resources granted to UE. (Ex. 1002, ¶176). In Qualcomm-386, UE can calculate a power headroom or buffer size values that can be sent to the eNB as part of the random access preamble. (Ex. 1007, ¶¶[0036] and [0040]-[0041]; Ex. 1002, ¶176). These values can be used to calculate both the uplink resource grant and the power control information. (Ex. 1007, ¶¶[0108], [0112], and [0118]; Ex. 1002, ¶176).

As noted above, as resources required to transmit a message increase, *e.g.*, the larger the message, so does the power requirements to transmit that message. (Ex. 1002, ¶177). When UE uses more power, power control becomes more critical as increasing the transmit power can cause more interference with other user equipment and/or eNBs. (*Id.*) This is why Qualcomm-386 notes that the benefits of power control are greater when Message 3 is large. (Ex. 1007, ¶[0100]; Ex. 1002, ¶177). As the benefits of power control are greater when Message 3 is large, Qualcomm-386 teaches that the power control information takes into account the granted uplink resources, via the buffer size information. (Ex. 1007, ¶¶[0108], [0112], and [0118]; Ex. 1002, ¶177).

The combination of relied upon teachings of Qualcomm-386 with the features of Qualcomm and TS 36.213 would have been obvious to a POSITA. (Ex. 1002, ¶178). First, all three references are related to the same technical subject, *e.g.,* LTE system access. (*Id.*) These references also focus on the same system access messaging used to access an LTE system. (*Id.*) The Qualcomm power control function, *e.g.*, Equation (4), includes an adjustment based on power control information received from the eNB but does not expressly include a parameter that depends on the uplink granted resources. (*Id.*) However, as noted in Qualcomm-386 the benefits of power control are greater when Message 3 is large. (*Id.*) Further, the power control information described in Qualcomm-386 takes into account the resources granted to the UE. (*Id.*) A POSITA would find the combination of using the power control information described in Qualcomm-386 with the teachings of Qualcomm to be obvious. (*Id.*) Specifically, a POSITA would use power control information from Qualcomm-386 to take into account the uplink resource grant in calculating the transmit power for Message 3. (*Id.*) Further, a POSITA would recognize the ability to use the uplink resources to adjust the PUSCH transmit power based on TS 36.213. (TS 36.213 5.1.1.1, p. 8; Ex. 1002, ¶178). Qualcomm-386 is consistent with TS 36.213 for the same reasons as Qualcomm because Qualcomm-386 describes a way UE can access an LTE system. (Ex. 1002, ¶178). Accordingly, a POSITA would find it obvious to combine the teachings from LTE specifications, e.g., TS 36.213 and TS 36.300, to ensure compatibility with LTE. (*Id.*).

In addition, a POSITA having the knowledge of Equation (4) of Qualcomm, which teaches the transmit power of Message 3 (PUSCH_power) can be calculated based on the preamble power, a power control correction, and a power offset from the preamble power, would find it obvious to derive Equation [5] based on

Equation [1] of the '966 patent, which is reproduced from the admitted prior art TS 36.213. (Ex. 1002 ¶¶179-186).

Claim 14 is an apparatus claim that includes the same features as Claim 5. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 5 and 14 are obvious in view of Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386. (Ex. 1002, §178; *see also* Ex. 1002, Appendix B).

**2. Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386 render dependent claims 6 and 15 obvious.**

Although different in scope, Claims 6 and 15 include similar features. Claims 6 and 15 recite features which are part of AAPA relating to existing random access procedure that is disclosed in LTE specifications, e.g., TS 36.213. (Ex. 1002, ¶187). Specifically, the equation recited in Claims 6 and 15 is identical to Equation [1] of the '966 patent, which is reproduced from existing 3GPP specification TS 36.213. (Ex. 1001, 4:28-5:35; Ex. 1004, §5.1.1.1; Ex. 1002, ¶187).

As described above in regard to Claim 2, Qualcomm only describes calculating the transmission power for the claimed Message 3. Qualcomm does not describe the transmit power for subsequent messages. TS 36.213, however, provides a formula used to calculate this power. As described above, a POSITA would have found obvious the combination of the teachings regarding the transmit power for Message 3 with TS 36.213 for calculating the transmit power for subsequent message. (Ex. 1002, ¶¶162-165). Further, the variable α in TS 36.213 provides for fractional power control and is determined by signaling. (Ex.1002, ¶162).

The '966 patent also admits that existing random access procedure discloses "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula. *** However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." (Ex. 1001, 2:39-49; emphasis added.)

Claim 15 is an apparatus claim that includes the same features as Claim 6. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 6 and 15 are obvious in view of Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386. (Ex. 1002, §178).

### 3. Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386 render dependent claims 7 and 16 obvious.

Although different in scope, Claims 7 and 16 include similar features. Specifically, Claims 7 and 16 further narrow Claims 6 and 15 by setting $\alpha = 1$ for the transmission of Message 3 and all retransmissions of Message 3, and setting $\alpha < 1$ for all subsequent messages and retransmissions of Message 3. (Ex. 1002,

¶192). As Claims 7 and 16 recite that retransmissions of Message 3 can be sent using both an $\alpha = 1$ and $\alpha < 1$, a POSITA would understand these claims to mean that Message 3 can be retransmitted with either $\alpha$ value and that the transmit power will reflect either full path loss compensation, *i.e.,* $\alpha = 1$, or a fractional path loss compensation, *i.e.*, $\alpha < 1$. (Ex. 1002, ¶193).

As discussed above with regard to claim 1, Qualcomm teaches using the full path loss compensation for calculating the Message 3 transmit power. (Ex. 1002, 8:37-40, 10:1-19; Ex. 1002 ¶¶125-129). The Message 3 transmit power therefore indicates a full path loss compensation. (Ex. 1002 ¶194). In addition, this power would be used for all retransmissions of Message 3. (*Id.*). For messages subsequent to the initial transmission of Message 3, the formula from TS 36.213 is used, which includes $\alpha < 1$or $\alpha = 1$. (Ex. 1004, §5.1.1.1, p. 8). This formula would also be used for calculating retransmissions of messages after Message 3. (Ex. 1002 ¶195). As described above, combining these teachings together would have been obvious to a POSITA. (Ex. 1002 ¶¶163-165).

Claim 16 is an apparatus claim that includes the same features as Claim 7. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 7 and 16 are obvious in view of Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386. (Ex. 1002, §178).

### 4. Qualcomm, TS 36.213, TS 36.300, and Qualcomm-386 render dependent claims 8 and 17 obvious.

Although different in scope, Claims 8 and 17 include similar features. Dependent claims 8 and 17 further narrow Message 3 to include an indication of a power difference between the initial transmit power using full path loss compensation and a fractional path loss computation of the initial transmit power.

TS 36.213 provides one example of a fractional path loss computation for transmit power on a shared uplink channel, which is also claimed in Claim 6 as discussed above. (Ex. 1002, ¶198). The '966 patent acknowledges that a transmit power calculated from the TS 36.213 Equation is computed using fractional path loss. (Ex. 1001, 8:51-53). In some cases, the fractional path loss transmit power will simply be the maximum allowed power for the user equipment. (Ex. 1004, §5.1.1.1, 8; Ex.1002, ¶198).

Qualcomm-386 teaches sending a power headroom value in Message 3. (Ex. 1007, ¶[0097]). The power headroom can indicate "the difference between the maximum transmit power at the UE and the transmit power used for the first message." (Ex. 1007, ¶[0108]). Thus, the power headroom indicates the difference between the transmit power of Message 3 that is based on full path loss compensation, *i.e.,* the PUSCH power formula from Qualcomm, and a value that corresponds with the TS 36.213 equation, which is the fractional path loss compensation of the initial transmit power. (Ex. 1002, ¶199). Further, as described above the initial transmit power of Message 3, *e.g*., the first message sent after a successful random access preamble, is calculated using full pass loss compensation, i.e., based upon the entire estimated path loss. (Ex. 1002, ¶¶125-129; Ex. 1003, 8:37-39).

Claim 17 is an apparatus claim that includes the same features as Claim 8. Qualcomm discloses that its disclosed embodiments can be implemented on "electronic hardware, computer software, or a combination of both." (Ex. 1003, 14:6-10). Thus, Claims 6 and 17 are obvious in view of Qualcomm, TS 36.213, TS 36.300, and the Qualcomm-386. (Ex. 1002, §178; *see also* Ex. 1002, Appendix B).

## IX. CONCLUSION

For the foregoing reasons, Petitioner requests institution of *Inter Partes* Review, and cancellation of claims 1-17 of the '966 patent.

Dated: May 30, 2017

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***Counsel for Petitioners***

## CERTIFICATE OF WORD COUNT

The undersigned hereby certifies that the foregoing Petition complies with the requirements of 37 C.F.R. § 42.24 and contains 10,625 words, excluding those contained in the following: Table of Contents, List of Exhibits, Mandatory Notices, Certificate of Word Count, and Certificate of Service.

/Steven A. Moore/ .
Steven A. Moore, Reg. No. 55,462

## CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on the 30th of May, 2017, a complete and entire copy of this Petition for *Inter Partes* Review, and all supporting exhibits, were served via FEDERAL EXPRESS to the Patent Owner by serving the correspondence address of record, as indicated below:

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US008385966B2

(12) **United States Patent**
Lindholm et al.

(10) **Patent No.: US 8,385,966 B2**
(45) **Date of Patent: Feb. 26, 2013**

(54) **METHOD, APPARATUS AND COMPUTER PROGRAM FOR POWER CONTROL RELATED TO RANDOM ACCESS PROCEDURES**

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(73) Assignee: **Nokia Siemens Networks Oy**, Espoo (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 587 days.

(21) Appl. No.: **12/387,661**

(22) Filed: **May 5, 2009**

(65) **Prior Publication Data**

US 2009/0286566 A1 Nov. 19, 2009

**Related U.S. Application Data**

(60) Provisional application No. 61/126,617, filed on May 5, 2008.

(51) **Int. Cl.**
*H04B 7/00* (2006.01)

(52) **U.S. Cl.** ........................................ **455/522**; 455/521

(58) **Field of Classification Search** ........................ None
See application file for complete search history.

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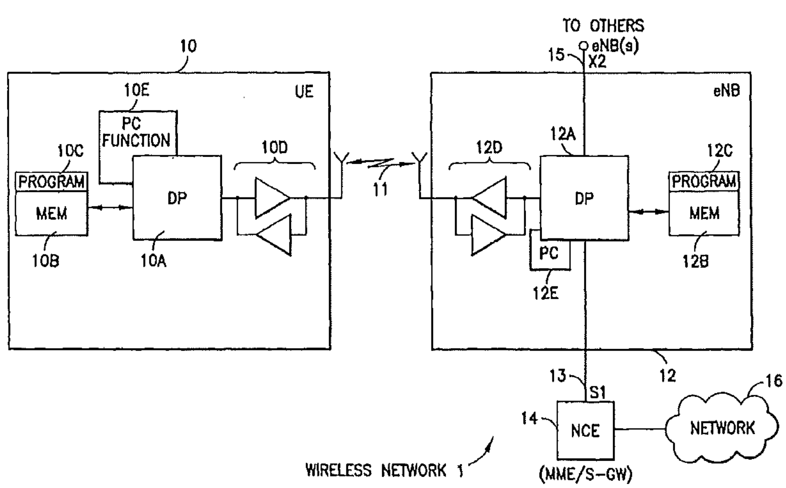
(74) *Attorney, Agent, or Firm* — Harrington & Smith

(57) **ABSTRACT**

A first power control adjustment state g(i) and a second power control adjustment state f(i) are initialized for i=0 to each reflect an open loop power control error. An initial transmit power for a shared uplink channel is computed using full pathloss compensation. The computed initial transmit power depends on a preamble power of a first message sent on an access channel, and the initial transmit power is initialized with the second power control adjustment state f(0). A third message is sent from a transmitter on an uplink shared channel at the initial transmit power. In various implementations, the power for i=0 on the uplink control channel is also initialized similar to the initial transmit power for the third message and using full pathloss compensation, and after the third message (and retransmissions of it), subsequent messages sent on the uplink shared channel are sent at a power that is computed using fractional pathloss compensation.

**17 Claims, 5 Drawing Sheets**




Δ π EXHIBIT 1001
Deponent Akl
Date 2.15.18 Rptr SK
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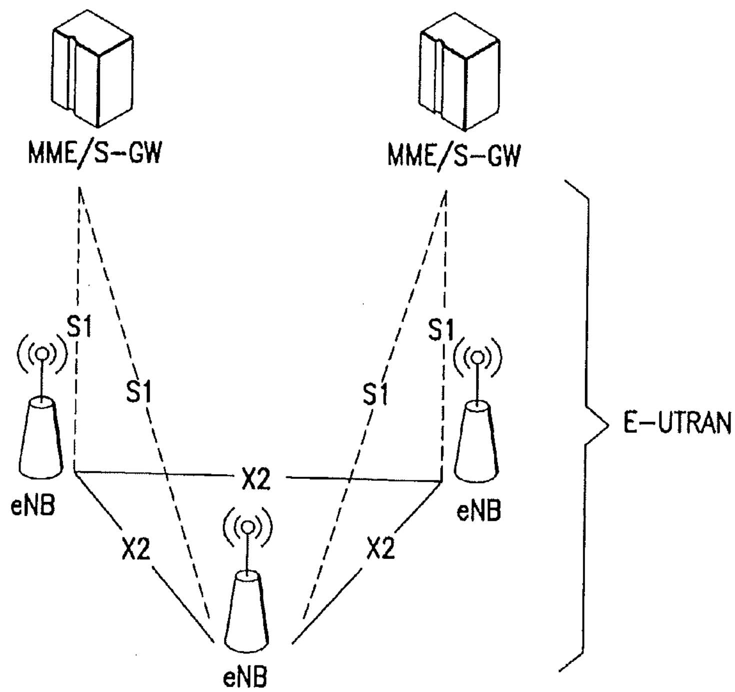


FIG. 1A
PRIOR ART

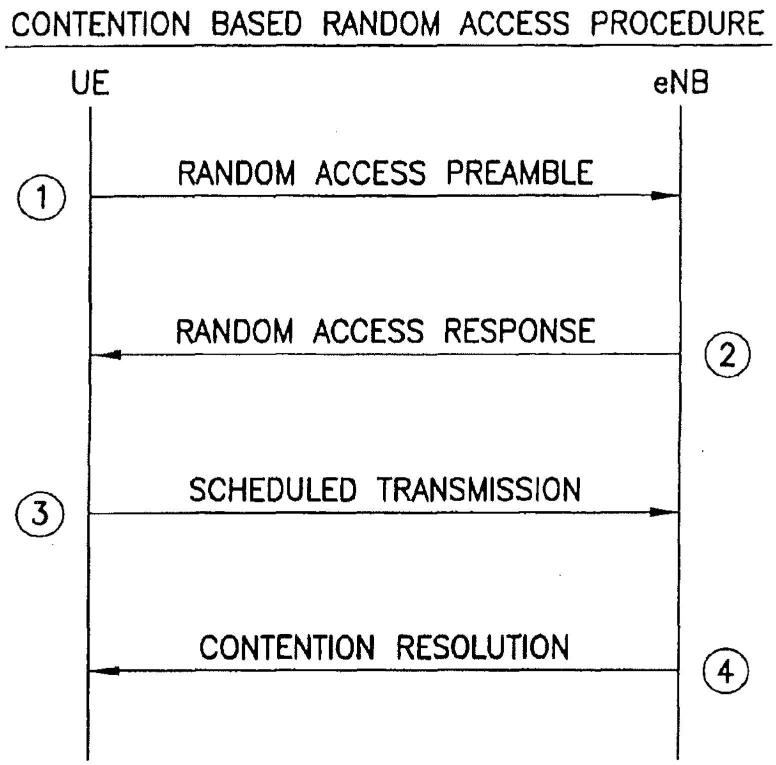


FIG. 1B
PRIOR ART

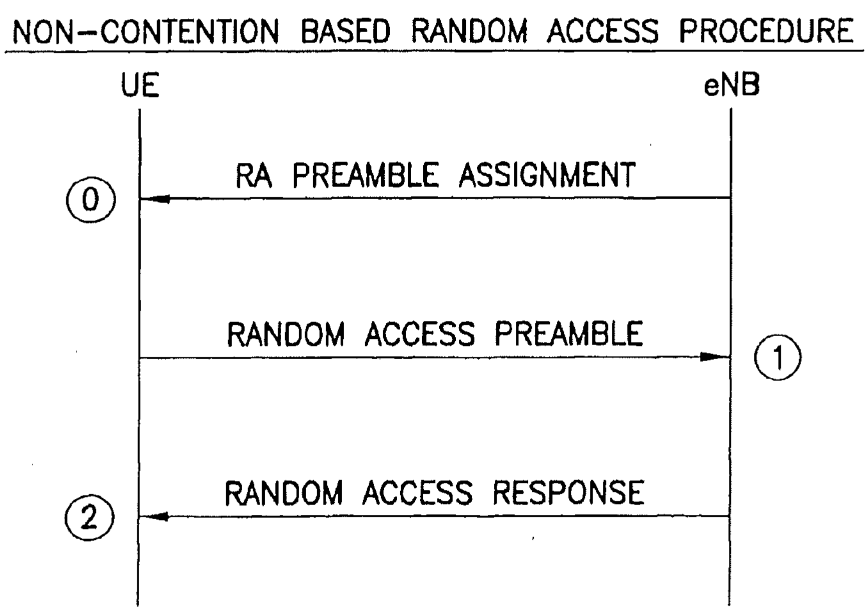


FIG. 1C
PRIOR ART

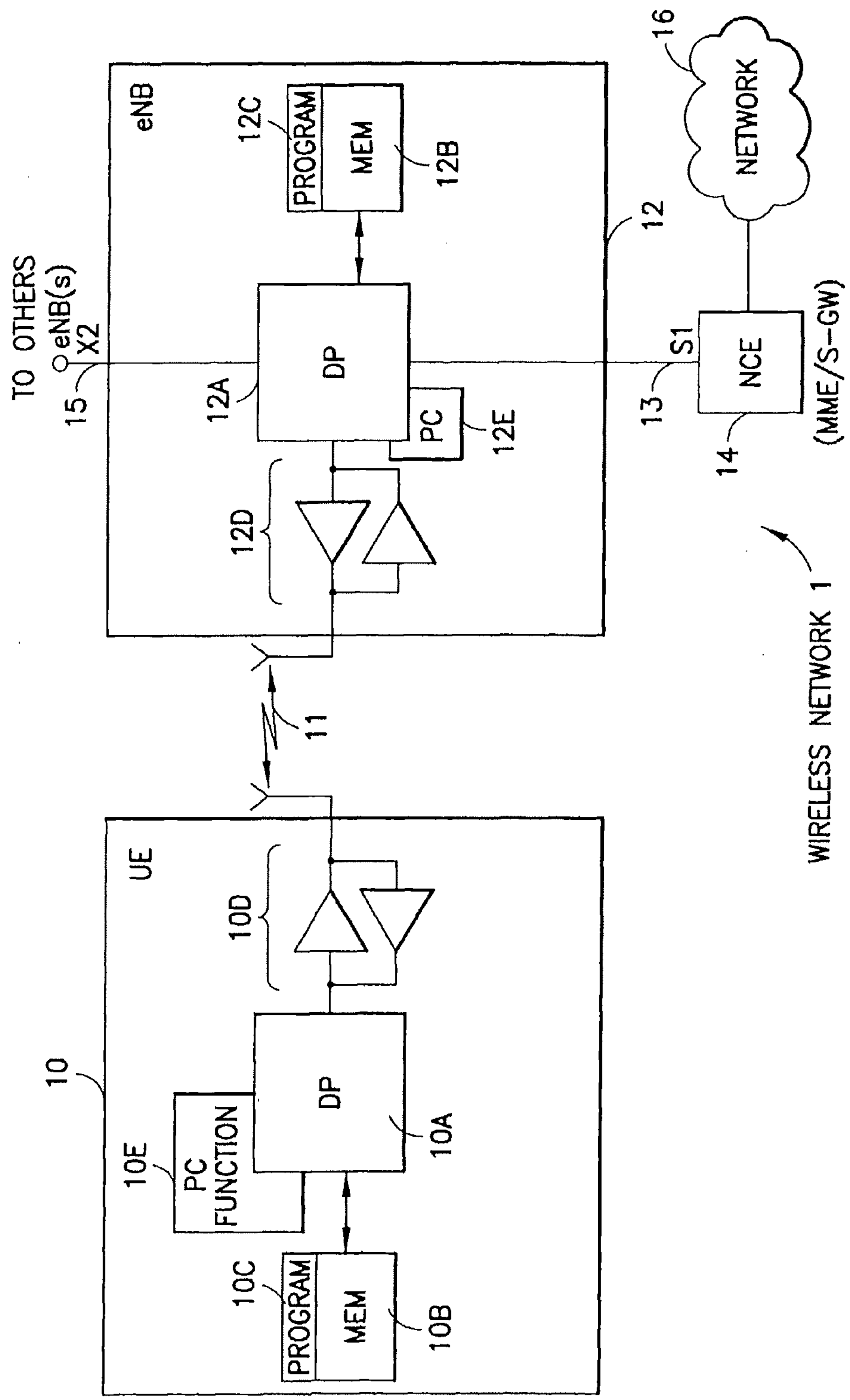
TO OTHERS
eNB(s)
X2
15
eNB
12C
PROGRAM
MEM
12B
12
16
NETWORK
12A
DP
PC
12E
13
S1
NCE
14
(MME/S-GW)
12D
11
WIRELESS NETWORK 1
10
UE
10D
DP
10A
10E
PC
FUNCTION
10C
PROGRAM
MEM
10B

FIG.2

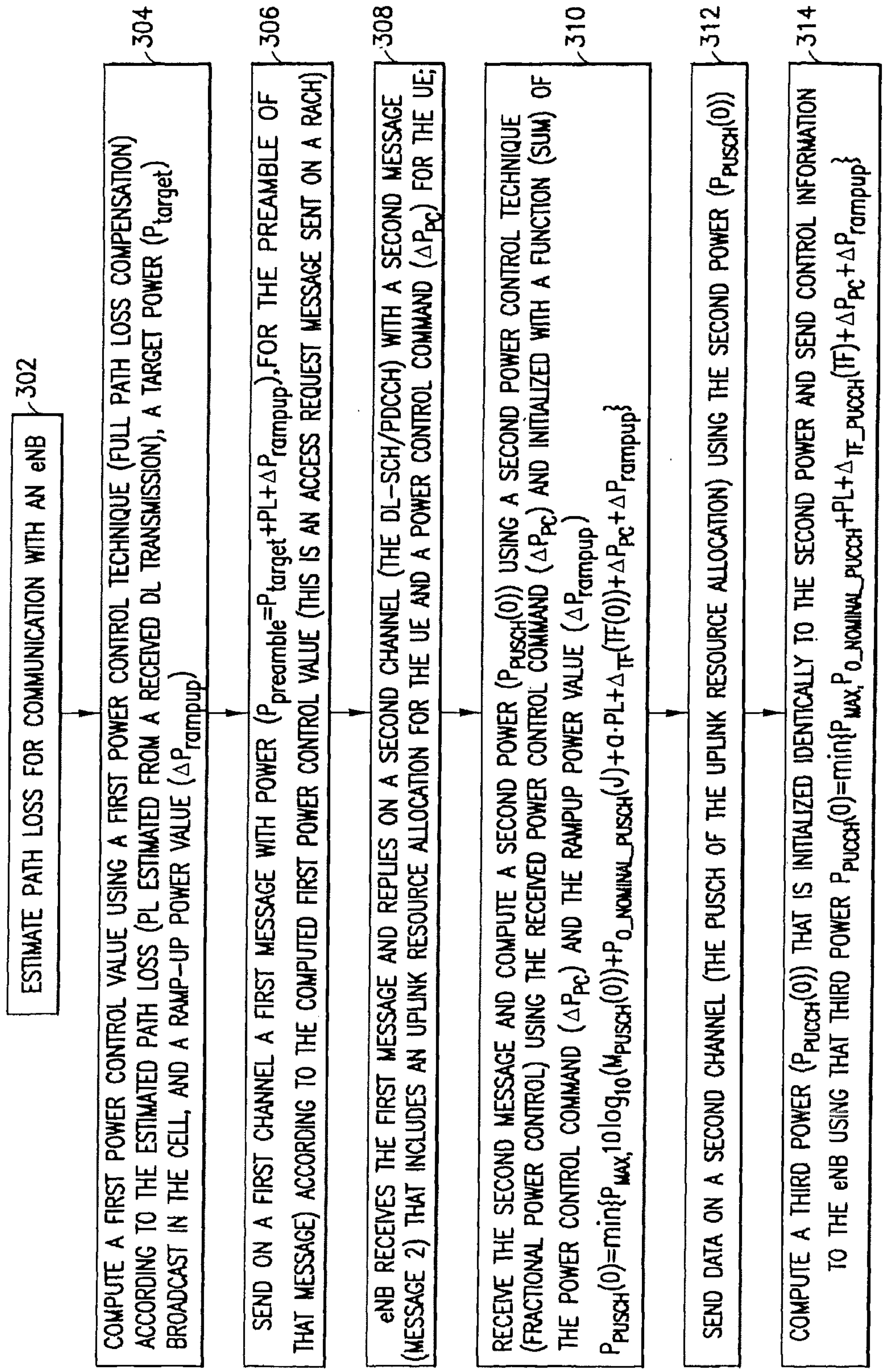
ESTIMATE PATH LOSS FOR COMMUNICATION WITH AN eNB
302
COMPUTE A FIRST POWER CONTROL VALUE USING A FIRST POWER CONTROL TECHNIQUE (FULL PATH LOSS COMPENSATION) ACCORDING TO THE ESTIMATED PATH LOSS (PL ESTIMATED FROM A RECEIVED DL TRANSMISSION), A TARGET POWER ($P_{target}$) BROADCAST IN THE CELL, AND A RAMP-UP POWER VALUE ($\Delta P_{rampup}$)
304
SEND ON A FIRST CHANNEL A FIRST MESSAGE WITH POWER ($P_{preamble}=P_{target}+PL+\Delta P_{rampup}$),FOR THE PREAMBLE OF THAT MESSAGE) ACCORDING TO THE COMPUTED FIRST POWER CONTROL VALUE (THIS IS AN ACCESS REQUEST MESSAGE SENT ON A RACH)
306
eNB RECEIVES THE FIRST MESSAGE AND REPLIES ON A SECOND CHANNEL (THE DL-SCH/PDCCH) WITH A SECOND MESSAGE (MESSAGE 2) THAT INCLUDES AN UPLINK RESOURCE ALLOCATION FOR THE UE AND A POWER CONTROL COMMAND ($\Delta P_{PC}$) FOR THE UE;
308
RECEIVE THE SECOND MESSAGE AND COMPUTE A SECOND POWER ($P_{PUSCH}(0)$) USING A SECOND POWER CONTROL TECHNIQUE (FRACTIONAL POWER CONTROL) USING THE RECEIVED POWER CONTROL COMMAND ($\Delta P_{PC}$) AND INITIALIZED WITH A FUNCTION (SUM) OF THE POWER CONTROL COMMAND ($\Delta P_{PC}$) AND THE RAMPUP POWER VALUE ($\Delta P_{rampup}$)
$P_{PUSCH}(0)=\min\{P_{MAX,}10\log_{10}(M_{PUSCH}(0))+P_{O\_NOMINAL\_PUSCH}(J)+\alpha\cdot PL+\Delta_{TF}(TF(0))+\Delta P_{PC}+\Delta P_{rampup}\}$
310
SEND DATA ON A SECOND CHANNEL (THE PUSCH OF THE UPLINK RESOURCE ALLOCATION) USING THE SECOND POWER ($P_{PUSCH}(0)$)
312
COMPUTE A THIRD POWER ($P_{PUCCH}(0)$) THAT IS INITIALIZED IDENTICALLY TO THE SECOND POWER AND SEND CONTROL INFORMATION TO THE eNB USING THAT THIRD POWER $P_{PUCCH}(0)=\min\{P_{MAX,}P_{O\_NOMINAL\_PUCCH}+PL+\Delta_{TF\_PUCCH}(TF)+\Delta P_{PC}+\Delta P_{rampup}\}$
314

FIG.3

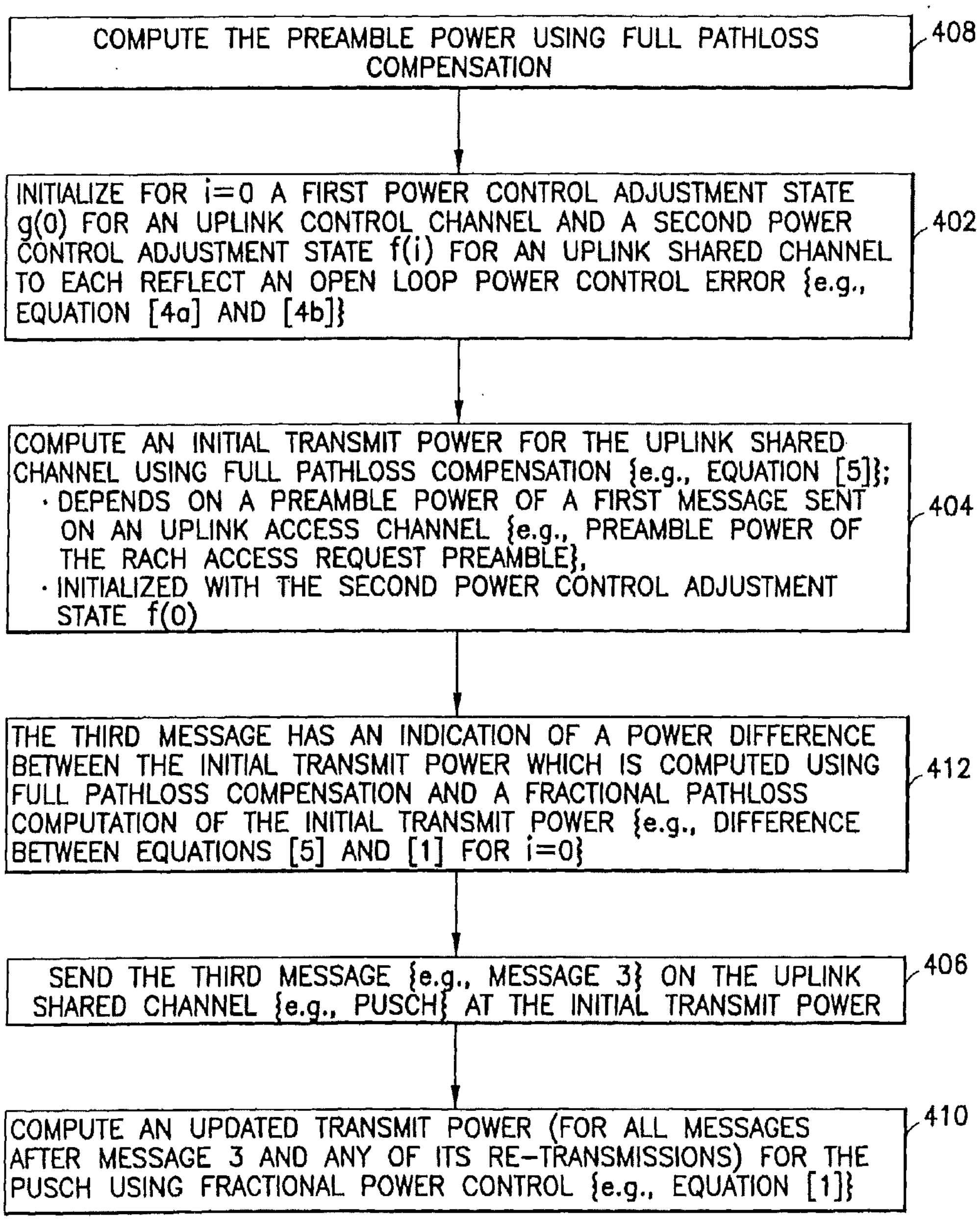
COMPUTE THE PREAMBLE POWER USING FULL PATHLOSS COMPENSATION
408
INITIALIZE FOR i=0 A FIRST POWER CONTROL ADJUSTMENT STATE g(0) FOR AN UPLINK CONTROL CHANNEL AND A SECOND POWER CONTROL ADJUSTMENT STATE f(i) FOR AN UPLINK SHARED CHANNEL TO EACH REFLECT AN OPEN LOOP POWER CONTROL ERROR {e.g., EQUATION [4a] AND [4b]}
402
COMPUTE AN INITIAL TRANSMIT POWER FOR THE UPLINK SHARED CHANNEL USING FULL PATHLOSS COMPENSATION {e.g., EQUATION [5]};
· DEPENDS ON A PREAMBLE POWER OF A FIRST MESSAGE SENT ON AN UPLINK ACCESS CHANNEL {e.g., PREAMBLE POWER OF THE RACH ACCESS REQUEST PREAMBLE},
· INITIALIZED WITH THE SECOND POWER CONTROL ADJUSTMENT STATE f(0)
404
THE THIRD MESSAGE HAS AN INDICATION OF A POWER DIFFERENCE BETWEEN THE INITIAL TRANSMIT POWER WHICH IS COMPUTED USING FULL PATHLOSS COMPENSATION AND A FRACTIONAL PATHLOSS COMPUTATION OF THE INITIAL TRANSMIT POWER {e.g., DIFFERENCE BETWEEN EQUATIONS [5] AND [1] FOR i=0}
412
SEND THE THIRD MESSAGE {e.g., MESSAGE 3} ON THE UPLINK SHARED CHANNEL {e.g., PUSCH} AT THE INITIAL TRANSMIT POWER
406
COMPUTE AN UPDATED TRANSMIT POWER (FOR ALL MESSAGES AFTER MESSAGE 3 AND ANY OF ITS RE-TRANSMISSIONS) FOR THE PUSCH USING FRACTIONAL POWER CONTROL {e.g., EQUATION [1]}
410

FIG.4

# METHOD, APPARATUS AND COMPUTER PROGRAM FOR POWER CONTROL RELATED TO RANDOM ACCESS PROCEDURES

## CROSS-REFERENCE TO RELATED APPLICATION

This patent application claims priority under 35 U.S.C. §119(e) from U.S. Provisional Patent Application No. 61/126,617, filed May 5, 2008, which is hereby incorporated by reference herein in its entirety, including Exhibits.

## TECHNICAL FIELD

The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs and, more specifically, relate to techniques for power control on different uplink messages sent from a communication device.

## BACKGROUND

Various abbreviations that appear in the specification and/or in the drawing figures are defined as follows:

3GPP third generation partnership project
DL downlink
DRX discontinuous reception
eNB EUTRAN Node B (evolved Node B)
EUTRAN evolved UTRAN (also referred to as LTE)
LTE long term evolution
MAC medium access control
MME mobility management entity
Node B base station
OFDMA orthogonal frequency division multiple access
PC power control
PDCCH physical downlink control channel
PDCP packet data convergence protocol
PDSCH physical downlink shared channel
PHY physical
PL path loss
PRACH physical random access channel
PUSCH physical uplink shared channel
RACH random access channel
RA-RNTI random access radio network temporary identifier
RLC radio link control
RRC radio resource control
SC-FDMA single carrier, frequency division multiple access
TA timing advance
UE user equipment
UL uplink
UTRAN universal terrestrial radio access network

A proposed communication system known as evolved UTRAN (E-UTRAN, also referred to as UTRAN-LTE, E-UTRA or 3.9 G) is currently under development within the 3GPP. The current working assumption is that the DL access technique will be OFDMA, and the UL access technique will be SC-FDMA.

One specification of interest to these and other issues related to the invention is 3GPP TS 36.300, V8.4.0 (2008-03), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Access Network (E-UTRAN); Overall description; Stage 2 (Release 8).

FIG. 1A reproduces FIG. 4-1 of 3GPP TS 36.300, and shows the overall architecture of the E-UTRAN system. The E-UTRAN system includes eNBs, providing the E-UTRA user plane (PDCP/RLC/MAC/PHY) and control plane (RRC) protocol terminations towards the UE. The eNBs are interconnected with each other by means of an X2 interface. The eNBs are also connected by means of an S1 interface to an EPC, more specifically to a MME (Mobility Management Entity) by means of a S1-MME interface and to a Serving Gateway (S-GW) by means of a S1-U interface. The S1 interface supports a many-to-many relation between MMEs/Serving Gateways and eNBs.

Reference can also be made to 3GPP TS 36.321, V8.0.0 (2007-12), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification (Release 8).

Also of interest herein are the random access procedures of the LTE (E-UTRA) system. These procedures are described in 3GPP TS 36.300 v.8.4.0 at section 10.1.5 (attached to the priority document as Exhibit A), shown at FIG. 1B for the Contention Based Random Access Procedure and at FIG. 1C for the Non-Contention Based Random Access Procedure. These respectively reproduce FIGS. **10.1.5.1-1** and **10.1.5.1-2** of 3GPP TS 36.300 v.8.4.0, and Exhibit A of the priority document details the various steps shown.

Briefly, the UE transmits a random access preamble and expects a response from the eNB in the form of a so-called Message 2 (e.g., Random Access Response at FIGS. 1B and 1C). Message 2 is transmitted on a DL shared channel DL-SCH (PDSCH, the PDCCH) and allocates resources on an UL-SCH (PUSCH). The resource allocation of Message 2 is addressed with an identity RA-RNTI that is associated with the frequency and time resources of a PRACH, but is common for different preamble sequences. The Message 2 contains UL allocations for the transmissions of a Message 3 in the UL (e.g., step 3 of the Contention Based Random Access Procedure at FIG. 1B).

RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. This is needed because several simultaneous preamble transmissions can take place in the same PRACH resource and in order to detect them, their power at the eNB needs to be roughly the same to avoid the well-known near-far problem for spread spectrum transmissions. However subsequent uplink transmissions on the PUSCH are orthogonal, and so called fractional power control can be used. This allows higher transmit TX powers for UEs that are near the eNB because interference that those UEs generate to neighbor cells is small as compared to cell edge UEs. This method allows higher average uplink bit rates on the PUSCH.

In general, the eNB does not know what is the path-loss value used by the UE in its full PL compensation PC formula used for the UE's RACH message. In the case of a UE being handed-over from another eNB, an estimate of the path-loss value could be provided to the target cell/eNB based on UE measurement reports sent to the serving eNB prior to the handover. However, for an initial access or for UL or DL data arrival this is not possible since there is no handover. Because of this, the eNB does not know the power difference between the UE's RACH preamble transmission and the UE's transmission using the PUSCH power formula.

It has been agreed that Message 2 contains a power control command for transmission of Message 3, but the definition and objective of that command is not yet specified. Therefore the eNB does not have sufficient information to give a correct power control command in response to the UE's RACH message. The result then, and as mentioned above, is that the power that the UE uses for transmission of Message 3 is not known to the eNB if the UE uses the PUSCH PC formula for sending Message 3.

The problem therefore may be stated as how best to define a transition from the full path loss compensated preamble transmission to the PUSCH (fractional) power control system.

## SUMMARY

In accordance with an exemplary embodiment of the invention is a method that comprises using a processor to initialize for i=0 a first power control adjustment state g(0) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error; using the processor to compute an initial transmit power for the uplink shared channel using full pathloss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel, and is initialized with the second power control adjustment state f(0); and sending from a transmitter a third message on the uplink shared channel at the initial transmit power.

In accordance with an exemplary embodiment of the invention is a computer readable memory storing a computer program that when executed by a processor results in actions. In this embodiment the actions comprise: initializing for i=0 a first power control adjustment state g(0) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error; computing an initial transmit power for the uplink shared channel using full pathloss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel, and is initialized with the second power control adjustment state f(0); and outputting the initial transmit power for transmission of a third message on the uplink shared channel.

In accordance with an exemplary embodiment of the invention is an apparatus which comprises at least a processor and a transmitter. The processor is configured to initialize, for i=0, a first power control adjustment state g(0) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error, and configured to compute an initial transmit power for the uplink shared channel using full pathloss compensation, in which the initial transmit power depends on a preamble power of a first message sent on an access channel, and the initial power is initialized with the second power control adjustment state f(0). The transmitter is configured to send a third message on the uplink shared channel at the initial transmit power.

These and other aspects of the invention are detailed with particularity below.

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other aspects of the exemplary embodiments of this invention are made more evident in the following Detailed Description, when read in conjunction with the attached Drawing Figures.

FIG. **1A** reproduces FIG. **4-1** of 3GPP TS 36.300, and shows the overall architecture of the E-UTRAN system.

FIGS. 1B and 1C respectively reproduce FIGS. **10.1.5.1-1** and **10.1.5.1-2** of 3GPP TS 36.300 v8.4.0, Contention Based Random Access Procedure and Non-Contention Based Random Access Procedure.

FIG. **2** shows a simplified block diagram of various electronic devices that are suitable for use in practicing the exemplary embodiments of this invention.

FIGS. **3-4** are logical flow diagrams that illustrate the operation of methods, and the result of execution of computer programs instructions by the data processor such as that shown in FIG. **2** according to various specific embodiments of the invention.

## DETAILED DESCRIPTION

In the specific examples given below, the problem solved by those embodiments is how the power control formulas for PUSCH and PUCCH are taken in use during or after the Random Access procedure.

To the inventors' knowledge this problem has not been solved before. Operation according to 3GPP TS 36.213 v.8.2.0 (attached to the priority document as Exhibit B) is that Message 3 (see FIG. 1B) is transmitted using the PUSCH PC formula taking into account the PC command received from the eNB in Message 2 (see FIGS. 1B and 1C). However, this does not specify how the UE specific parameters of the PUSCH and PUCCH power control formulas are initialized.

The PUSCH PC formula for the UE in the Ah subframe is defined at section 5.1.1.1 of 3GPP TS 36.213 v8.2.0 as follows:

$$P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i))+P_{O\_PUSCH}(j)+\alpha\cdot PL+\Delta_{TF}(TF(i))+f(i)\}\text{(dBm)}; \quad [1]$$

where,

$P_{MAX}$ is the maximum allowed power that depends on the UE power class

$M_{PUSCH}(i)$ is the size of the PUSCH resource assignment expressed in number of resource blocks valid for subframe i.

$P_{O\_PUSCH}(j)$ is a parameter composed of the sum of a 8-bit cell specific nominal component $P_{O\_NOMINAL\_PUSCH}(j)$ signalled from higher layers for j=0 and 1 in the range of [−126, 24] dBm with 1 dB resolution and a 4-bit UE specific component $P_{O\_UE\_PUSCH}(i)$ configured by RRC for j=0 and 1 in the range of [−8, 7] dB with 1 dB resolution. For PUSCH (re)transmissions corresponding to a configured scheduling grant then j=0 and for PUSCH (re)transmissions corresponding to a received PDCCH with DCI format 0 associated with a new packet transmission then j=1.

$\alpha\in\{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ is a 3-bit cell specific parameter provided by higher layers

PL is the downlink pathloss estimate calculated in the UE

$\Delta_{TF}(TF(i))=10\log_{10}(2^{MPR\cdot K_S}-1)$ for $K_S=1.25$ and 0 for $K_S=0$ where $K_S$ is a cell specific parameter given by RRC

TF(i) is the PUSCH transport format valid for subframe i

MPR=modulation×coding rate=$N_{INFO}/N_{RE}$ where $N_{INFO}$ are the number of information bits and $N_{RE}$ is the number of resource elements determined from TF(i) and $M_{PUSCH}(i)$ for subframe i

$\delta_{PUSCH}$ is a UE specific correction value, also referred to as a TPC command and is included in PDCCH with DCI format 0 or jointly coded with other TPC commands in PDCCH with DCI format 3/3A. The current PUSCH power control adjustment state is given by f(i) which is defined by:

$f(i)=f(i-1)+\delta_{PUSCH}(i-K_{PUSCH})$ if f(*) represents accumulation

where $f(0)=0$ and $K_{PUSCH}=4$

The UE attempts to decode a PDCCH of DCI format 0 and a PDCCH of DCI format 3/3A in every subframe except when in DRX

$\delta_{PUSCH}=0$ dB for a subframe where no TPC command is decoded or where DRX occurs.

The $\delta_{PUSCH}$ dB accumulated values signalled on PDCCH with DCI format 0 are [−1, 0, 1, 3].

The $\delta_{PUSCH}$ dB accumulated values signalled on PDCCH with DCI format 3/3A are one of [−1, 1] or [−1, 0, 1, 3] as semi-statically configured by higher layers.

If UE has reached maximum power, positive TPC commands are not accumulated

If UE has reached minimum power, negative TPC commands shall not be accumulated

UE shall reset accumulation

at cell-change

when entering/leaving RRC active state

when an absolute TPC command is received

when $P_{O\_UE\_PUSCH}$ (j) is received

when the UE (re)synchronizes

$f(i)=\delta_{PUSCH}(i-K_{PUSCH})$ if f(*) represents current absolute value

where $\delta_{PUSCH}(i-K_{PUSCH})$ was signalled on PDCCH with DCI format 0 on subframe $i-K_{PUSCH}$

where $K_{PUSCH}=4$

The $\delta_{PUSCH}$ dB absolute values signalled on PDCCH with DCI format 0 are [−4, −1, 1, 4].

$f(i)=f(i-1)$ for a subframe where no PDCCH with DCI format 0 is decoded or where DRX occurs.

f(*) type (accumulation or current absolute) is a UE specific parameter that is given by RRC.

The PUCCH PC formula for the UE in the ith subframe is defined at section 5.1.2.1 of 3GPP TS 36.213 v8.2.0 as follows:

$$P_{PUCCH}(i)=\min\{P_{MAX},P_{O\_PUCCH}+PL+\Delta_{TF\_PUCCR}(TF)+g(i)\}(\text{dBm}); \quad [2]$$

where

$\Delta_{TF\_PUCCH}$(TF) table entries for each PUCCH transport format (TF) defined in Table 5.4-1 in [3] are given by RRC

Each signalled $\Delta_{TF\_PUCCH}$(TF) 2-bit value corresponds to a TF relative to PUCCH DCI format 0.

$P_{O\_PUCCH}$ is a parameter composed of the sum of a 5-bit cell specific parameter $P_{O\_NOMINAL\_PUCCH}$ provided by higher layers with 1 dB resolution in the range of [−127, −96] dBm and a UE specific component $P_{O\_UE\_PUCCH}$ configured by RRC in the range of [−8, 7] dB with 1 dB resolution.

$\delta_{PUCCH}$ is a UE specific correction value, also referred to as a TPC command, included in a PDCCH with DCI format 1A/1/2 or sent jointly coded with other UE specific PUCCH correction values on a PDCCH with DCI format 3/3A.

The UE attempts to decode a PDCCH with DCI format 3/3A and a PDCCH with DCI format 1A/1/2 on every subframe except when in DRX.

$\delta_{PUCCH}$ from a PDCCH with DCI format 1A/1/2 overrides that from a PDCCH with DCI format 3/3A when both are decoded in a given subframe.

$\delta_{PUCCH}=0$ dB for a subframe where no PDCCH with DCI format 1A1/2/3/3A is decoded or where DRX occurs.

$g(i)=g(i-1)+\Delta_{PUCCH}(i-K_{PUCCH})$ where g(i) is the current PUCCH power control adjustment state with initial condition $g(0)=0$.

The $\delta_{PUCCH}$ dB values signalled on PDCCH with DCI format 1A/1/2 are [−1, 0, 1, 3].

The $\delta_{PUCCH}$ dB values signalled on PDCCH with DCI format 3/3A are [−1, 1] or [−1, 0, 1, 3] as semi-statically configured by higher layers.

If UE has reached maximum power, positive TPC commands are not accumulated

If UE has reached minimum power, negative TPC commands shall not be accumulated

UE shall reset accumulation

at cell-change

when entering/leaving RRC active state

when $P_{O\_UE\_PUCCH}$(j) is received

when the UE (re)synchronizes

The preamble PC formula for the UE's transmission on the RACH is:

$$P_{preamble}=P_{target}+PL+\Delta P_{rampup}(\text{dBm}), \quad [3]$$

where

$P_{target}$ is the broadcasted target power;

PL is the path loss that UE estimates from DL; and

$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.

As can be seen above at equation [1], the formula for $P_{PUSCH}$ (i) depends on the current PUSCH power control adjustment state which is termed f(i). For accumulation, this adjustment state depends on previous adjustments made in previous subframes, even for the case where f(i) is set to an absolute value since it is set for the subframe ($i-K_{PUSCH}$). When the UE first sends data on the PUSCH, there is no previous subframe and so i=0, which is addressed in 3GPP TS 36.213 v8.2.0 as zeroing out the entire term so that f(0)=0. Further, while it is true that the UE is to reset its accumulation whenever it receives a new UE-specific portion $P_{O\_UE\_PUSCH}$(j) of the $P_{O\_PUSCH}$(j) (and similarly for $P_{O\_PUCCH}$), after a RACH access the UE has received no UE-specific portion and so it lacks that parameter to reset according to 3GPP TS 36.213.

Also, at equation [2] the power control formula for the PUCCH $P_{PUCCH}$(i) depends on the current PUCCH power control adjustment state which is termed g(i) and which also depends on previous adjustments made in previous PUCCH subframes. When the UE first sends a message on the PUCCH, there is no previous subframe and so i=0, which is similarly addressed in 3GPP TS 36.213 v8.2.0 as zeroing out the entire term so that g(0)=0.

Consider the case for contention-less random access such as that shown at FIG. 1C, where the UE transmits preambles that are dedicated for that UE. The embodiments of the invention described for contention-less random access may also be used for contention based random access when it is considered that collisions will be infrequent enough in the contention-based system so as not to substantially affect operation in the cell.

According to an embodiment of the invention, the UE receives a power control command (e.g., $\Delta P_{PC}$) in the preamble response from the eNB, which is Message 2. The UE then initiates the PC formula for PUSCH and PUCCH, or compensates open loop error, according to the following equations:

$$P_{0\_UE\_PUSCH}+f(0)=\Delta P_{PC}+\Delta P_{rampup} \quad [4a]$$

$$P_{0\_UE\_PUCCH}+g(0)=\Delta P_{PC}+\Delta P_{rampup} \quad [4b]$$

These equations say that the sum of the UE specific power control constants ($P_{O\_UE\_PUSCH}$ or $P_{O\_UE\_PUCCH}$) and the power control initial states (f(0) or g(0)) is equal to the open loop power control error, taking into account the preamble power ramp-up. $\Delta P_{PC}$ is here assumed to be the difference between the target preamble power and the power that eNB actually observes. The actual value of $\Delta P_{PC}$ may be signalled directly by the eNB as the power control command, or to save on signalling overhead the eNB may explicitly signal a bit sequence (one, two or more bits) as the power control command which the receiving UE uses as an index to look up the true value $\Delta P_{PC}$ that is associated in a locally stored table with that index.

There are several options for dividing the correction between the UE specific constants and the power control states. For example, in a first option the UE specific power control terms $P_{O\_UE\_PUSCH}$ and $P_{O\_UE\_PUCCH}$ could be initialized to zero and the whole correction is covered by f(0) or g(0). In this case then equations 4a and 4b would read $f(0)=g(0)=\Delta P_{PC}+\Delta P_{rampup}$ for initiating the closed loop correction values for PUCCH and PUSCH. This can be always done as far as the power control state f is accumulated. (According to current 3GPP agreements g is always accumulating.) However, if f is modified with absolute PC commands, its dynamic range is limited and may not cover the whole open loop correction $\Delta P_{PC}+\Delta P_{rampup}$. If this happens, the part of the correction that cannot be included in f(0) could be taken into account by adjusting $P_{O\_UE\_PUSCH}$. As another example, a second option is to take the open loop error into account adjusting principally the UE specific power control terms $P_{O\_UE\_PUSCH}$ and $P_{O\_UE\_PUCCH}$. These parameters have a limited range and the part of the open loop error that cannot be compensated by adjusting these UE specific constants could be covered by initializing the power control states f(0) or g(0) to a nonzero value. The benefit of the first option is that the eNB would know the UE specific constants $P_{O\_UE\_PUSCH}$ and $P_{O\_UE\_PUCCH}$ (at least when f is accumulating), which might make later adjustments of these constants easier. However, the second option could be more natural because the purpose of the UE specific constants is mainly to compensate systematic errors in the PL determination and TX power setting and these are already visible as an error in the open loop power control of the preambles. Of course, the above two options are presented only as non-limiting examples and this aspect of the invention is not limited to only those two.

For the case of a dedicated preamble such as is shown at FIG. 1C or when the preamble collisions of a contention-based system are otherwise infrequent, the power for Message 3 may be generated by using the PUSCH PC formula directly according to the above explained embodiment of the invention. This may lead to UE transmit TX power that is unnecessarily high, but the inventors do not see this as a problem.

The inventors have determined that a problem could arise in the above explained procedure, specifically where two UEs transmit the same preamble sequence and use fractional PL compensation for Message 3. The problem appears most pronounced when the preamble of a UE with a large PL is received at the eNB stronger than the preamble of another UE with small PL. The fractional PC could result in Message 3 of the UE with the smaller PL being received at the eNB with a stronger signal strength than the Message 3 of the UE with the larger PL. This would of course make detection by the eNB of the weaker Message 3 less likely, despite the fact that in the above scenario the weaker Message 3 is from the UE who has received correct timing advance. Decoding of the stronger Message 3 is likely to fail because the timing advance of a wrong UE has been used when transmitting it. Further, if the timing advance for Message 3 transmissions are set based on the preamble of the UE with the larger PL, then the UE with the smaller PL would use a large power and the wrong TA value when transmitting its Message 3, and thereby generate interference to other transmissions.

To achieve improved performance when the UE performs contention based random access and when preamble collisions are assumed to be frequent, another embodiment of the invention defines the Message 3 power relative to preamble power, i.e. full path loss compensation used. The objective is that transmit TX power of Message 3 would not be unnecessary high. In one particular embodiment, this objective can be realized by using the following formula:

$$P_{Msg3}=P_{preamble}+\Delta_{0,preamble\_Msg3}+\Delta_{PC\_Msg3}+10\log_{10}(M_{PUSCH}(i))+\Delta_{TF}(TF(i)). \quad [5]$$

The terms $M_{PUSCH}$ (i) and $\Delta_{TF}$(TF(i)) in equation [5] are the same terms as in equation [1]. Like equation [1], $P_{Msg3}$ is the minimum of $P_{MAX}$ and the above summation, but $P_{MAX}$ is not explicitly shown at equation [5]. Note that $\Delta_{TF}$(TF(i)) is calculated at the UE from signalling the UE receives (e.g., $\alpha$ and $K_S$), and that for the case where $\alpha=1$ full path loss compensation is used in this Message 3 power, just as for the preamble power. Different from equation [1] is the equation [5] term $\Delta_{0,preamble\_Msg3}$ which corresponds to a typical power offset between a Message 3 and the preamble whose power corresponds to the detection threshold. The term $\Delta_{0,preamble\_Msg3}$ can be a parameter broadcast in System Information or it could be specified in the appropriate wireless standard governing RACH procedures and pre-stored in the UE's memory. The term $\Delta_{PC\_Msg3}$ is the power control command included in the preamble response (e.g., Message 2), and as above the eNB may signal it directly or more likely as a short bit sequence that is an index which the UE uses to access a lookup table for the true value. It is here named differently than the corresponding parameter $\Delta_{PC}$ of the first embodiment above because this power control command of the second embodiment is applicable only to Message 3 or to the PUSCH transmissions following Message 3, whereas the parameter $\Delta_{PC}$ initializes the PC system for all the UL transmissions. After transmitting Message 3 or soon after that the UE should move to using Eq. [1] of the normal PUSCH power control. For this purpose, the UE could report as early as possible, preferably already in Message 3, the power offset between the used power and the power calculated with the PC Equation 1. More generally, the UE can report as early as Message 3 the power difference (or an indication of the difference) between the second power (the transmit power of Message 3 from equation [5]) which was computed using full pathloss compensation, and a fractional computation of the second power (e.g., if the power for Message 3 were instead computed using equation [1]). With this knowledge, the eNB could then initialize the UE specific constants. The UE could also report other parameters that are unknown to eNB and provide same information e.g., power rampup value and pathloss or power rampup, power headroom and max UE power (UE power class). From a signalling point of view reporting the difference of the two formulas is most efficient. Alternative to reporting one or more parameters, the UE could, after transmitting Message 3, apply the first embodiment, equating $\Delta_{PC}$ to $\Delta_{PC\_Msg3}$ in Equations 4a and 4b

Reference is now made to FIG. 2 for illustrating a simplified block diagram of various electronic devices that are suitable for use in practicing the exemplary embodiments of this invention. In FIG. 2 a wireless network 1 is adapted for communication with an apparatus, such as a mobile communication device which may be referred to as a UE **10**, via a network access node, such as a Node B (base station), and more specifically an eNB **12**. The network **1** may include a network control element (NCE) **14** that may include the MME/S-GW functionality shown in FIG. **1**A, and which provides connectivity with a network **16**, such as a telephone network and/or a data communications network (e.g., the internet). The UE **10** includes a data processor (DP) **10**A, a memory (MEM) **10**B that stores a program (PROG) **10**C, and a suitable radio frequency (RF) transceiver **10**D for bidirectional wireless communications with the eNB **12**, which also includes a DP **12**A, a MEM **12**B that stores a PROG **12**C, and a suitable RF transceiver **12**D. The eNB **12** is coupled via a data path **13** to the NCE **14**, which may be implemented as the S1 interface shown in FIG. **1**A. An instance of the X2 interface **15** may be present for coupling to another eNB (not shown). At least the PROG **12**C may be assumed to include program instructions that, when executed by the associated DP **12**A, enable the electronic device to operate in accordance with the exemplary embodiments of this invention, as detailed above and in the process diagram described below.

The exemplary embodiments of this invention may be implemented at least in part by computer software executable by the DP **10**A of the UE **10**, or by hardware, or by a combination of software and hardware (and firmware).

For the purposes of describing the exemplary embodiments of this invention the UE **10** may be assumed to also include a power control PC functional unit **10**E, and the eNB **12** also includes a PC functional unit **12**E. The PC functional units **10**E, **12**E, which may be in embodied as software stored in the MEM **10**B, **12**B, or as circuitry or some combination of computer software and hardware (and firmware), are assumed to be constructed and operated in accordance with the exemplary embodiments of this invention.

In general, the various embodiments of the UE **10** can include, but are not limited to, cellular telephones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

The MEMs **10**B and **12**B may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memory, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The DPs **10**A and **12**A may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multicore processor architecture, as non-limiting examples.

Typically there will be a plurality of UEs **10** serviced by the eNB **12**. The UEs **10** may or may not be identically constructed, but in general are all assumed to be electrically and logically compatible with the relevant network protocols and standards needed for operation in the wireless network **1**.

From the perspective of the UE, exemplary embodiments of this invention encompass a method; an apparatus that includes a processor, memory, transmitter and receiver; and a memory embodying a computer program; that operate to compute a first power using a first power control technique (algorithm) that is a function of a first variable (e.g., rampup power, $\Delta P_{rampup}$), to send a preamble of an access request message with the first power, in response to the access request message to receive a second message (e.g., Message 2) that includes a power control command ($\Delta P_{PC}$ or a bit sequence indicating it), to compute a second power using a different second power control technique (algorithm) that is initiated with a function of the first variable and of the received power control indication, and to send a third message using the second power. In a specific embodiment, the function is the sum of $\Delta P_{rampup}$ and $\Delta P_{PC}$ which is plugged into equation [1] above. Other parameters of equation [1] are known: $M_{PUSCH}(i)$ is known from the UE's resource allocation it gets in Message 2; the nominal portion $P_{O\_NOMINAL\_PUSCH}(j)$ of $P_{O\_PUSCH}(j)$ is received in a broadcast in the cell, as is $\alpha$ and $K_S$ from which $\Delta_{TF}(TF(i))$ is calculated; and PL is estimated by the UE itself such as from Message 2. If the UE has started the Random Access procedure in order to make a handover, it has received the parameters $P_{O\_NOMINAL\_PUSCH}(j)$ and $\alpha$ in the handover command. Similar holds true for equation [2] and PUCCH. The end result for initializing equation [1] with the summed terms $\Delta P_{PC}+\Delta P_{rampup}$ would then be:

$$P_{PUSCH}(0)=\min\{P_{MAX},10\log_{10}(M_{PUSCH}(0))+P_{O\_NOMINAL\_PUSCH}(j)+\alpha\cdot PL+\Delta_{TF}(TF(0))+\Delta P_{PC}+\Delta P_{rampup}\}$$

Further details and implementations are described particularly below with reference to FIG. **3**.

The exemplary embodiment of the power control algorithms can be described in more detail as having the steps of (referring to the process flow diagram of FIG. **3**):

**302**: the UE estimates path loss for communication with an eNB;

**304**: the UE computes a first power control value using a first power control technique (full path loss compensation) according to the estimated path loss (PL estimated from a received DL transmission), a target power ($P_{target}$) broadcast in the cell, and a ramp-up power value ($\Delta P_{rampup}$);

**306**: the UE sends on a first channel a first message to the eNB with power ($P_{preamble}=P_{target}+PL+\Delta P_{rampup}$, for the preamble of that message) according to the computed first power control value (this is an access request message sent on a RACH);

**308**: the eNB receives the first message and replies on a second channel (the DL-SCH/PDCCH) with a second message (Message 2) that includes an uplink resource allocation for the UE and a power control command ($\Delta P_{PC}$) for the UE;

**310**: the UE receives the second message and computes a second power control value ($P_{PUSCH}(0)$) using a second power control technique (fractional power control/fractional pathloss compensation) using the received power control command ($\Delta P_{PC}$) and initialized with a function (sum) of the power control command ($\Delta P_{PC}$) and the ramp-up power value ($\Delta P_{rampup}$) {e.g., the second power is given by equation [1] with substitutions using the equality of equation [4a]};

**312**: the UE sends data on a second channel (the PUSCH of the uplink resource allocation) using the second power control value ($P_{PUSCH}(0)$)

**314**: the UE may also or alternatively compute a third power control value ($P_{PUCCH}(0)$) that is initialized identically to the second power control value above and send control information to the eNB using that third power control value on a shared uplink control channel (PUCCH) {e.g., the third power is given by equation [2] with substitutions using the equality of equation [4b]}.

Alternative to block **310**, the UE can send the data at block **312** on the allocated resource using a second power value ($P_{Msg3}$) that the UE calculates using an offset ($\Delta_{0,preamble\_Msg3}$) from the first power value and the received power control command ($\Delta_{PC\_Msg3}$), scaling the power according to the allocated payload size and the number of assigned resource blocks according to equation [5]. This alternative includes a switching to the normal PUSCH PC equation [1] after the transmission of the Message 3. Such a switch-over can be done after the UE has reported parameter values for initializing of the UE specific constants. Alternatively to reporting parameters, the UE can take the Eq. [1] in use by initializing the PC parameters immediately after the Message 3 transmission as in block **310**, substituting $\Delta P_{PC}=\Delta_{PC\_Msg3}$.

There is also the embodiment noted above in which Message 3 is the first or initial message sent on PUSCH with its transmit power computed as in equation [5], and further transmissions are sent with power accumulated according to equation [1]. This is shown at FIG. **4** with actions undertaken at the UE side of the UE/network divide are as follows:

**402**, initialize for i=0 a first power control adjustment state g(0) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error;

**404**: compute an initial transmit power for the uplink shared channel using full pathloss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel {e.g., preamble power of the RACH access request preamble}, and is initialized with the second power control adjustment state f(0) {e.g., equation [5]}; and

**406**: send from a transmitter a third message {e.g., Message 3} on the uplink shared channel {e.g., PUSCH} at the initial transmit power.

Additional optional features and/or implementation details for FIG. **4** include:

**408**: the preamble power is computed using full pathloss compensation,

**410**: compute an updated transmit power (for all messages after Message3 and any of its re-transmissions) for the shared uplink channel using fractional power control {e.g., equation [1]}, and the UE sends subsequent messages (those after Message3 and any re-transmissions of it) on the PUSCH using the updated transmit power, and

**412**: the third message comprises an indication of a power difference between the initial transmit power which is computed using full pathloss compensation and a fractional pathloss computation of the initial transmit power {e.g., difference between computations from equations [5] and [1] for i=0}.

Note that the various blocks shown in FIGS. **3-4** for a particular entity (UE or eNB) may be viewed as method steps, and/or as operations that result from operation of computer program code, and/or as a plurality of coupled logic circuit elements constructed to carry out the associated function(s).

In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the exemplary embodiments of this invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

As such, it should be appreciated that at least some aspects of the exemplary embodiments of the inventions may be practiced in various components such as integrated circuit chips and modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be fabricated on a semiconductor substrate. Such software tools can automatically route conductors and locate components on a semiconductor substrate using well established rules of design, as well as libraries of pre-stored design modules. Once the design for a semiconductor circuit has been completed, the resultant design, in a standardized electronic format (e.g., Opus, GDSII, or the like) may be transmitted to a semiconductor fabrication facility for fabrication as one or more integrated circuit devices.

Various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. For example, certain steps shown in FIG. **3** may be executed in other than the order shown, and certain of the computations described may be performed in other ways. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention.

Further, while the exemplary embodiments have been described above in the context of the E-UTRAN (UTRAN-LTE) system, it should be appreciated that the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system, and that they may be used to advantage in other types of wireless communication systems.

It should be noted that the terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and/or printed electrical connections, as well as by the use of electromagnetic energy, such as electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as several non-limiting and non-exhaustive examples.

Furthermore, some of the features of the examples of this invention may be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles, teachings, examples and exemplary embodiments of this invention, and not in limitation thereof.

We claim:

1. A method comprising:

using a processor to initialize for i=0 a first power control adjustment state g(i) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error;

using the processor to compute an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0); and

sending from a transmitter a third message on the uplink shared channel at the initial transmit power;

wherein the second power control adjustment state f(i) for i=0 is initialized as:

$$P_{0\_UE\_PUSCH}+f(0)=\Delta P_{PC}+\Delta P_{rampup};$$

in which:

$P_{0\_UE\_PUSCH}$ is a power control constant for the uplink shared channel that is specific for a user equipment executing the method;

$\Delta P_{rampup}$ is a ramp-up power for preamble transmissions; and

$\Delta P_{PC}$ is a power control command indicated in a second message that is received in response to sending the first message.

2. The method according to claim 1, wherein the first message comprises a random access request message, the method further comprising:

computing the preamble power using full path loss compensation,

sending from the transmitter on the access channel the first message and in response receiving at a receiver a second message that comprises an allocation of resources on which the third message is sent;

and after sending the third message, the method further comprises using the processor to compute an updated transmit power for the uplink shared channel using fractional power control and sending from the transmitter a subsequent message on the uplink shared channel using the updated transmit power.

3. The method according to claim 1, wherein the first power control adjustment state g(i) for i=0 is initialized as:

$$P_{0\_UE\_PUCCH}+g(0)=\Delta P_{PC}+\Delta P_{rampup};$$

wherein: $P_{O\_UE\_PUCCH}$ is a power control constant for the uplink control channel power that is specific for a user equipment executing the method.

4. The method according to claim 3, wherein $P_{0\_UE\_PUSCH}=P_{O\_UE\_PUCCH}=0$ when computing initial values at i=0 of power control states for the respective shared and control channels.

5. The method according to claim 1,

wherein the initial transmit power $P_{Msg3}$ of the third message for i=0 is equal to:

$$P_{Msg3}=\min\{P_{max},P_{preamble}+\Delta_{0,preamble\_Msg3}+\Delta_{PC\_Msg3}+10\log_{10}(M_{PUSCH}(i))+\Delta_{TF}(TF(i))\};$$

in which:

$P_{MAX}$ is a maximum allowed transmission power;

$P_{preamble}$ is the preamble power of the first message;

$M_{PUSCH}(i)$ is determined from an uplink resource allocation of a second message received in response to sending the first message;

$\Delta_{TF}(TF(i))$ is calculated from received signaling;

$\Delta_{PC\_Msg3}$ is indicated by a power control command received at the receiver; and

$\Delta_{0,preamble\_Msg3}$ is an offset from the preamble power.

6. A method according to claim 5, further comprising, after sending the third message, using the processor to compute an updated transmit power for the shared uplink channel using fractional power control and sending from the transmitter a subsequent message on the uplink shared channel using the updated transmit power, wherein the updated transmit power $P_{PUSCH}$ (i) is equal to:

$$P_{PUSCH}(i)=\min\{P_{MAX},10\log_{10}(M_{PUSCH}(i)+P_{O\_PUSCH}(j)+\alpha\cdot PL+\Delta_{TF}(TF(i)+f(i)\};$$

wherein:

$P_{O\_PUSCH}$ (j) is calculated from received signaling,

α or an indication of α is received in signaling, and

PL is path loss that is estimated from received signaling.

7. The method according to claim 6, wherein α=1 for the third message and for all retransmissions of the third message indicating full path loss compensation, and α<1 for messages after the third message and all retransmissions of the third message indicating fractional path loss compensation.

8. The method according to claim 7, executed by a user equipment; and wherein the third message comprises an indication of a power difference between the initial transmit power which is computed using full path loss compensation and a fractional path loss computation of the initial transmit power.

9. A computer readable memory storing a computer program that when executed by a processor results in actions comprising:

initializing for i=0 a first power control adjustment state g(i) for an uplink control channel and a second accumulation power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error;

computing an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0); and

outputting the initial transmit power for transmission of a third message on the uplink shared channel;

wherein the second accumulation power control adjustment state f(i) for i=0 is initialized as:

$$P_{0\_UE\_PUSCH}+f(0)=\Delta P_{PC}+\Delta P_{rampup};$$

in which:

$P_{0\_UE\_PUSCH}$ is a power control constant for the uplink shared channel that is specific for a user equipment which sends the first and third messages;

$\Delta P_{rampup}$ is a ramp-up power for preamble transmissions; and

$\Delta P_{PC}$ is a power control command indicated in a second message that is received in response to the first message.

10. An apparatus comprising:

a processor; and

a memory storing a computer program;

in which the processor is configured with the memory and the computer program to cause the apparatus to:

initialize for i=0 a first power control adjustment state g(i) for an uplink control channel and a second accumulation power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error, and

compute an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0); and

compile a third message to be sent on the uplink shared channel at the initial transmit power;

wherein the second power control adjustment state f(i) for i=0 is initialized as:

$$P_{0\_UE\_PUSCH}+f(0)=\Delta P_{PC}+\Delta P_{rampup};$$

in which:

$P_{0\_UE\_PUSCH}$ is a power control constant for the uplink shared channel that is specific for a user equipment;

$\Delta P_{rampup}$ is a ramp-up power for preamble transmissions; and

$\Delta P_{PC}$ is a power control command indicated in a second message received at a receiver of the apparatus in response to the transmitter sending the first message.

**11**. The apparatus according to claim **10**, wherein the first message comprises a random access request message, and:

the processor is configured with the memory and the computer program to compute the preamble power using full path loss compensation,

the apparatus further comprising a transmitter is configured to send on the access channel the first message;

the apparatus further comprising a receiver configured to receive, in response to the transmitter sending the first message, a second message that comprises an allocation of resources on which the third message is sent;

the processor with the memory and the computer program is configured, after the transmitter sends the third message, to compute an updated transmit power for the uplink shared channel using fractional power control;

and the transmitter is configured to send a subsequent message on the uplink shared channel using the updated transmit power.

**12**. The apparatus according to claim **10**, wherein the first power control adjustment state g(i) for i=0 is initialized as:

$$P_{0\_UE\_PUCCH}+g(0)=\Delta P_{PC}+\Delta P_{rampup};$$

wherein: $P_{O\_UE\_PUCCH}$ is a power control constant for the uplink control channel that is specific for a user equipment.

**13**. The apparatus according to claim **12**, wherein $P_{0\_UE\_PUSCH}=P_{O\_UE\_PUCCH}=0$ when the processor computes initial values at i=0 of power control states for the respective shared and control channels.

**14**. The apparatus according to claim **10**,

wherein the initial transmit power $P_{Msg3}$ for i=0 is equal to:

$$P_{Msg3}=\min\{P_{max}, P_{preamble}+\Delta_{0,preamble\_Msg3}+\Delta_{PC\_Msg3}+10\log_{10}(M_{PUSCH}(i))+\Delta_{TF}(TF(i))\};$$

in which:

$P_{MAX}$ is a maximum allowed transmission power;

$P_{preamble}$ is the preamble power of the first message;

$M_{PUSCH}(i)$ is determined from an uplink resource allocation of a second message received in response to sending the first message;

$\Delta_{TF}(TF(i))$ is calculated from received signaling;

$\Delta_{PC\_Msg3}$ is indicated by a power control command received at the receiver; and

$\Delta_{0,preamble\_Msg3}$ is an offset from the preamble power.

**15**. The apparatus according to claim **14**, wherein the processor is configured with the memory and the computer program to compute an updated transmit power for the shared uplink channel using fractional power control and the transmitter is configured to send from the transmitter a subsequent message on the uplink shared channel using the updated transmit power, wherein the updated transmit power $P_{PUSCH}$ (i) is equal to:

$$P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i))+P_{O\_PUSCH}(j)+\alpha\cdot PL+\Delta_{TF}(TF(i))+f(i)\};$$

wherein:

$P_{O\_PUSCH}$ (j) is calculated from received signaling,

$\alpha$ or an indication of $\alpha$ is received in signaling, and

PL is path loss that is estimated from received signaling.

**16**. The apparatus according to claim **15**, wherein $\alpha=1$ for the third message and for all retransmissions of the third message indicating full path loss compensation, and $\alpha<1$ for messages after the third message and all retransmissions of the third message indicating fractional path loss compensation.

**17**. The apparatus according to claim **15**, in which the apparatus comprises a user equipment, and wherein the third message comprises an indication of a power difference between the initial transmit power which is computed using full path loss compensation and a fractional path loss computation of the initial transmit power.

* * * * *

**UNITED STATES PATENT AND TRADEMARK OFFICE**

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**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

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HTC Corporation and ZTE (USA), Inc.
Petitioner

v.

CELLULAR COMMUNICATIONS EQUIPMENT LLC
Patent Owner

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*INTER PARTES* REVIEW OF U.S. PATENT NO. 8,385,966
Case IPR No.: *To Be Assigned*

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# DECLARATION OF DR. ROBERT AKL, D.Sc.

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TABLE OF CONTENTS

## I. INTRODUCTION

1. My name is Robert Akl, and I have been retained by counsel for HTC Corporation and ZTE (USA), Inc. as an expert witness in the above-captioned proceeding.

2. My opinions are based on my years of education, research and experience, as well as my investigation and study of relevant materials. The materials that I studied for this declaration include all exhibits of the petition.

3. I may rely upon these materials, my knowledge and experience, and/or additional materials to rebut arguments raised by the patent owner. Further, I may also consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.

4. My analysis of the materials produced in this investigation is ongoing and I will continue to review any new material as it is provided. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

5. I am being compensated on a per hour basis for my time spent working on issues in this case. My compensation does not depend on the outcome of this matter or the opinions I express.

## II. QUALIFICATIONS

6. I am an expert in the field of wireless communications. I have studied, taught, practiced, and researched in the field of wireless communications for over twenty years. I have summarized in this section my educational background, work experience, and other relevant qualifications. A true and accurate copy of my curriculum vitae is attached as Appendix A to my declaration.

7. I earned my Bachelor of Science degrees in Electrical Engineering and Computer Science summa cum laude with a grade point average of 4.0/4.0 and a ranking of first in my undergraduate class from Washington University in Saint Louis in 1994. In 1996, I earned my Master of Science degree in Electrical Engineering from Washington University in Saint Louis with a grade point average of 4.0/4.0. I earned my Doctorate of Science in Electrical Engineering from Washington University in Saint Louis in 2000, again with a grade point average of 4.0/4.0, with my dissertation on "Cell Design to Maximize Capacity in Cellular Code Division Multiple Access (CDMA) Networks."

8. While a graduate student, from 1996 through 2000, I worked at MinMax Corporation in St. Louis, where I designed software packages that provided tools to flexibly allocate capacity in a CDMA communications network and maximize the number of subscribers. As part of this work, I validated the hardware architecture for an Asynchronous Transfer Mode (ATM) switch capable

of channel group switching, as well as performed logical and timing simulations, and developed the hardware architecture for the ATM switch. I also worked with Teleware Corporation in Seoul, South Korea, where I designed and developed algorithms that were commercially deployed in a software package suite for analyzing the capacity in a CDMA network implementing the IS-95 standard to maximize the number of subscribers.

9. After obtaining my Doctorate of Science degree, I worked as a Senior Systems Engineer at Comspace Corporation from October of 2000 to December of 2001. In this position, I designed and developed advanced data coding and modulation methods for improving the reliability and increasing the available data rates for cellular communications. I coded and simulated different encoding schemes (including Turbo coding, Viterbi decoding, trellis coded modulation, and Reed-Muller codes) and modulation techniques using amplitude and phase characteristics and multi-level star constellations. This work further entailed the optimization of soft decision parameters and interleavers for additive white Gaussian and Rayleigh faded channels. In addition, I also extended the control and trunking of Logic Trunked Radio (LTR) to include one-to-one and one-to-many voice and data messaging.

10. In January of 2002, I joined the faculty of the University of New Orleans in Louisiana as an Assistant Professor in the Department of Electrical

Engineering. While on this faculty, I designed and taught two new courses called "Computer Systems Design I and II." I also developed a Computer Engineering Curriculum with strong hardware-design emphasis, formed a wireless research group, and advised graduate and undergraduate students.

11. In September of 2002, I received an appointment as an Assistant Professor in the Department of Computer Science and Engineering at the University of North Texas (UNT), in Denton, Texas. In May of 2008, I became a tenured Associate Professor in the Department of Computer Science and Engineering. As a faculty member, I taught courses and directed research in wireless communications, including 2G, 3G, 4G, CDMA/WCDMA, GSM, UMTS, LTE, wireless sensors, Bluetooth, VoIP, multi-cell network optimization, call admission control, channel coding, ad-hoc networks, and computer architecture. I was the director of the Wireless Sensor Lab ("WiSL"). Several of my research projects were funded by industry. In January of 2015, I was appointed Associate Chair of Graduate Studies.

12. In addition to advising and mentoring students at UNT, I was asked to join the faculty of the University of Arkansas in Little Rock as an Adjunct Assistant Professor from 2004 to 2008 in order to supervise the research of two Ph.D. graduate students who were doing research in wireless communications. At UNT, I have advised and supervised more than 250 undergraduate and graduate

students, many of whom received a master's or doctorate degree under my guidance.

13. In addition to my academic work, I have remained active in the communication industry through my consulting work. In 2002, I consulted for Input/Output Inc. and designed and implemented algorithms for optimizing the frequency selection process used by sonar for scanning the bottom of the ocean. In 2004, I worked with Allegiant Integrated Solutions in Ft. Worth, Texas to design and develop an integrated set of tools for fast deployment of wireless networks. Among other features, these tools optimize the placement of Access Points and determine their respective channel allocations to minimize interference and maximize capacity. I also assisted the Collin County Sheriff's Office (Texas) in a double homicide investigation, analyzing cellular record data to determine user location.

14. I have authored and co-authored approximately 75 journal publications, conference proceedings, technical papers, book chapters, and technical presentations, in a broad array of communications-related technology, including networking and wireless communication. I have also developed and taught over 100 courses related to communications and computer system designs, including a number of courses on LTE, VoIP, wireless communication, communications systems, sensor networks, computer systems design, and

computer architecture. These courses have included introductory courses on communication networks and signals and systems, as well as more advanced courses on wireless communications. A complete list of my publications and the courses I have developed and/or taught is also contained in my curriculum vitae.

15. My professional affiliations include services in various professional organizations and serving as a reviewer for a number of technical publications, journals, and conferences. I have also received a number of awards and recognitions, including the IEEE Professionalism Award (2008), UNT College of Engineering Outstanding Teacher Award (2008), and Tech Titan of the Future (2010) among others, which are listed in my curriculum vitae.

16. A complete list of cases in which I have testified at trial, hearing, or by deposition within the preceding four years is provided in my curriculum vitae, which is attached as **Appendix A**. In the listed cases, I have been retained by both patent owners as well as petitioners.

## III. SCOPE OF OPINION

17. I have been asked to provide my opinions regarding whether claims 1-17 of the U.S. Patent No. 8,385,966 ("the '966 patent") would have been obvious to one of ordinary skill in art at the time of the alleged invention in view of U.S. Patent No. 5,599,706 ("Qualcomm"), U.S. Patent Publication No. 2010/0093386 ("Qualcomm-386"), and Applicant Admitted Prior Art ("AAPA"), which includes

3GPP TS 36.213 v8.2.0, 3GPP TS 36.300 v8.4.0, and 3GPP TS 36.321 v8.0.0. This declaration, including the exhibits hereto, sets forth my opinions regarding this assignment.

## IV. MATERIALS REVIEWED AND CONSIDERED

18. In connection with my work on this matter, I have reviewed and considered the following documents:

| Exhibit No. | Exhibit |
|---|---|
| Ex.1001 | U.S. Patent No. 8,385,966 ("'966 patent") |
| Ex.1003 | U.S. Patent No. 5,599,706 ("Qualcomm") |
| Ex.1004 | 3GPP TS 36.213 v8.2.0 (2008-03) ("TS 36.213") |
| Ex.1005 | 3GPP TS 36.300 v8.4.0 (2008-04) ("TS 36.300") |
| Ex.1006 | 3GPP TS 36.321 v8.0.0 (2007-12) ("TS 36.321") |
| Ex.1007 | U.S. Patent Publication No. 2010/0093386 ("Qualcomm-386") |
| Ex.1008 | 3GPP Draft Proposal "Transmission Power Control in E-UTRA Uplink" ("R1-070870") by NTT DoCoMo (Feb. 2007) |
| Ex.1009 | 3GPP Draft Proposal "Uplink power control procedures and Text Proposal for E-UTRA" ("R1-074704") by InterDigital Communications, LLC (November 2007) |
| Ex.1010 | 3GPP Draft Proposal "Reply to RAN2 LS on RACH Power Control Optimisation Use Case" ("R1-080612") by Jung A. Lee of Alcatel Lucent (January 2008) |
| Ex.1011 | 3GPP Draft Proposal "Uplink power control procedures and Text Proposal for E-UTRA" ("R1-080879") by Ericsson (February 2008) |
| Ex.1012 | 3GPP Specifications Home, http://www.3gpp.org/specifications/specifications (accessed 2017-04-19) |
| Ex.1013 | Prosecution History of U.S. Patent No. 8,385,966 ("'966 file history") |
| Ex.1014 | Provisional Application of U.S. Patent No. 8,385,966 ("'966 provisional") |

I also have relied on my academic and professional experience in reaching the opinions expressed in this declaration.

## V. DESCRIPTION OF THE RELEVANT FIELD AND THE RELEVANT TIMEFRAME

19. I have carefully reviewed the '966 patent. Based on my review, I believe that the relevant field for the purposes of the '966 patent is generally wireless communication systems and more specifically power control of mobile terminals in cellular systems. I have been informed that the relevant timeframe is on or before May 5, 2008, based on the provisional application filing date of the '966 patent, and this declaration will focus on technologies and state of the art that existed prior to May 5, 2008.

20. As described above and as shown in my CV, I have extensive experience in cellular communications. Based on my experience, I have a good understanding of the relevant field in the relevant timeframe.

## VI. LEVEL OF ORDINARY SKILL IN THE ART

21. In rendering the opinions set forth in this declaration, I was asked to consider the patent claims and the prior art through the eyes of a person of ordinary skill in the art ("POSITA"). I considered factors such as the educational level and years of experience of those working in the pertinent art; the types of problems encountered in the art; the teachings of the prior art; patents and publications of other persons or companies; and the sophistication of the technology. I understand

that a POSITA is not a specific real individual, but rather a hypothetical individual having the qualities reflected by the factors discussed above.

22. Taking these factors into consideration, it is my opinion that a POSITA at a relevant timeframe for the '966 patent would have had a B.S. degree in computer science, computer engineering, electrical engineering, or a related field, and around 2 years of experience in the design or development of wireless communication systems, or the equivalent. Such a person would have been familiar with various working group proposals presented in the 3GPP meetings related to uplink power control and 3GPP specifications, including 3GPP TS 36.213, 3GPP TS 36.300, and 3GPP TS 36.321.

23. Based on my experience, I have an understanding of the capabilities of a person of ordinary skill in the relevant field. I have supervised and directed many such persons over the course of my career in academia. Further, I had at least those capabilities myself at the relevant timeframe for the '966 patent.

## VII. LEGAL PRINCIPLES

24. It is my understanding that there are two ways in which prior art may render a patent claim unpatentable. First, the prior art can be shown to "anticipate" the claim. Second, the prior art can be shown to have made the claim "obvious" to a person of ordinary skill in the art.

25. It is my understanding that a patent claim is unpatentable as being obvious in view of prior art if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the alleged invention was made to a POSITA to which said subject matter pertains. I further understand that an obviousness analysis takes into consideration factual inquiries such as the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the patent claim.

26. I understand that the U.S. Supreme Court has recognized several rationales for combining references and for modifying a reference as part of an obviousness analysis. These rationales include combining prior art elements according to known methods to yield predictable results, simple substitution of a known element for another to obtain predictable results, a predictable use of prior art elements in accordance with their established functions, applying a known technique to improve a known device (or process) and yield predictable results, and choosing from a finite number of known predictable solutions with a reasonable expectation of success. It is further my understanding that an obviousness analysis takes into consideration whether the prior art provides a teaching, suggestion, or motivation to combine teachings of multiple prior art references to arrive at the patent claim.

## VIII. LTE OVERVIEW

27. Conceptually, all cellular radio systems can be described at a high level in terms of user equipment devices, air interface standards, base station systems, core networks and linkages to external networks. A modern historical view of air interface standards groups them according to successive "generations" of technology where today "4th generation" (or "4G") standards are prevalent especially for cellular data networking.

28. By the late 2000s timeframe as the 3G systems became pervasive in coverage and smartphones and tablets were becoming commonplace as "always-on" Internet-connected mobile devices, engineers were developing and especially in the USA starting trial deployments of 4G cellular radio systems. The fundamental subscriber benefit of 4G is much more robust packet data networking support at even higher data rates, of 100 Mb/s or more as the network infrastructure is successively upgraded over the next several years. 4G capability would enable mobile connected devices such as laptop computers to run Internet based applications with a user experience similar to the now much faster wired broadband services available compared to 10 years earlier. To achieve this goal again required fundamental changes to the core network and very different physical layers for communications between mobile stations and base stations.

29. Three competing 4G standards proposals emerged. One proposed 4G standard was started by 3GPP2 as an evolution of CDMA2000 into a 4G standard called "Ultra Mobile Broadband" (or "UMB"). However, no cellular operators have deployed UMB and efforts on it are now largely abandoned. A second proposed 4G standard was led by the IEEE 802.16 committee; several cellular operators in the USA and elsewhere have deployed IEEE 802.16e (also known as "WiMax") mobile networks that use the IP based core network of all IEEE 802 standards and physical layers based on "Orthogonal Frequency Division Multiplexing" (or "OFDM"). The third proposed 4G standard called "Long Term Evolution" (or "LTE") was led by 3rd Generation Partnership Project (3GPP).

30. Every major US based cellular operator has made a commitment to LTE and much of the USA already has LTE service. LTE has an "Evolved Packet Core" (or "EPC") that is mostly IP-based but with excellent interoperability to 3G UMTS core networks. LTE uses physical layers based on OFDM with many aspects in common with the physical layers of IEEE 802.16e. It is expected that over the next several years in the USA, 4G LTE service will almost completely replace existing 3G UMTS or CDMA2000 service and in many cases the 3G networks will be discontinued so that the 3G spectrum can be reallocated to 4G LTE usage.

31. The 3GPP working group publishes draft proposals from working groups and working specifications on its website, www.3gpp.org. These draft proposals and specifications are freely provided to the public without access controls such as login/passwords. For example, all of the specifications for TS 36.213 can be found here: https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=2427. And the draft proposals for working group R1 of the 3GPP can be found here: http://www.3gpp.org/dynareport/Meetings-R1.htm?Itemid=404.

32. As 3GPP is the organization that was managing the LTE specification process, a POSITA would be familiar with the draft proposals from the working groups and the working specifications on the 3GPP website. A POSITA would also look to the 3GPP website and the various proposals and specifications available on the 3GPP website for LTE information. As an example, a POSITA wishing to access information about random access procedures or the transmit power used in the random access procedures would look to the relevant proposals and specifications found on the 3GPP website. As noted above, these proposals and specifications are freely accessible to the public and can also be found through popular search engines such as www.google.com.

33. The 3GPP TS 36.213 v8.2.0 specification ("TS 36.213") was available to the public no later than May 3, 2008. (TS 36.213, p. 30). In addition,

the '966 patent admits that the TS 36.213 specification was publicly available as of the filing date of the provisional application ("'966 Provisional") on May 5, 2008. Specifically, the '966 Provisional cites to the TS 36.213 specification and attaches an excerpt of this specification. (¶ [0019] of the '966 Provisional; '966 patent, 4:21-6:17). Accordingly, TS 36.213 is also part of AAPA of the '966 patent.

34. The 3GPP TS 36.300 v8.4.0 specification ("TS 36.300") was available to the public no later than March, 2008. (TS 36.300, p. 128). In addition, the '966 patent admits that the TS 36.300 specification was publicly available as of the filing date of the '966 Provisional on May 5, 2008. Specifically, the '966 Provisional cites to the TS 36.300 specification and attaches an excerpt of this specification. (¶¶ [0005], [0007] of the '966 Provisional; '966 patent, 2:1-12; 2:18-38). Accordingly, TS 36.300 is also part of AAPA of the '966 patent.

35. The 3GPP TS 36.321 v8.0.0 specification was available to the public no later than December 2007. (TS 36.321, p. 23). In addition, the '966 patent admits that TS 36.321 specification was publicly available as of the filing date of the '966 Provisional on May 5, 2008, and cites to the TS 36.321 specification. (¶¶ [0006], [0022] of the '966 Provisional; '966 patent, 2:13-17; 6:18-26). Accordingly, TS 36.321 is also part of AAPA of the '966 patent.

### A. Random Access Procedures on Shared Wireless Channels

36. In 4G LTE, a mobile station (known as User Equipment or UE) communicates with the base station (known as evolved Node B or eNB) via transmissions on the downlink and uplink. The downlink (or forward link) refers to the communication link from the eNBs to the UEs, and the uplink (or reverse link) refers to the communication link from the UEs to the eNBs.

37. In LTE, user equipment or UE can request a system access or connection setup with an evolved Node B (eNB). Figure 10.1.5.1-1 of TS 36.300 (annotated), which is reproduced in Figure 1B of the '966 patent, shows a contention based random-access procedure.

#### 10.1.5.1 Contention based random access procedure

The contention based random access procedure is outlined on Figure 10.1.5.1-1 below:

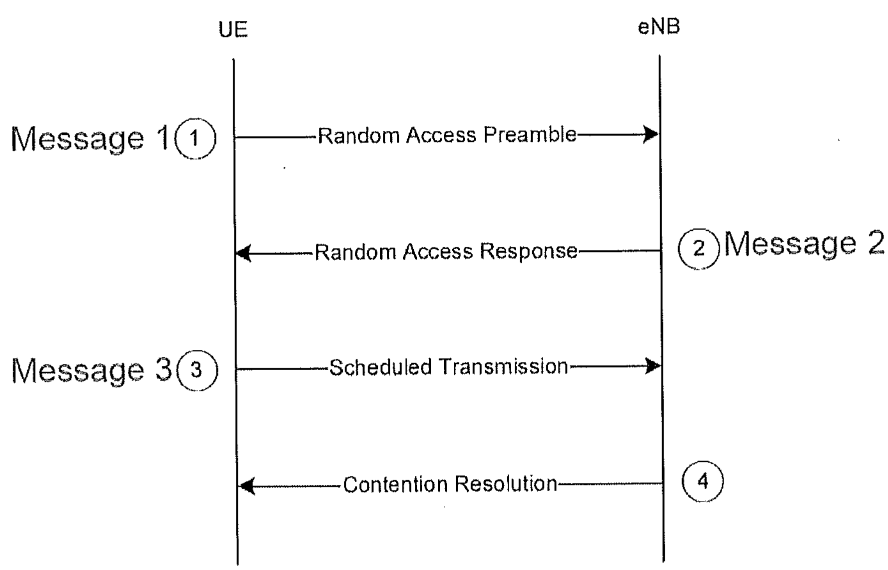



**Figure 10.1.5.1-1: Contention based Random Access Procedure**

38. As shown in Figure 10.1.5.1-1 of TS 36.300, contention-based random access procedure includes four messages: a random-access preamble sent by the UE; a random-access response sent by the eNB; a scheduled uplink transmission from the UE; and a contention resolution (downlink transmission) from the eNB. The '966 patent refers to TS 36.300 in describing the LTE random access procedure in Figures 1B and 1C. ('966 patent, 4:1-4).

39. The random access preamble is transmitted on a physical channel called physical random access channel (PRACH), which has a corresponding transport channel called random access channel (RACH). (TS 36.213, 6.1, p. 12; TS 36.300, §10.1.5.1, p. 48). This preamble transmission is identified in the LTE protocol as Message 1 or "Msg1." The claimed "first message" of claims 2 and 11 of the '966 patent corresponds to this Message 1, which is a random access preamble. The transmit power of the preamble is set to a preamble transmission value. (TS 36.213, 6.1, p. 12). As will be discussed in more detail, open loop power control is used in determining the transmit power of the random access preamble due to the lack of any feedback (e.g., power correction or power control adjustment) parameter. (*Infra* ¶¶ 56-57). According to AAPA of the '966 patent, "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula." ('966 patent, 2:39-40).

40. As shown in Figure 10.1.5.1-1 of TS 36.300, when an eNB receives a random access preamble, the eNB responds with a random access response. This transmission is identified in the LTE protocol as Message 2 or "Msg2." In Message 2, the eNB sends the UE a cell radio network temporary identity (RNTI) and a timing advance value to ensure that all UEs will send signals that arrive at the eNB at the same time. In addition, the eNB assigns the UE an allocation of channel resources on the uplink shared channel. The claimed "second message" of claims 2 and 11 of the '966 patent corresponds to Message 2, which is the random access response.

41. The AAPA of the '966 patent also describes that "the UE transmits a random access preamble and expects a response from the eNB in the form of a so-called **Message 2** (e.g., Random Access Response at FIGS. 1B and 1C). Message 2 is transmitted on a DL [downlink] shared channel DL-SCH (PDSCH, the PDCCH) and **allocates resources on an UL-SCH (PUSCH)**. The resource allocation of Message 2 is addressed with an identity RA-RNTI that is associated with the frequency and time resources of a PRACH, but is common for different preamble sequences. The **Message 2 contains UL [uplink] allocations for the transmissions of a Message 3 in the UL** (e.g., step 3 of the Contention Based Random Access Procedure at FIG. 1B)." ('966 patent, 2:27-38; emphasis added).

42. If the UE transmits a random access preamble but does not receive a random access response within a prescribed period of time, the UE can retransmit the random access preamble. The transmit power for a retransmission, however, is increased by a ramp-up amount. This increase in transmit power helps ensure that the UE's random access preamble will be successfully received by the eNB. (*See* Qualcomm, 9:42-53). Indeed, TS 36.321 §5.1.3 specifies that during Random Access Procedure the UE sends Message 1 with a preamble power determined by the following formula: PREAMBLE_TRANSMISSION_POWER = PREAMBLE_INITIAL_POWER + POWER_RAMP_STEP. The POWER_RAMP_STEP is the incremental power to be used every time the random access is attempted again. A POSITA would understand that POWER_RAMP_STEP parameter is the same as the power ramp-up, $\Delta P_{rampup}$, parameter described in the AAPA of the '966 patent. ('966 patent, Equation [3] 6:18-26).

43. As shown in Figure 10.1.5.1-1 of TS 36.300, after receiving the random access response, the user equipment can respond with a first scheduled transmission on the uplink shared channel. This transmission is identified in the LTE protocol as Message 3 or "Msg3." In the Qualcomm reference, this message is referred to as the "first uplink message sent after successful transmission of the random access preamble ...." (Qualcomm, 10:1-3). The claimed "initial transmit

power" of claims 1 and 9 of the '966 patent corresponds to the transmit power of Message 3.

44. According to AAPA of the '966 patent, "RACH preambles are transmitted by the UEs using a **full path-loss compensation** PC formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. This is needed because several simultaneous preamble transmissions can take place in the same PRACH resource and in order to detect them, their power at the eNB needs to be roughly the same to avoid the well-known near-far problem for spread spectrum transmissions. However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." ('966 patent, 2:39-49; emphasis added). A POSITA would understand the phrase "subsequent uplink transmissions on the PUSCH" in the AAPA refers to the transmission of Message 3 and subsequent uplink transmissions after Message 3. Further, a POSITA would understand the "fractional power control" refers to a fractional path-loss compensation PC formula. The concept of path loss during wireless signal transmission will be discussed in detail below. (*Infra* ¶¶ 46-53).

45. The final step in the random access procedure is for the eNB to send a contention resolution message to the UE indicating that Message 3 was

successfully received. This transmission is identified in the LTE network as Message 4 or "Msg4." This message is not discussed in depth in the '966 patent.

### B. Wireless Signal Path Loss

46. Wireless communications systems must operate in the presence of impairments that limit the ability to communicate and send information at high speeds. Noise is one impairment that is present in every electronic system and sets the theoretical limit for communications. Interference from other users is another impairment that can be controlled to some extent, but generally is another limiting factor in communications. These impairments set the floor for signal strength a receiver can process; the transmitter must generate enough power to overcome these impairments when the signal arrives at the receiver.

47. As a wireless signal propagates from the transmitter to the receiver, there is a reduction of the signal power called "path loss", making it more difficult to detect the wireless signal in the presence of noise and interference. There are several components of this path loss and these path loss components vary based on the time, frequency, and location of the communications.

48. The first component of path loss is called free-space path loss. This refers to the reduction in signal power that would occur if a signal were propagating through space with no obstacles or other objects. As the signal moves through space, the signal energy that is available for detection in any given area

decreases as the inverse square of the distance. Thus, this free-space path loss is sometimes referred to as inverse square law attenuation.

49. In a terrestrial environment, that is, near the Earth's surface, where most wireless transmitters and receivers are located, as opposed to being in space, the path loss encountered by propagating signals increases faster than it would in a free-space environment. This is due to foliage, buildings, and other objects in the environment that attenuate signals. In contrast to free-space path loss, where the signal power is reduced by a factor of $1/r^2$, where r is the path length, in a terrestrial environment, the received signal power may be reduced by a factor of $1/r^{2.5}$ to $1/r^4$ or more. Of course, the transmitter and receiver generally have no means to accurately determine their actual separation and the specifics of the environment that changes path loss, so these models are just estimates of the total path loss.

50. In addition to the path loss caused by distance between the transmitter and receiver, there is a path loss caused by multipath fading. Because objects in the environment cause wireless signals to reflect and refract, there will be multiple copies of the transmitted signal arriving at the receiver over different paths. Because each copy of the signal travels over a different path, the path distance, and therefore the path loss, will be different. In addition, each copy of the signal arrives at a slightly different time, resulting in a different carrier phase shift. This creates

the potential for some of the signals to cancel each other, resulting in path loss that varies with time and specific location. This type of change in path loss is known as multipath fading.

51. In LTE, calculating the transmit power for the uplink shared channel takes into account the path loss between eNB and the user equipment (UE). (TS 36.213, §5.1.1.1, p. 8). Either the full path loss or a fraction of the path loss can be used to calculate the transmit power. The amount of path loss to use is determined based on the α parameter, which is called the path-loss compensation factor. (TS 36.213, §5.1.1.1, p. 8; R1-074704). When $\alpha = 1$, the entire path loss is used in calculating the transmit power, which results in full path loss compensation. ('966 patent, 8:21-25; R1-074704). When $\alpha < 1$, a fractional portion of path loss is used in calculating the transmit power, which results in fractional path loss compensation. The '966 patent also refers to using fractional path loss compensation as fractional power control. ('966 patent, 2:39-49; 10:50-52).

52. The AAPA of the '966 patent admits that prior art 3GPP specifications require RACH preambles to be transmitted using full path loss compensation. ('966 patent, 2:39-40 "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula."). The AAPA of the '966 patent further describes "However subsequent uplink transmissions on the PUSCH are orthogonal, and so called fractional power control can be used." ('966 patent, 2:47-

49). In other words, 3GPP specifications describe that subsequent uplink transmissions on the PUSCH (which includes Message 3) can be transmitted using a fractional path loss compensation. (TS 36.213, §5.1.1.1, p. 8; R1-074704).

53. User equipment is able to calculate a path loss of various received signals since these signals are transmitted from an eNB at known power levels. For example, 3GPP draft proposal R1-074704 describes the path loss ("PL") parameter as "the downlink pathloss calculated in the UE from a RSRP measurement and signaled RS transmit power." (R1-074704, §2.1). A POSITA would understand that the downlink path loss can be calculated by the UE based on the difference between the transmit power of a Reference Signal (RS) from the eNB and received power of the Reference Signal at the UE, which is the Reference Signal Received Power (RSRP).

### C. Transmitter Power Control in Wireless Systems

54. As indicated above, the received signal power of a wireless communication system will constantly vary. If only one transmitter were communicating with one receiver, a transmit power level could be set to guarantee that, at all times, with any amount of path loss, the received signal level would be greater than the background noise and interference at all times. However, in a real system, there can be multiple transmitters and receivers attempting to operate in the same spatial, temporal, and spectral region. To optimize communications, this

means that adjustments must be made to eliminate as much interference as possible.

55. For example, two transmitters may be operating at the same time in adjacent frequency bands with very different path losses to the receiver, perhaps because one transmitter is closer or because it is experiencing less multipath fading, and it has long been recognized in multi-access wireless systems that transmitter power control is needed to equalize the received signal levels. This is the well-known "near-far" problem mentioned in the AAPA of the '966 patent (2:45-46), referring to a transmitter that is near the receiver with a low path loss competing with a transmitter that is far away, creating a high path loss. The coordination problem is made worse because of another well-known "hidden transmitter problem," where one transmitter is "hidden" from the other, undetectable by the first, making impossible to guarantee the two will not transmit at the same time.

56. There are generally two approaches to power control: open loop power control and closed loop power control. In open loop power control, the transmit power is calculated at the transmitter (e.g., at the UE for uplink) based on one or more parameters, and the calculated value is used to set the transmit power level. In particular, the transmit power is adjusted in order to match an estimated

path loss so that the signal is received at the base station at a predetermined power level.

57. Closed loop power control relies on feedback from the receiver (e.g., the eNB for uplink) so that the transmitter (at the UE) knows, for example, at what power level (and sometimes also at what interference level) the transmitted signal was received. Using this feedback (which is also known as a power control adjustment factor), the transmitter (e.g., the UE for uplink) then appropriately adjusts its transmit power level. Alternatively, the receiver may simply order the transmitter to increase or decrease its transmit power. The additionally received feedback information means that closed loop power control is generally more accurate than open loop power control.

58. In many respects, transmit power control on a randomly varying channel is similar to the cruise control on a car – as the car goes up and down a hill (i.e., channel path loss changes with fading), fuel demands (i.e., transmit power) change and must be accounted for to maintain a constant speed (i.e., receive signal level). It is desirable for each car (i.e., transmitter) to maintain a constant speed so traffic (i.e., other transmitters) flows smoothly (i.e., every transmitter's received signal power is the same). The solution to both transmit power control and the car's cruise control is the same – a control system that makes adjustments based on an error signal or a power control adjustment factor. The error signal is the

difference between the observed state and the desired state, whether this is vehicle speed or received signal power level.

# IX. State of the Art: 3GPP Draft Proposals

## A. R1-070870 by NTT DoCoMo (Exhibit 1008)

59. 3GPP draft proposal R1-070870, titled "Transmission Power Control in E-UTRA Uplink" ("R1-070870"), was provided by NTT DoCoMo, NEC, Panasonic, Sharp, and Toshiba at the 3GPP TSG RAN WG1 meeting held in St. Louis, USA (Meeting #48), during February 12 – 16, 2007. The Introduction of R1-070870 states "Transmission power control (TPC) is a key technique to achieve link adaptation. TPC is also effective in decreasing interference to other users. This paper presents TPC schemes for the physical channels in the E-UTRA uplink."

60. R1-070870 describes uplink power control during the Random Access Procedure. Regarding transmitter power control for the random access preamble (Message 1), R1-070870 states "Open-loop-type slow TPC is applied to the non-synchronized RACH preamble similar to that in W-CDMA." (R1-070870, §2.1). "The transmission power of the RACH preamble is decided based on the uplink interference power and **path loss** between a UE and a Node B, which is calculated from the measured average received signal power (or SINR) and transmission power information at the Node B." (*Id.*; emphasis added). And "**Power ramping is applied** when retransmission is performed." (*Id.*; emphasis added). A POSITA

would understand this description in R1-070870 is similar to Equation [3] of the AAPA of the '966 patent, which admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated based on a path loss and a power ramp-up for retransmission:

**Equation [3] of AAPA**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where

$P_{target}$ is the broadcasted target power;
PL is the path loss that UE estimates from DL; and
$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.

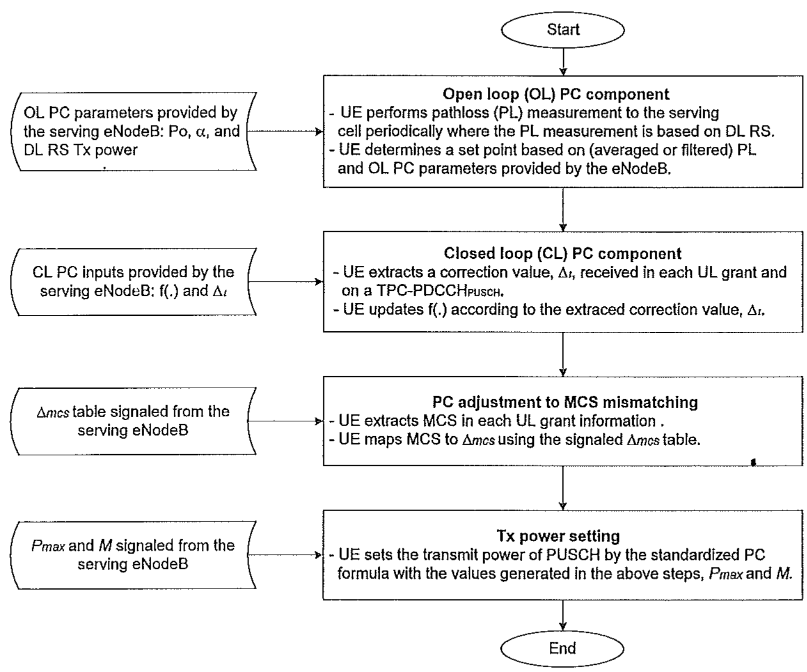
61. Regarding transmitter power control for the random access message part (Message 3), R1-070870 states "the transmission power of message part, i.e. the **initial transmission of the shared data channel**, is decided based on the **transmission power of the preamble part** after power ramping by applying a pre-determined **power spectrum density (PSD) offset**." (*Id.*; emphasis added). A POSITA would understand this description in R1-070870 is similar to Equation (4) of Qualcomm (Exhibit 1003) and Equation [5] of the '966 patent, which calculate the transmission power of Message 3 based on the transmission power of the preamble, a power control command, and a power offset.

**B. R1-074704 by InterDigital (Exhibit 1009)**

62. 3GPP draft proposal R1-074704, titled "Uplink power control procedures and Text Proposal for E-UTRA" ("R1-074704"), was provided by InterDigital Communications, LLC at the 3GPP TSG RAN WG1 meeting held in

Jeju, Korea (Meeting #51), during November 05 – 09, 2007. The Introduction of R1-074704 states "This contribution describes UE and eNodeB behavior for uplink power control."

63. R1-074704 describes two power control components associated with the physical uplink shared channel, PUSCH: "The PUSCH power control has two components, an **open loop** and a **closed-loop** component. Both open and closed loop components run consecutively, but asynchronously." (R1-074704, §2.1). Figure 1 of R1-074704 shows a flow chart for PUSCH power control:




64. According to R1-074704, if PUSCH is transmitted in subframe *i*, it is transmitted with the power $P_{PUSCH}(i)$, which is provided by the equation:

$$P_{PUSCH}(i) = \min(P_{\max}, 10\log_{10}(M) + P_o + \alpha \cdot PL + \Delta_{mcs} + f[\Delta_{PUSCH}(\mathrm{i} - \mathrm{K}_{\mathrm{PUSCH}})]$$

where:

- $P_{\max}$ is the maximum allowed power (in dBm) that depends on the UE power class;
- $M$ is the number of assigned resource blocks as indicated in the UL scheduling grant;
- $P_o$ is a UE specific parameter (in dBm) with 1 dB resolution over the range: [-126dBm, 24dBm];
- $\alpha$ is cell specific path loss compensation factor (can be set to one to allow full path loss compensation) that has 8 values from 0.4 to 1 in steps of 0.1 with one of the possible values being zero;
- $PL$ is the downlink pathloss calculated in the UE from a RSRP measurement and signaled RS transmit power;
- $\Delta_{mcs}$ is signaled by RRC ($\Delta_{mcs}$ table entries can be set to zero); and
- $\Delta_{PUSCH}$ is a UE specific correction value and is included in every N$^{th}$ UL scheduling grant, (where N can be 1), or jointly coded with other UE specific correction values on a TPC-PDCCH$_{PUSCH}$.

(R1-074704, §2.1).

65. A POSITA would understand the above PUSCH power control equation is similar to Equation [1] of the AAPA of the '966 patent, which is reproduced from section 5.1.1.1 of TS 36.213. Notably, R1-074704 describes the α parameter as a "path loss compensation factor" and it "can be set to one to allow full path loss compensation." This description of the α parameter is consistent with the '966 patent, which states "for the case where α = 1 full path loss compensation is used in this Message 3 power, just as for the preamble power." ('966 patent, 8:23-24). Further, R1-074704 describes the PL parameter as "the downlink pathloss calculated in the UE from a RSRP measurement and signaled RS transmit power." A POSITA would understand that the downlink path loss is calculated by

the UE based on the difference between the Reference Signal (RS) transmit power and the Reference Signal Received Power (RSRP).

66. Regarding the open loop component of the PUSCH transmission power control, R1-074704 states "The UE first determines the open loop component based on a filtered linear pathloss estimate, *pl*, from the serving eNodeB to the UE. The pathloss is updated in the power control formula after each downlink RSRP measurement." (R1-074704, §2.1.1).

67. In addition to the open loop component of the PUSCH transmission power control, R1-074704 describes a closed loop component to compensate for open loop errors. "Additionally, the UE applies a closed-loop power correction factor relative to the open loop power, primarily in order to compensate for open loop errors, including the pathloss estimation error due to non-perfect reciprocity in UL and DL in FDD, and the UE impairments due to power amplifier and receiver non-linearities." (R1-074704, §2.1.2). Specifically, the closed loop component (which is the open loop power correction factor) is derived at the UE based on the transmission power control (TPC) command received from the eNB in Message 2. (*Id.*). "When the UE receives one correction command from the serving eNodeB in a UL grant since the last Tx power adjustment, it derives a correction factor, $\Delta_{PUSCH}$, from the received correction command for the next power adjustment." (R1-074704, §2.1.3). A POSITA would understand that the

closed loop correction factor, $\Delta_{PUSCH}$, of R1-074704 is equivalent to the power control command, $\Delta P_{PC}$, of the '966 patent, which also represents the open loop power control error. ('966 patent, 7:1-5).

### C. R1-080612 by Alcatel Lucent (Exhibit 1010)

68. 3GPP draft proposal R1-080612, titled "Reply to RAN2 LS on RACH Power Control Optimisation Use Case" ("R1-080612"), was provided by Jung A. Lee of Alcatel Lucent at the 3GPP TSG RAN WG1 meeting held in Sevilla, Spain (Meeting #51bis), during January 14 – 18, 2008. R1-080612 states "Power control for PRACH was discussed in RAN1#51bis. It was agreed that **open-loop power control** is employed. UE computes the PRACH transmit power based on eNB signalled power control parameters. **Path loss compensation** is applied at the UE based on a measurement of the DL reference signal." (R1-080612, p. 1; emphasis added).

69. Further, R1-080612 describes that PRACH transmit power for transmission of Nth preamble is computed as:

P_ preamble(N_pre) = min(Pmax, PL + Po_pre + (N_pre-1)*dP_rampup);

PL is downlink pathloss;
Po_pre is the desired target (received) power level at the eNB;
N_pre is the number of preambles transmitted, and
dP_rampup is the power ramp-up for preamble retransmission.

A POSITA would recognize the above equation in R1-080612 to be the same as Equation [3] of the AAPA of the '966 patent, which admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated based on a path loss and a power ramp-up for retransmission:

**Equation [3]**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where

$P_{target}$ is the broadcasted target power;
PL is the path loss that UE estimates from DL; and
$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.

70. R1-080612 describes that path loss (PL) in the above PRACH transmit power formula is applied at UE Layer 1. "As a consequence, rather than providing Layer 1 with the desired preamble transmission power, higher layers should provide Layer 1 with the **path-loss-normalized** desired power Po_pre + (N_pre-1)*dP_rampup." (R1-080612, p1). This path-loss normalized PRACH transmit power is specified by TS 36.321 §5.1.3. in the following formula:

PREAMBLE_TRANSMISSION_POWER =
PREAMBLE_INITIAL_POWER + POWER_RAMP_STEP

71. The PREAMBLE_INITIAL_POWER is the target power level the eNB would like to receive for a random access. A POSITA would understand that PREAMBLE_INITIAL_POWER is similar to the Po_pre parameter of R1-080612 and the $P_{target}$ parameter in Equation [3] of the '966 patent. The POWER_RAMP_STEP is the incremental power to be used every time the random access is attempted again. A POSITA would also understand that POWER_RAMP_STEP is similar to the dP_rampup parameter of R1-080612 and the $\Delta P_{rampup}$ parameter in Equation [3] of the '966 patent.

72. According to R1-080612, the RACH power control parameters, i.e. preamble target power level Po_pre, and power step size for retransmission dP_rampup, are signalled from the eNB to the UE. (R1-080612, p. 2).

**D. R1-080879 by Ericsson (Exhibit 1011)**

73. 3GPP draft proposal R1-080879, titled "Uplink power control procedures and Text Proposal for E-UTRA" ("R1-080879"), was provided by Ericsson at the 3GPP TSG RAN WG1 meeting held in Sorrento, Italy (Meeting #52), during February 11-15, 2008. The Introduction of R1-080879 states "This paper proposes a basic parameterized open-loop and power ramping power control principle for PRACH." (R1-080879 at §1).

74. R1-080879 describes that "Power control for the PRACH is needed to reach sufficient received power levels while limiting the generated interference. PRACH power control affects both the physical layer procedures specification [TS 36.213] and the MAC specification [TS 36.321]." (*Id.*). "The PRACH is typically used for transmissions not explicitly controlled by the Node B, but after the UE has read the system information. This mandates an **open loop power control** principle, based on cell specific parameters sent in the system information. As excessive channel quality is of little use for the PRACH, **full pathloss compensation** is used. To increase the success probability for PRACH retransmission, and **compensate**

**for open loop inaccuracies, ramping of the power** for retransmissions may be used." (*Id.* at §2).

75. Notably, R1-080879 states that the RACH preamble power transmission is based on open loop power control using a full path loss compensation. Further, R1-080879 states that **power ramp-up** can be used to compensate for open loop power control error.

## X. U.S. PATENT NO. 8,385,966 ("'966 patent") and Applicant's Admitted Prior Art ("AAPA")

76. As noted above, the AAPA of the '966 patent includes at least FIGs. 1A, 1B, 1C (which are labelled "Prior Art") and descriptions related to those figures. The AAPA also includes 3GPP LTE specifications referenced in the '966 patent, including TS 36.213 (Exhibit 1004), TS 36.300 (Exhibit 1005), TS 36.321 (Exhibit 1006) and description related to those specifications; e.g., 1:24 – 3:6 and 4:21– 6:49 of the '966 patent.

77. The '966 patent relates to determining the transmit power on uplink messages sent from a UE. The '966 patent discloses a way to calculate the transmit power of Message 3 by specifying how UE specific parameters are initialized. ('966 patent, 4:25-27). For all subsequent messages sent on the uplink shared channel (PUSCH) from the UE after Message 3, the '966 patent discloses using the power control equations published in the relevant LTE specifications. (TS 36.213, §5.1.1.1, p. 8). Specifically, the AAPA of the '966 patent admits that TS 36.213

discloses a formula (Equation [1]) for calculating the transmit power on an uplink shared channel ($P_{PUSCH}$) ('966 patent, 4:28-5:35) and a formula (Equation [2]) for calculating the transmit power on an uplink control channel ($P_{PUCCH}$). ('966 patent, 5:36-6:17).

78. The '966 patent states: "However, [TS 36.213] does not specify how the UE specific parameters of the PUSCH and PUCCH power control formulas are initialized." ('966 patent, 4:25-27). Equation [1] of the AAPA of the '966 patent states that $P_{PUSCH}$ is dependent on various parameters, including $P_{O\_PUSCH}$ and f(i). (TS 36.213, §5.1.1.1, p. 8). Equation [1] explains that f(i) is the current PUSCH power control adjustment state and it is dependent on $\delta_{PUSCH}$, which is a **UE specific correction value** and also known as a TPC (transmission power control) command. ('966 patent, 4:62-5:3). Equation [1] further explains that $P_{O\_PUSCH}$ is the sum of $P_{0\_NOMINAL\_PUSCH}$ and $P_{0\_UE\_PUSCH}$, which is a **UE specific component** configured by RRC. (TS 36.213, p. 8; '966 patent, 4:40-50). Thus, Equation [1] specifies that the transmit power on an uplink shared channel ($P_{PUSCH}$) depends on UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(i).

79. Equation [2] of the AAPA of the '966 patent states that the transmit power on an uplink control channel ($P_{PUCCH}$) is dependent on various parameters, including $P_{O\_PUCCH}$ and g(i). (TS 36.213, §5.1.2.1, p. 9). Equation [2] explains that g(i) is the current PUCCH power control adjustment state and it is dependent on

$\delta_{PUCCH}$, which is a **UE specific correction value** and also known as a TPC (transmission power control) command. ('966 patent, 5:54-6:3). Equation [2] further explains that $P_{O\_PUCCH}$ is the sum of $P_{0\_NOMINAL\_PUCCH}$ and $P_{0\_UE\_PUCCH}$, which is a **UE specific component** configured by RRC. (TS 36.213, §5.1.2.1, p. 10; '966 patent, 5:48-53). Thus, Equation [2] specifies that the transmit power on an uplink control channel ($P_{PUCCH}$) depends on UE specific parameters, $P_{0\_UE\_PUCCH}$ and g(i).

80. The '966 patent further admits that except for the UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(i) or g(i)), **"[o]ther parameters of equation [1] are known**: $M_{PUSCH}(i)$ is known from the UE's resource allocation it gets in Message 2; the nominal portion $P_{0\_NOMINAL\_PUSCH}(j)$ of $P_{O\_PUSCH}(j)$ is received in a broadcast in the cell, as is α and $K_S$ from which $\Delta_{TF}(TF(i))$ is calculated; and PL is estimated by the UE itself such as from Message 2. If the UE has started the Random Access procedure in order to make a handover, it has received the parameters $P_{0\_NOMINAL\_PUSCH}(j)$ and α in the handover command. **Similar holds true for equation [2] and PUCCH**." ('966 patent, 10:11-20; emphasis added).

81. The '966 patent attempts to teach the "initialization" of power control formulas for PUSCH and PUCCH. To solve for the unknown, UE specific parameters of Equations [1] and [2] the '966 patent provides Equations [4a] and

[4b]. ('966 patent, 6:58-67). Equation [4a] recites "$P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup}$" and Equation [4b] recites: "$P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$." ('966 patent, 6:65-66). Equations [4a] and [4b] describe how the UE specific parameters of Equations [1] and [2] can be initialized (which means setting the subframe parameter, *i*, to 0). The AAPA of the '966 patent discloses that $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can have an initial value of zero. ('966 patent, 4:40-50; 7:16-21). Accordingly, Equations 4[a] and 4[b] can be rewritten as $f(0) = g(0) = \Delta P_{PC} + \Delta P_{rampup}$. In this instance, a POSITA would recognize that initializing f(0) also initializes g(0) as there is no need to calculate the same formula twice.

82. The '966 patent describes that Equations [4a] and [4b] are used to compensate open loop power control error. ('966 patent, 6:60-67). The open loop power control error is embodied in the power control command, $\Delta P_{PC}$ parameter, which is "the sum of the UE specific power control constants ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and the power control initial states (f(0) and g(0)) ... taking into account the preamble power ramp-up." ('966 patent, 7:1-5). Accordingly, rearranging Equation [4a] to be consistent with this description, $\Delta P_{PC} = P_{0\_UE\_PUSCH} + f(0) - \Delta P_{rampup}$. Further, $\Delta P_{PC}$ is "assumed to be the difference between the target preamble power and the power that eNB actually observes." ('966 patent, 7:5-7). As noted above, prior to the invention of the '966 patent, R1-074704 disclosed using a correction factor, $\Delta_{PUSCH}$, to correct for the open loop power control error.

(*Supra* ¶¶ 62-67). In addition, R1-080879 disclosed that the RACH preamble power transmission is based on open loop power control using a full path loss compensation and that power ramp-up can be used to compensate for open loop power control error. (*Supra* ¶¶ 73-75).

83. Equations [4a] and [4b] of the '966 patent equate the sum of UE specific parameters ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(i) or g(i)) with the sum of $\Delta P_{PC}$ (power control command) and $\Delta P_{rampup}$ (power ramp-up) parameters. Both $\Delta P_{PC}$ and $\Delta P_{rampup}$ parameters were well known to a POSITA by the time of the '966 patent. For example, as noted above, Equations [1] and [2] of AAPA of the '966 patent include a UE specific correction value called a transmission power control (TPC) command, $\delta_{PUSCH}$ or $\Delta_{PUSCH}$, which is included in PDCCH as a part of Message 2 from the eNB. Similar to the TPC command, the '966 patent describes $\Delta P_{PC}$ (power control command) as an information that the UE receives in Message 2, which is the preamble response, from the eNB. A POSITA would understand that the $\Delta P_{PC}$ parameter is the same as the TPC command, $\delta_{PUSCH}$ or $\Delta_{PUSCH}$, specified in Equation [1] of AAPA. (*See* ¶¶ 59-67 above related to 3GPP draft proposals R1-070870 and R1-074704).

84. Also, prior to the time of the '966 patent, TS 36.321 §5.1.3 already specified that during Random Access Procedure the UE sends Message 1 with a preamble power based on a target power level and a power ramp-up step. A

POSITA would understand that power ramp-up step of TS 36.321 is similar to the $\Delta P_{rampup}$ parameter described in the '966 patent. The TS 36.321 specification is AAPA because the '966 patent states "Reference can also be made to 3GPP TS 36.321, v8.0.0 (2007-12), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification (Release 8)." ('966 patent, 2:13-17). In addition, 3GPP draft proposal R1-080879 discloses "To increase the success probability for PRACH retransmission, and **compensate for open loop inaccuracies, ramping of the power** for retransmissions may be used." (R1-080879 at §2, emphasis added; *see also* ¶¶ 68-75 above related to R1-080879 and R1-080612).

85. The UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access response, which is Message 2. Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$.

86. The claims of the '966 patent relate to how the transmit power of Message 3 is determined. The transmit power of Message 3 is referred to as the claimed "initial transmit power." The "initial" description refers to initial message that is sent after a successful transmission of the random access preamble. All messages sent after Message 3 are transmitted with a power control according to Equation [1] of the AAPA of the '966 patent. ('966 patent at 8:42-44 "After transmitting Message 3 or soon after that the UE should move to using Eq. [1] of the normal PUSCH power control.").

87. The claimed "initial transmit power" depends on a preamble power and a power control adjustment state, which is initialized based on Equation [4a]. Specifically, claims 1, 9, and 10 recite the steps described in the flow chart of Figure 4 of the '966 patent. As shown in Figure 4, the "initial transmit power" is calculated based on Equation [5] of the '966 patent, which is in turn derived from Equation [1] of the AAPA of the '966 patent. (*Infra* ¶¶ 179-186). Equation [5] calculates the transmit power of Message 3 based on the preamble power ($P_{preamble}$), the power control command ($\Delta_{PC\_Msg3}$), and a power offset ($\Delta 0_{,preamble\_Msg3}$). ('966 patent, 8:32-34). The independent claims of the '966 patent refer to the power control command as $\Delta P_{PC}$; however, in dependent claims 5 and 14 (and Equation [5]), the parameter $\Delta_{PC\_Msg3}$ is used for power control command. Because both the independent claims and dependent claims 5 and 14 use these parameters for

calculating an initial transmit power of Message 3, $\Delta P_{PC}$ equals $\Delta_{PC\_Msg3}$ for the purposes of the claims of the '966 patent.

88. Equation [5] also refers to additional parameters that are recited in Equations [1] and [2] of the AAPA of the '966 patent but not in the independent claims. $\Delta_{TF}TF(i)$ is a parameter that is calculated from received signaling that can be zero. ('966 patent, 4:54-55). Accordingly, this term effectively drops out of the disclosed equations when the value is zero. $M_{PUSCH}(i)$ is an adjustment to uplink transmit power that depends on an uplink resource allocation. ('966 patent, 4:37-39). The eNB determines the UE's uplink resource allocation and can send the uplink resource allocation to the user equipment in Message 2. ('966 patent, 2:30-36).

89. Thus, the power control equations disclosed in the '966 patent were all known prior to the invention of the '966 patent. As discussed below, Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) teach all of the claimed features of the independent claims, including calculating a transmit power of Message 3 that depends on $\Delta P_{PC}$ + $\Delta P_{rampup}$, as well as preamble power, power control command, and power offset.

## XI. U.S. PATENT NO. 5,599,706 ("Qualcomm")

90. Qualcomm is directed to techniques "for transmitting random access signaling for system access …." (Qualcomm, Abstract). The disclosed techniques

were designed to be used in LTE systems. (Qualcomm, 2:55-3:14). Qualcomm is also directed to determining the transmit power of Message 3 that is part of LTE's random access procedure. (Qualcomm, 10:1-19).

91. The random access preamble discussed in Qualcomm is the same as the "random access request" message claimed in the '966 patent and the random access preamble in Figure 1B. Specifically, they are both messages (Message 1) that are sent by the user equipment to initiate a random access procedure. (Qualcomm, 8:37-40). In response to sending the random access request, the user equipment expects to receive a random access response, which is Message 2. (Qualcomm, Abstract). Both messages, therefore, are consistent with the random access procedure described in the 3GPP LTE specifications.

92. Layer 3 signaling and data messages described in Qualcomm are messages sent after Message 3. Qualcomm does not expressly describe the power used to transmit these messages. One of skill in the art would recognize that TS 36.213 provides a formula that is used to calculate the transmit power for messages on the shared uplink channel. As Qualcomm is directed to calculating the transmit power of Message 3, a POSITA would turn to the LTE specifications on how to determine the transmit power for subsequent messages sent on the uplink shared channel. TS 36.213 is the relevant specification to determine transmit power for messages sent by the user equipment on various channels, such as the shared

channel. Specifically for LTE systems, a POSITA would look to the TS 36.213 specification to calculate the transmit power for subsequent messages.

## XII. 3GPP TS 36.213 v8.2.0 ("TS 36.213")

93. TS 36.213 is part of the LTE specification that describes the physical layer procedures. As part of these procedures, the formulas used to calculate transmit power for messages sent on the physical uplink shared channel and physical uplink control channel are described. A POSITA would turn to TS 36.213 if they wanted to understand the details of the physical layer procedures of LTE. As described above, TS 36.213 is part of AAPA of the '966 patent. (*Supra* ¶ 33).

## XIII. 3GPP TS 36.300 v8.4.0 ("TS 36.300")

94. TS 36.300 is part of the LTE specification that describes LTE radio interface protocol architecture. This specification provides the details of the random access procedure. To understand the detailed information regarding random access procedure discussed in the '966 patent or Qualcomm, and/or the Qualcomm-386, a POSITA would have reviewed TS 36.300. As described above, TS 36.300 is part of AAPA of the '966 patent. (*Supra* ¶ 34).

## XIV. U.S. PATENT PUBLICATION NO. 2010/0093386 ("Qualcomm-386")

95. Qualcomm-386 is directed to "sending messages for system access ...." (Abstract). As part of the described messages, Qualcomm-386 discusses Messages 1 and/or Message 3 having a power headroom and/or buffer size values.

The eNB can use these values, when sent as part of Message 1, to calculate the power control command that is sent to the user equipment in Message 2. Qualcomm-386 is directed to the same type of wireless system, *e.g.,* LTE, as Qualcomm.

## XV. CLAIMS OF THE '966 PATENT

### A. Claims 1, 9, and 10 of the '966 Patent

96. Claims 1, 9, and 10 include features which are taught in Qualcomm and in AAPA of the '966 patent, which include LTE specifications, *e.g.*, TS 36.213. Claims 1, 9, and 10 claim different invention types, method, computer readable memory, and an apparatus, but contain nearly identical features.

97. These claims require initializing f(0) and g(0); calculating an initial transmit power; and sending the third message with the initial transmit power. Qualcomm and AAPA (e.g., TS 36.213) teach all the features of these claims.

#### 1. "compute/computing an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0)"

98. Claims 1, 9, and 10 state the initial transmit power for a third message (Message 3), which is sent on an uplink shared channel (e.g., PUSCH), depends on "the preamble power of a first message" and "the second power control adjustment

state f(0)." In addition, the initial transmit power is computed "using full path loss compensation."

99. Qualcomm teaches calculating the "initial transmit power", which is the transmit power for Message 3, in the form of PUSCH_power. (Qualcomm, 10:1-19 ("PUSCH_power is the transmit power of the message sent on the PUSCH" and is "the transmit power of the first uplink message sent after successful transmission of the random access preamble")). Qualcomm teaches the PUSCH transmit power depends on both the preamble power of the first message sent on a random access channel and the power control adjustment state f(0). For example, Qualcomm discloses "FIG. 10 shows a design of a process 1000 for transmitting a message for system access. A random access preamble may be sent for system access (block 1012). A random access response with a PC correction may be received (block 1014). The transmit power of a message may be determined **based on the PC correction** and possibly other parameters (block 1016). For example, the transmit power of the message may be determined further **based on the transmit power of the random access preamble**, a power offset between a first channel used to send the random access preamble and a second channel used to send the message, etc. The message may be sent with the determined transmit power (block 1018)." (Qualcomm, 13:34-45; emphasis added).

a. **"the initial transmit power depends on a preamble power of a first message sent on an access channel"**

100. Qualcomm discloses a formula for calculating the transmit power for Message 3 (PUSCH_power) in Equation (4): "PUSCH_power = RACH_power + PC_correction + PUSCH_RACH_power_offset." (Qualcomm, 10:1-19).

101. The parameter RACH_power "is the transmit power of the successful transmission of the random access preamble on the RACH [random access channel]." (Qualcomm, 10:12-13). The initial transmit power (PUSCH_power), therefore, depends on the preamble power of the first message, *i.e.,* the transmit power of the random access preamble (RACH_power).

b. **"the initial transmit power depends on ... power control adjustment state f(0)"**

102. As noted above, Equation [4a] of the '966 patent can be rewritten as $f(0) = \Delta P_{PC} + \Delta P_{rampup}$. (*Supra* ¶ 81). Qualcomm discloses that initial transmit power (PUSCH_power) depends on both $\Delta P_{PC}$ and $\Delta P_{rampup}$. For example, TX_power (the transmit power for the random access preamble, or RACH_power; 8:37-9:36) is defined in units of decibels in Equation (2) of Qualcomm. As shown below, TX_power (or RACH_power) depends on the power_ramp_up parameter.

> Equation (2): **TX_power = RACH_power** = -RX_power + interference_correction + offset_power + added_correction + **power_ramp_up**.

103. The power_ramp_up parameter describes the increase in the user equipment's transmit power for subsequent transmissions of the random access preamble. (Qualcomm, 9:45-49). It is used to increase the transmit power of a subsequent random access preamble that is sent when the UE does not receive a response from the eNB from an earlier sent random access preamble. The power_ramp_up parameter is the same as "a ramp-up power for preamble transmissions," *i.e.,* $\Delta P_{rampup}$ of claims 1, 9, and 10 of the '966 patent.

104. Further, the PUSCH_power described in Equation (4) of Qualcomm can be rewritten by substituting the parameter RACH_power with Qualcomm's Equation (2), which describes the transmit power of the preamble. As shown below, after this substitution, the Modified Equation (4) of Qualcomm shows that PUSCH_power depends on power_ramp_up + PC_correction:

Equation (4): PUSCH_power = RACH_power + PC_correction + PUSCH_RACH_power_offset.

Equation (2): TX_power = RACH_power = -RX_power + interference_correction + offset_power + added_correction + power_ramp_up.

**Substituting Equation (2) into Equation (4) to obtain:**
Modified Equation (4): **PUSCH_power** = -RX_power + interference_correction + offset_power + added_correction + **power_ramp_up** + **PC_correction** + PUSCH_RACH_power_offset.

**Rearranging Modified Equation (4) to obtain:**

Modified Equation (4): **PUSCH_power = power_ramp_up + PC_correction** - RX_power + interference_correction + offset_power + added_correction + PUSCH_RACH_power_offset.

105. Qualcomm describes that PC_correction "indicates an amount of increase or decrease in transmit power" and it "is the PC correction received in the random access response" (Qualcomm, 10:20-21; 10:16-17). The random access response (which is Message 2) is the response sent by the eNB after receiving the random access preamble. As noted above, in the '966 patent the UE receives a power control command, $\Delta P_{PC}$, in the preamble response from the eNB, which is Message 2. ('966 patent, 6:58-60). $\Delta P_{PC}$ indicates if the user equipment should increase or decrease its transmit power. Thus, PC_correction is "a power control command indicated in a second message that is received in response to sending the first message," *i.e.*, $\Delta P_{PC}$ of claims 1, 9, and 10 of the '966 patent. Accordingly, the initial transmit power (PUSCH_power) described in Qualcomm also depends on f(0), *i.e.* $\Delta P_{PC} + \Delta P_{rampup}$.

106. As described in the '966 patent, the open loop power control error is "the sum of the UE specific power control constants ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and the power control initial states (f(0) and g(0)) ... taking into account the preamble power ramp-up." ('966 patent, 7:1-5). Specifically, $\Delta P_{PC}$ reflects the open loop power control error. (*Supra* ¶ 82). The PC_correction of Qualcomm may be based on a received signal quality of the random access preamble at the eNB, thus

reflecting an open loop power control error. (Qualcomm, 13:46-47). Therefore, calculating a transmit power or any formula that includes $\Delta P_{PC}$ or PC_correction reflects an "open loop power control error."

107. In addition, it would have been obvious to a POSITA to come up with Equation [4a] based on AAPA of the '966 patent. For example, TS 36.213 discloses an equation for PUSCH transmit power, which is Equation [1] of AAPA:

> **Equation [1]**: $P_{PUSCH}(i) = \min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{O\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(i))(TF(i)) + f(i)\}$ [dBm].

('966 patent, 4:28-5:35; TS 36.213, §5.1.1.1, p. 8).

108. According to AAPA of the '966 patent, the variable $P_{O\_PUSCH}(j)$ is a parameter composed of the sum of two other parameters:

> $\mathbf{P_{O\_PUSCH}(j) = P_{0\_NOMINAL\_PUSCH}(j) + P_{0\_UE\_PUSCH}(j)}$; where,
>
> $P_{0\_NOMINAL\_PUSCH}(j)$ is an 8-bit cell specific nominal component signaled from higher layers for j=0 and 1 in the range of [-126, 24] dBm with 1 dB resolution;
>
> $P_{0\_UE\_PUSCH}(j)$ is a 4-bit **UE specific component** configured by RRC for j=0 and 1 in the range of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7] dB;
>
> j = 0 for PUSCH (re)transmissions corresponding to a configured scheduling grant; and
>
> j = 1 for PUSCH (re)transmissions corresponding to a received PDCCH with DCI format 0 associated with a new packet transmission.

(Emphasis added; TS 36.213, §5.1.1.1; '966 patent, 4:40-50).

109. A POSITA would understand that Equation [1] can be rewritten by expanding $P_{O\_PUSCH}(j)$ and rearranging the terms to obtain:

**<u>Expand</u>** $P_{O\_PUSCH}(j)$ **<u>and rearrange the terms of Equation [1] to obtain:</u>**

➔ **Equation [1]**: $P_{PUSCH}(i) = \min\{P_{MAX}, [10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))] + P_{0\_NOMINAL\_PUSCH}(j) + \alpha \bullet PL + \mathbf{P_{0\_UE\_PUSCH}(j) + f(i)}\}$;

110. As shown above, a POSITA would understand Equation [1] is dependent on UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(i). According to the AAPA of the '966 patent, f(i) is dependent on a parameter, $\delta_{PUSCH}$, which is a **UE specific correction value**, also referred to as a **TPC [transmission power control] command**, and it is included in PDCCH [Message 2]. (TS 36.213, §5.1.1.1; '966 patent, 4:62-5:35).

111. A POSITA would understand when the UE first sends data on the PUSCH, there is no previous subframe and so i = 0. By substituting i = 0 for initial subframe, Equation [1] becomes:

**<u>Substitute i = 0 for initial subframe, Equation [1] becomes:</u>**

➔ **Equation [1]**: $P_{PUSCH}(0) = \min\{P_{MAX}, [10\log_{10}(M_{PUSCH}(0)) + \Delta_{TF}(TF(0))] + \alpha \bullet PL + P_{0\_NOMINAL\_PUSCH}(j) + \mathbf{P_{0\_UE\_PUSCH}(j) + f(0)}\}$.

112. The '966 patent admits that except for the UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), "**Other parameters of equation [1] are known**: $M_{PUSCH}(i)$ is known from the UE's resource allocation it gets in Message 2; the nominal portion $P_{0\_NOMINAL\_PUSCH}(j)$ of $P_{O\_PUSCH}(j)$ is received in a broadcast in the cell, as is α and

$K_S$ from which $\Delta_{TF}(TF(i))$ is calculated; and PL is estimated by the UE itself such as from Message 2. If the UE has started the Random Access procedure in order to make a handover, it has received the parameters $P_{0\_NOMINAL\_PUSCH}(j)$ and $\alpha$ in the handover command. **Similar holds true for equation [2] and PUCCH.**" ('966 patent, 10:11-20; emphasis added).

113. Thus, a POSITA would have been motivated to use other parameters relevant to the Random Access Procedure in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to initialize Equation [1]. Specifically, a POSITA would have been motivated to use parameters that are known to the UE and that allow for transmit power changes. For example, a POSITA would have been motivated to look to TS 36.321, which describes the Random Access preamble transmission power. Indeed, the AAPA of the '966 patent admits "Reference can also be made to 3GPP TS 36.321, V8.0.0 (2007-12), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification (Release 8)." ('966 patent, 2:13-17).

114. TS 36.321 §5.1.3 specifies that during Random Access Procedure the UE sends Message 1 with a preamble power determined by the following formula:

PREAMBLE_TRANSMISSION_POWER =
PREAMBLE_INITIAL_POWER + POWER_RAMP_STEP.

The PREAMBLE_INITIAL_POWER is the target power level the eNB would like to receive for a random access. A POSITA would understand that PREAMBLE_INITIAL_POWER is equivalent to the $P_{target}$ parameter described in the '966 patent. The POWER_RAMP_STEP is the incremental power to be used every time the random access is attempted again. A POSITA would also understand that POWER_RAMP_STEP of AAPA is equivalent to the $\Delta P_{rampup}$ parameter described in the '966 patent. (*Supra* ¶¶ 59-61, 68-72 related to 3GPP Draft Proposals R1-080612 and R1-070870).

115. A POSITA would understand this description of preamble power in TS 36.321 §5.1.3 is similar to Equation [3] of the AAPA of the '966 patent, which admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated based on a path loss and a power ramp-up for retransmission:

**Equation [3] of AAPA**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where

$P_{target}$ is the broadcasted target power;
PL is the path loss that UE estimates from DL; and
$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.

116. Accordingly, a POSITA would have been motivated to use a parameter known to the UE and that allows for transmit power change, such as the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to calculate Equation [1].

117. Besides the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, a POSITA would also have been motivated to look to the power control command, $\delta_{PUSCH}$, which is sent to the UE via the Random Access Response or Message 2, to replace the unknown UE specific parameters in calculating Equation [1]. According to the '966 patent, "the UE receives a power control command (e.g., $\Delta P_{PC}$) in the preamble response from the eNB, which is Message 2." ('966 patent, 6:58-60). A POSITA would understand that $\delta_{PUSCH}$ of the AAPA is equivalent to the $\Delta P_{PC}$ parameter described in the '966 patent.

118. The UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access Response, which is Message 2. Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. Accordingly, Equation [4a] of the '966 patent simply uses two parameters, $\Delta P_{PC}$ and $\Delta P_{rampup}$, known to the UE in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), for calculating $P_{PUSCH}(0)$.

c. **"depends on"**

119. In the context of the '966 patent, the claim term "depends on" means both direct dependency and indirect dependency. That is to say, the initial transmit power can depend directly on a parameter or depend indirectly on a parameter. This reading of "depends on" is consistent with the claims and the specification of the '966 patent.

120. For example, dependent claims 5 and 14, which depend from claims 1 and 10, provide an equation (which is Equation [5] of the '966 patent) for the initial transmit power:

**Equation [5]**: $P_{Msg3} = \min\{P_{MAX}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10 \log 10(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$

121. Claims 1 and 10 recite "wherein the initial transmit power depends on **a preamble power** of a first message sent on an access channel and the second power control adjustment state **f(0)**." (emphasis added) Because claims 5 and 14 are dependent claims, they must include the limitations of their independent claims; e.g., the limitation that an initial transmit power depends on the preamble power and f(0). Equation [5] shows an initial transmit power that directly depends on $P_{preamble}$ ("the preamble power of the first message") and $\Delta_{PC\_Msg3}$, which is "a power control command received at the receiver," *i.e.*, $\Delta P_{PC}$. (*Supra* ¶¶ 87).

122. However, Equation [5] does not show an initial transmit power that directly depends on f(0), which is $\Delta P_{rampup} + \Delta P_{PC}$. Specifically, Equation [5] does not include the $\Delta P_{rampup}$ parameter. The $\Delta P_{rampup}$ parameter, however, is part of the

preamble transmission power equation: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$. (Equation [3] '966 patent). No other parameter in Equation [5] has a relationship with $\Delta P_{rampup}$. Rewriting Equation [5], by expanding the $P_{preamble}$ term and substituting $\Delta P_{PC}$ for $\Delta_{PC\_Msg3}$, shows that the initial transmit power does depend on f(0) where $f(0) = \Delta P_{rampup} + \Delta P_{PC}$:

**Modified Equation [5]**: $P_{Msg3} = \min\{P_{MAX}, P_{target} + PL + \mathbf{\Delta P_{rampup}} + \mathbf{\Delta P_{PC}}$ $\Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10 \log10(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;

123. Thus, exactly as described in Qualcomm, Equation [5] of the '966 patent "depends on" the $\Delta P_{rampup}$ parameter as part of both the preamble power and the f(0) component. Such a reading is consistent with independent claims 1 and 10. Any other definition of "depends" would cause an inconsistency between claims 1 and 10 and their respective dependent claims; *i.e.,* Equation [5] would otherwise not depend on $\Delta P_{rampup}$.

124. As discussed above, PUSCH_power as described in Qualcomm depends on both the preamble power, *i.e.,* RACH_power, and f(0), *i.e.,* $\Delta P_{PC} + \Delta P_{rampup}$ or PC_correction + power_ramp_up. The power_ramp_up parameter is part of both the preamble power and f(0). In this manner, the initial transmit power (PUSCH_power) of Qualcomm depends directly on a preamble power and depends indirectly on the power_ramp_up parameter.

d. **"compute/computing an initial transmit power for the uplink shared channel using full path loss compensation"**

125. In the context of the '966 patent, the terms "path loss", "pathloss", and "PL" are used interchangeably and they all refer to the downlink path loss estimate calculated by the UE. Specifically, the '966 patent states "PL is the downlink pathloss estimate calculated in the UE" ('966 patent, 4:53) and "PL is the path loss that UE estimates from DL." ('966 patent, 6:24).

126. In addition, the term "full path loss compensation" means that the entire estimated PL (as opposed to a fractional portion of estimated PL) is used in the power control calculation. In the '966 patent, the preamble power (Equation [3]) is calculated using the entire path loss (PL), i.e., with an $\alpha$ value equal to 1. ('966 patent, 6:18-22; compare Equation [3] with Equation [1] of the '966 patent). The '966 patent admits that "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula." ('966 patent, 2:39-40). The '966 patent further describes the existing preamble power control formula in Equation [3]: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$. Thus, Equation [3] is described as using a "full path loss compensation" because it uses the entire estimated value of "PL" and not just a fractional portion of estimated "PL".

127. The initial transmit power (PUSCH_power) in Equation (4) of Qualcomm also uses full path loss compensation because it uses the entire value of "PL" in the power control formula. The preamble power described in Qualcomm is based on the entire path loss. First, the preamble power is calculated using an open

loop method. (Qualcomm, 8:37-39*)*. The '966 patent admits that preamble power is calculated using full path loss compensation in an open loop method. ('966 patent, 2:39-40; 6:60-62; 7:3-4). In contrast, a closed loop method implies that the power is determined based on a feedback parameter; e.g., a power correction value. (*Supra* ¶¶ 57).

128. As discussed above, path loss (PL) is the difference or ratio between transmit power and the receive power of a signal. (*Supra* ¶¶ 51-53). And in the context of the '966 patent, "path loss" or "PL" refers to the downlink path loss estimate calculated by the UE. The parameter PL does not expressly appear in Qualcomm Equation (1), but its components, *i.e.* transmit power of a reference signal ($P_{TX}^{eNB}$) and the received power of the reference signal ($P_{RX}^{UE}$), are disclosed. According to Equation (1) of Qualcomm, $P_{TX}^{eNB}$ "is the transmit power of the reference signal from the recipient eNB" and $P_{RX}^{UE}$ "is the received power at the UE for time-frequency slots used for a reference signal (*e.g.*, a pilot signal) from the recipient eNB." (Qualcomm, 8:49-51; 8:58-59). Thus, the path loss for the downlink reference signal can be calculated at the UE as $PL = P_{TX}^{eNB} / P_{RX}^{UE}$, or the difference of the power values in the logarithm domain.

129. As shown in Qualcomm, Equation (2) of the preamble power includes both $P_{TX}^{eNB}$ and $P_{RX}^{UE}$. The parameter RX_power is $P_{RX}^{UE}$ written in the logarithm domain. The parameter offset_power parameter includes $P_{TX}^{eNB}$ in the logarithm

domain. Accordingly, rewriting Equation (2) with the RX_power and offset_power values expanded and rearranging the terms:

> **Modifiled Equation (2)**: TX_power = $[10\log_{10}(\mathbf{P_{TX}}^{eNB}) - 10\log_{10}(\mathbf{P_{RX}}^{UE})]$ + interference_correction + $10\log_{10}(SNR_{target})$ + $10\log_{10}(N_0+I_{oc}^{eNB})$ + added_correction + power_ramp_up.

The path loss in Modified Equation (2) is $PL = [10\log_{10}(P_{TX}^{eNB}) - 10\log_{10}(P_{RX}^{UE})]$. The entire path loss is used ($\alpha = 1$) because there is no fractional portion in the equation, so the preamble power uses full path loss compensation. Because the transmit power of Message 3, which is Equation (4) in Qualcomm, uses the preamble power, the transmit power of Message 3 is also calculated using full path loss compensation.

**2. "initialize/initializing for i = 0 a first power control adjustment state g(i) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error"**

130. Claims 1, 9, and 10 recite initializing a first power control adjustment state g(0), but do not define the formula g(0) or the general formula g(i). Dependent claims 3 and 12 though do provide an example of g(0) in the form of $P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$. The AAPA of the '966 patent also provide that $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can be equal to 0. (*Infra* ¶¶ 152-153). Accordingly, initializing for i = 0 a first power control adjustment state g(i) and a second power control adjustment state f(i) leads to $g(0) = f(0) = \Delta P_{PC} + \Delta P_{rampup}$.

131. The parameters f(i) and g(i) are disclosed in the AAPA and TS 36.213 as "power control adjustment state." ('966 patent, 4:65-5:35, 6:1-17; TS 36.213, §5.1.1.1, §5.1.2.1). The parameter f(i) is the power control adjustment state relevant to messages sent on the uplink shared channel; the parameter g(i) is the power control adjustment state relevant to messages sent on the uplink control channel. The Qualcomm reference does not expressly show these power control adjustment states using the same terminology. A POSITA, however, would understand that Qualcomm teaches these states and/or would look at least to TS 36.213 in regards to the two claimed power control adjustment states. As the claims only require that g(0) is initialized and that f(0) can be equal to g(0), Qualcomm teaches initializing both f(0) and g(0). TS 36.213 makes explicit what a POSITA would have known, i.e., that f(i) exists for use in calculating power for a shared channel and that g(i) exists for use in calculating power for a control channel. (TS 36.213, §5.1.1.1, p. 9; and §5.1.2.1, p. 10). The teachings of Qualcomm combined with the teachings of TS 36.213 allow UE to "efficiently transmit the random access preamble and signaling for system access," while maintaining compatibility with the LTE standards such as TS 36.213. (Qualcomm, 1:45-47). Such a combination, therefore, would be obvious to a POSITA in creating a more efficient random access signaling that is compliant with the LTE specifications.

132. As described above, when calculating the transmit power of Message 3, the value f(0) is initialized and calculated. Because f(0) and g(0) can be the exact same formula and were both disclosed in TS 36.213, calculating f(0) also calculates g(0). Accordingly, Qualcomm discloses initializing for i = 0 a first power control adjustment state g(i) and a second power control adjustment state f(i) as $f(0) = g(0) = \Delta P_{PC} + \Delta P_{rampup}$. (*Supra* ¶¶ 102-118).

**3. "sending from a transmitter a third message on the uplink shared channel at the initial transmit power"/"outputting the initial transmit power for transmission of a third message on the uplink shared channel"/"compile a third message to be sent on the uplink shared channel at the initial transmit power"**

133. Qualcomm discloses calculating a "transmit power of the first uplink message sent after successful transmission of the random access preamble…" (Qualcomm, 10:1-3). Equation (4) of Qualcomm defines the variable PUSCH_power as "the transmit power of the message sent on the PUSCH." (Qualcomm, 10:14-15). PUSCH is a physical uplink shared channel. (Qualcomm, Table 1; 4:24-25). Qualcomm, therefore, teaches sending a third message on an uplink shared channel at the calculated transmit power, as claimed.

134. As described in Qualcomm, the invention can be implemented using various technologies such as software, computer-readable media, processors, methods, etc. (Qualcomm, 14:6-10; 37-44; 52-60). Accordingly, the transmit

power calculation for Message 3 described in Qualcomm could be implemented as a method, computer-readable medium, or an apparatus.

135. Qualcomm describes that its disclosed inventions can be used in an LTE system. (Qualcomm, 3:3-10). Further, Qualcomm relies on LTE terminology and examples in describing the disclosed inventions. (Qualcomm, 3:10-14). In reviewing Qualcomm, a POSITA would also be familiar with or reference the LTE specifications available on the 3GPP website. The LTE specifications define how equipment, such as user equipment, operates to be compatible with LTE. Accordingly, a POSITA reading about the random access procedure described in Qualcomm that can be used in an LTE system would naturally be familiar with and look to LTE specifications, such as 3GPP TS 36.213 and TS 36.300. Combining teachings from Qualcomm and AAPA would achieve rational and expected results, user equipment that is compliant with and can successfully operate in an LTE system.

136. Based on the above, Qualcomm and TS 36.213 disclose, suggest, or teach the features of independent Claims 1, 9, and 10. Specifically, Qualcomm provides the claim features added to the independent claims during prosecution to overcome the prior art rejections, namely addition of the equation: $P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup}$. Equation (4) of Qualcomm defines a transmit power for Message 3 that depends on a preamble transmit power, a PC correction (which is

$\Delta P_{PC}$ in the claimed equation as defined in the claim) and a power_ramp_up value (which is $\Delta P_{rampup}$ in the claimed equation). Thus, Qualcomm and TS 36.213 disclose, suggest, or teach the claimed features of Claims 1, 9, and 10, including the same equation added by Patent Owner during prosecution to overcome prior art rejections.

### B. Claims 3 and 12 of the '966 Patent

137. Claims 3 and 12 include features which are taught in Qualcomm and in LTE specifications, *e.g.,* TS 36.213. Claims 3 and 12 initialize the first power control adjustment state g(0) as $P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$. The '966 patent admits that calculation of power control adjustment states f(i) and g(i) can use the same formula. ('966 patent, 5:1-3 and 6:1-3). Specifically, Equations [1] and [2] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.1.1, disclose $f(i) = f(i-1) + \delta_{PUSCH}(i- K_{PUSCH})$ where f(0) = 0, and $g(i) = g(i-1) + \Delta_{PUCCH}(i- K_{PUCCH})$ where g(0) = 0 ( *Id.*)

138. As described above for claims 1, 9 and 10, calculating the initial transmit power includes initializing f(0). As $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can be equal to zero, the Equations f(0) and g(0) can be equal to one another, *i.e.* $f(0) = g(0) = \Delta P_{PC} + \Delta P_{rampup}$. (*See* claims 4 and 13). Accordingly, calculating f(0) as $\Delta P_{PC} + \Delta P_{rampup}$ also teaches calculating the initial state of g(0) as $\Delta P_{PC} + \Delta P_{rampup}$.

139. In addition, it would have been obvious to a POSITA to come up with Equation [4b] based on AAPA of the '966 patent. For example, TS 36.213 discloses an equation for PUSCH transmit power, which is Equation [2] of AAPA:

**Equation [2]**: $P_{PUCCH}(i) = \min\{P_{MAX}, P_{O\_PUCCH} + PL + \Delta_{TF\_PUCCH}(TF) + g(i)\}$[dBm].

('966 patent, 5:39-40; TS 36.213, §5.1.2.1).

140. According to AAPA of the '966 patent, the variable $P_{O\_PUCCH}$ is a parameter composed of the sum of two other parameters:

$\mathbf{P_{O\_PUCCH} = P_{0\_NOMINAL\_PUCCH} + P_{0\_UE\_PUCCH}}$; where,

$P_{0\_NOMINAL\_PUCCH}$ is a 5-bit cell specific parameter provided by higher layers in the range of [-127, -96] dBm with 1 dB resolution;

$P_{0\_UE\_PUCCH}$ is a **<u>UE specific component</u>** configured by RRC in the range of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7] dB.

(TS 36.213, §5.1.2.1; '966 patent, 5:48-54).

141. A POSITA would understand that Equation [2] can be rewritten by expanding $P_{O\_PUCCH}$ and rearranging the terms to obtain:

**<u>Expand</u>** $P_{O\_PUCCH}$ **<u>and rearrange the terms of Equation [2] to obtain:</u>**

➔ **Equation [2]**: $P_{PUCCH}(i) = \min\{P_{MAX}, P_{0\_NOMINAL\_PUCCH} + PL + \Delta_{TF\_PUCCH}(TF) + \mathbf{P_{0\_UE\_PUCCH} + g(i)}\}$.

142. As shown above, a POSITA would understand Equation [2] is dependent on UE specific parameters, $P_{0\_UE\_PUCCH} + g(i)$. According to the AAPA of the '966 patent, g(i) is dependent on a parameter, $\delta_{PUCCH}$ or $\Delta_{PUCCH}$, which is a

**UE specific correction value**, also referred to as a **TPC [transmission power control] command**, and it is included in PDCCH [Message 2]. (TS 36.213, §5.1.2.1; '966 patent, 5:54-6:17).

143. A POSITA would understand when the UE first sends data on the PUCCH, there is no previous subframe and so i = 0. By substituting i = 0 for initial subframe, Equation [2] becomes:

**Substitute i = 0 for initial subframe, Equation [2] becomes:**

➔ **Equation [2]**: $P_{PUCCH}(0) = \min\{P_{MAX}, P_{0\_NOMINAL\_PUCCH} + PL + \Delta_{TF\_PUCCH}(TF) + \mathbf{P_{0\_UE\_PUCCH} + g(0)}\}$.

144. The '966 patent admits that except for the UE specific parameters, $P_{0\_UE\_PUCCH} + g(0)$, "**Other parameters of equation [1] are known**: $M_{PUSCH}(i)$ is known from the UE's resource allocation it gets in Message 2; the nominal portion $P_{0\_NOMINAL\_PUSCH}(j)$ of $P_{O\_PUSCH}(j)$ is received in a broadcast in the cell, as is α and $K_S$ from which $\Delta_{TF}(TF(i))$ is calculated; and PL is estimated by the UE itself such as from Message 2. If the UE has started the Random Access procedure in order to make a handover, it has received the parameters $P_{0\_NOMINAL\_PUSCH}(j)$ and α in the handover command. **Similar holds true for equation [2] and PUCCH.**" ('966 patent, 10:11-20; emphasis added).

145. Thus, a POSITA would have been motivated to use other parameters relevant to the Random Access Procedure in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH} + g(0)$, to initialize Equation [2]. Specifically, a POSITA

would have been motivated to use parameters that are known to the UE and that allow for transmit power changes. For example, a POSITA would have been motivated to look to TS 36.321, which describes the Random Access preamble transmission power. Indeed, the AAPA of the '966 patent admits "Reference can also be made to 3GPP TS 36.321, V8.0.0 (2007-12), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification (Release 8)." ('966 patent, 2:13-17).

146. TS 36.321 §5.1.3 specifies that during Random Access Procedure the UE sends Message 1 with a preamble power determined by the following formula:

PREAMBLE_TRANSMISSION_POWER =
PREAMBLE_INITIAL_POWER + POWER_RAMP_STEP

The PREAMBLE_INITIAL_POWER is the target power level the eNB would like to receive for a random access. A POSITA would understand that PREAMBLE_INITIAL_POWER is equivalent to the $P_{target}$ parameter described in the '966 patent. The POWER_RAMP_STEP is the incremental power to be used every time the random access is attempted again. A POSITA would also understand that POWER_RAMP_STEP of AAPA is equivalent to the $\Delta P_{rampup}$ parameter described in the '966 patent. (*Supra* ¶¶ 59-61, 68-72 related to 3GPP Draft Proposals R1-080612 and R1-070870).

147. A POSITA would understand this description of preamble power in TS 36.321 §5.1.3 is similar to Equation [3] of the AAPA of the '966 patent, which admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated based on a path loss and a power ramp-up for retransmission:

**Equation [3] of AAPA**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where

$P_{target}$ is the broadcasted target power;
PL is the path loss that UE estimates from DL; and
$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.

148. Accordingly, a POSITA would have been motivated to use a parameter known to the UE and allows for transmit power change, such as the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH} + g(0)$, to initialize and calculate Equation [2].

149. Besides the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, a POSITA would also have been motivated to look to the power control command, $\delta_{PUCCH}$ or $\Delta_{PUCCH}$, which is sent to the UE via the Random Access Response or Message 2, to replace the unknown UE specific parameters in calculating Equation [1]. According to the '966 patent, "the UE receives a power control command (e.g., $\Delta P_{PC}$) in the preamble response from the eNB, which is Message 2." ('966 patent, 6:58-60). A POSITA would understand that $\delta_{PUSCH}$ of the AAPA is equivalent to the $\Delta P_{PC}$ parameter described in the '966 patent.

150. The UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access Response, which is Message 2. Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. Accordingly, Equation [4b] of the '966 patent simply uses two parameters, $\Delta P_{PC}$ and $\Delta P_{rampup}$, known to the UE in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH}$ + g(0), for calculating $P_{PUCCH}(0)$.

### C. Claims 4 and 13 of the '966 Patent

151. Claims 4 and 13 recite features which are part of applicant admitted prior art (AAPA) relating to existing random access procedure that is disclosed in LTE specifications, e.g., TS 36.213.

152. Claim 1 provides that f(0) depends on $P_{0\_UE\_PUSCH}$ and claim 3 provides that g(0) depends on $P_{0\_UE\_PUCCH}$. The '966 patent admits that both of these values can be 0. ('966 patent, 7:16-18). Equation [1] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.1.1, discloses $P_{0\_UE\_PUSCH}$ (j) is a 4-bit UE specific component configured by RRC for j=0 and 1 in the range

of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, **0**, 1, 2, 3, 4, 5, 6, 7] dB. ('966 patent, 4:40-50).

153. Equation [2] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.2.1, discloses $P_{0\_UE\_PUCCH}(j)$ is a UE specific component configured by RRC in the range of [-8, 7] dB with 1 dB resolution; *i.e.*, a range of [-8, -7, -6, -5, -4, -3, -2, -1, **0**, 1, 2, 3, 4, 5, 6, 7] dB. ('966 patent, 5:48-53).

154. Accordingly, the recited features of claims 4 and 13 are disclosed in the AAPA; specifically, TS 36.213 §5.1.1.1 and §5.1.2.1.

### D. Claims 2 and 11 of the '966 Patent

155. Claims 2 and 11 include additional features which are part of AAPA (existing random access procedure) and taught in Qualcomm and in LTE specifications, *e.g.,* TS 36.213 and TS 36.300.

156. Claims 2 and 11 recite the first message is a random access request message. Qualcomm teaches this. In Qualcomm the first message is referred to as a random access preamble. (Qualcomm, 8:38-40). This is also how the '966 patent and TS 36.300 refer to the first message sent from the user equipment in a contention based random access procedure. ('966 patent, Figure 1B and 4:1-4, TS 36.300, Fig. 10.1.5-1).

157. Claims 2 and 11 further recite that the preamble power is computed using full path loss compensation. Here, preamble power refers to the random

access preamble power used to transmit the RACH preamble. ('966 patent, claim 1). The '966 patent admits that existing random access procedure discloses this limitation. ('966 patent, 2:39-40 "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula."). As described above, Qualcomm teaches calculating the preamble transmit power using the full path loss, *i.e.*, the difference between the transmit power of a reference signal and the receive power at the user equipment of the reference signal. *(Supra* ¶¶ 125-129). Because the entire estimated path loss of the reference signal is used to calculate the preamble power, the preamble power is computed using full path loss compensation.

158. Claims 2 and 11 also recite transmitting the first message on an access channel and in response receiving the second message that includes an allocation of resources that are used to transmit Message 3. The random access preamble of Qualcomm is sent on a random access channel (RACH). (Qualcomm, 4:19-20 and 13:16-20). The '966 patent admits that existing random access procedure discloses "the UE transmits a **random access preamble** and expects a response from the eNB in the form of a so-called **Message 2** (e.g., Random Access Response at FIGS. 1B and 1C). Message 2 is transmitted on a DL [downlink] shared channel DL-SCH (PDSCH, the PDCCH) and **allocates resources** on an UL-SCH (PUSCH). The **resource allocation of Message 2** is addressed with an identity RA-RNTI that is associated with the frequency and time resources of a PRACH,

but is common for different preamble sequences. The Message 2 contains **UL [uplink] allocations for the transmissions of a Message 3** in the UL (e.g., step 3 of the Contention Based Random Access Procedure at FIG. 1B)." ('966 patent, 2:27-38; emphasis added).

159. Qualcomm describes that an eNB responds to receiving a random access preamble by sending a random access response. (Qualcomm, 6:16-18). This message can include "UL [uplink] resources" that "indicate resources granted to the UE for uplink transmission." (Qualcomm, 6:26-27; *See also* TS 36.300, §10.1.5.1, p. 49 (initial UL grant)). Message 3 is an uplink transmission and these UL resources would be used to transmit Message 3. (TS 36.300, §10.1.5.1, p. 49 (transport blocks depends on the UL grant conveyed in step 2)). The uplink resources mentioned in Qualcomm are the same as those from TS 36.300. They are both received by the user equipment in a random access response message sent by an eNB that has successfully received a random access preamble from the user equipment. While Qualcomm mentions that the uplink resources are "for uplink transmission," TS 36.300 specifically notes that one such uplink transmission is the transmission of Message 3. (TS 36.300, §10.1.5.1, p. 49).

160. Finally, claims 2 and 11 recite that an updated transmit power for the uplink shared channel using fractional power control is computed and that a message after Message 3 is sent on the uplink shared channel using the updated

transmit power. The '966 patent admits that existing random access procedure discloses "RACH preambles are transmitted by the UEs using a **full path-loss compensation PC** formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. *** However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." ('966 patent, 2:39-49; emphasis added).

161. Also, these last two elements of claims 2 and 11 are simply a verbal description of the TS 36.213 PUSCH transmit power function. (TS 36.213, §5.1.1.1, p. 8). This function, also recited verbatim in the '966 patent, is $P_{PUSCH}(i) = \min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{0\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(i))(TF(i)) + f(i)\}$ [dBm].

162. The term α, which can be a value less than 1 represents the fractional power control element. Fractional power control as used in the '966 patent is when some amount less than the entire estimated path loss is used. ('966 patent, 7:54-57 and 8:50-53). The '966 patent admits that Equation [1], *i.e.,* the $P_{PUSCH}$ Equation from TS 36.213, can use "fractional" path loss rather than "full path loss." ('966 patent, 7:47-53). The fractional component described in the prior art $P_{PUSCH}$ Equation is $\alpha$. *As* α can be less than 1, $\alpha \bullet PL$ represents calculating the power for messages that are transmitted subsequent to Message 3 on the shared uplink channel, PUSCH, with a fractional power control.

163. The $P_{PUSCH}$ Equation in TS 36.213 describes the power used to transmit message on a shared uplink channel, PUSCH. (TS 36.213, §5.1.1.1). Qualcomm, however, describes an enhancement to TS 36.213 where the transmit power of Message 3 is based on the preamble power, a power control correction, and a power offset, similar to Equation [5] of the '966 patent. Qualcomm, however, is silent on the transmission power for messages sent after Message 3. A POSITA would recognize, based at least on Qualcomm's disclosure, that the PUSCH formula as described in TS 36.213, §5.1.1.1, would be used to calculate the transmit power for messages sent after Message 3. The techniques described in Qualcomm can be used in a 3GPP LTE system. (Qualcomm, 3:3-10). Further, Qualcomm relies on system access in LTE to explain the disclosed embodiments. (Qualcomm, 3:12-14). Accordingly, specifications related to LTE would be highly relevant to anyone implementing the embodiments disclosed in Qualcomm.

164. For example, to determine transmit power for uplink messages subsequently sent after Message 3 in an LTE system, a POSITA would turn to the 3GPP LTE documentation; specifically, a POSITA would reference the TS 36.213 and TS 36.300 specifications that describe the physical layer procedures and the power used to transmit messages over the physical layer. Using TS 36.213 to calculate the transmission power for messages sent after Message 3 would ensure that the UE operated consistently with TS 36.213. Further, TS 36.300 simply

makes explicit what is implied in Qualcomm. The uplink resources that are granted to the user equipment as described in Qualcomm are used in transmitting Message 3. (TS 36.300, p. 49; Qualcomm, 6:26-27). Qualcomm and TS 36.300 are consistent in that the uplink resources are received by the user equipment in a random access response. (*Id.*). While Qualcomm only notes that the uplink resources are "for uplink transmission," TS 36.300 makes explicit that the uplink resources are used in transmitting Message 3. (*Id.*).

165. Qualcomm describes that its disclosed inventions can be used in an LTE system. (Qualcomm, 3:3-10). Further, Qualcomm relies on LTE terminology and examples in describing the disclosed inventions. (Qualcomm, 3:10-14). Because Qualcomm is silent on how to calculate the transmit power for messages after Message 3, a POSITA would have to look to other sources for calculating the transmit power for subsequent messages. A POSITA would naturally turn to the 3GPP specifications for an LTE system. Combining the transmit power calculation of Message 3 with the transmit power for subsequent messages described in the LTE specifications would be obvious to a POSITA. The teachings of Qualcomm combined with the teachings of TS 36.213 and TS 36.300 allow user equipment to "efficiently transmit the random access preamble and signaling for system access," while maintaining compatibility with the LTE standards such as TS 36.213 and TS 36.300. (Qualcomm, 1:45-47). Such a combination, therefore, would be obvious to

a POSITA in creating a more efficient random access signaling that is compliant with the LTE specifications.

### E. Claims 5 and 14 of the '966 Patent

166. Claims 5-8 and 14-17 include additional features that are taught in Qualcomm, TS 36.213, and the Qualcomm-386. Dependent claims 5 and 14 recite a specific function, *i.e.,* Equation [5] for calculating the transmit power for Message 3. (*See* '966 patent, 8:15-17).

**Equation [5]**: $P_{Msg3} = \min\{P_{max}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$.

#### 1. "$P_{max}$"

167. $P_{max}$ refers to "the maximum allowed power that depends on the UE power class." ('966 patent, 4:35-36). The idea of ensuring that the Message 3 transmit power does not exceed $P_{max}$ is well known in the telecommunications world. As one example, TS 36.213 includes a similar check to ensure that the transmit power cannot exceed $P_{max}$. (TS 36.213, §5.1.1.1, p. 8).

#### 2. "$\Delta_{TF}(TF(i))$"

168. The parameters 10 log10($M_{PUSCH}$(i)) + $\Delta_{TF}$(TF(i)) are also directly from the TS 36.213 transmit power formula. (TS 36.213, §5.1.1.1, p. 8). As noted by TS 36.213 and acknowledged by the '966 patent, $\Delta_{TF}$(TF(i)) can be equal to zero. (*See* '966 patent, 4:54-56; 8:18-19). This effectively removes $\Delta_{TF}$(TF(i)) from the Equation. The claimed formula, therefore, can be rewritten as

**Equation [5]**: $P_{Msg3} = \min\{P_{max}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log_{10}(M_{PUSCH}(i))\}$.

169. As detailed below, the disclosures of Qualcomm, TS 36.213 and the Qualcomm-386 teach the claimed $P_{Msg3}$ formula in Equation [5] of the '966 patent.

### 3. "$P_{preamble}$"

170. Equation (4) of Qualcomm teaches the transmit power of Message 3 (PUSCH_power) is calculated based on RACH_power parameter, which is transmit power of a successfully received random access preamble. (Qualcomm, 10:12-13). This RACH_power parameter is the same as the claimed $P_{preamble}$. (*See* '966 patent, 6:18-21).

### 4. "$\Delta_{PC\_Msg3}$"

171. The '966 patent Equation [5] includes parameter $\Delta_{PC\_Msg3}$, which "is the power control command included in the preamble response (*e.g.*, Message 2)." ('966 patent, 8:32-35). Similarly, the parameter PC_correction used in Qualcomm's Equation (4) "is the PC correction received in the random access response." (Qualcomm, 10:16-17). Accordingly, the PC_correction parameter is the same as the $\Delta_{PC\_Msg3}$ parameter. *Supra* ¶ 87 (discussing $\Delta_{PC\_Msg3} = \Delta_{PC}$).

### 5. "$\Delta_{0,preamble\_Msg3}$"

172. The '966 patent Equation [5] includes parameter $\Delta_{0,preambie\_Msg3}$ which is "an offset from the preamble power" (claim 5) and "corresponds to a typical power offset between a Message 3 and the preamble whose power corresponds to

the detection threshold." ('966 patent, 8:26-28). The parameter PUSCH_RACH_power_offset used in Qualcomm's Equation (4) "is a power offset between the PUSCH and RACH." (Qualcomm, 10:18-19). The random access preamble is sent on a random access channel (RACH). (Qualcomm, 4:19-20; 4:38-41; and 6:14-15). PUSCH is a physical uplink shared channel and is used to transmit Message 3. (Qualcomm, 4:24-25, 10:14-15). Thus, PUSCH_RACH_power_offset as used in Qualcomm corresponds to a power offset between a message sent on a PUSCH, *e.g.,* Message 3, and a power used to transmit a successful random access preamble. Accordingly, the parameter PUSCH_RACH_power_offset in Qualcomm is the same as the claimed parameter $\Delta_{0,preamble\_Msg3}$.

### 6. "$10\log_{10}(M_{PUSCH}(i))$"

173. Equation (4) from Qualcomm does not expressly include the $10\log_{10}(M_{PUSCH}(i))$ expression. The $10\log_{10}(M_{PUSCH}(i))$ expression, however, is still present in Equation (4) as part of the PC_correction parameter.

174. As noted above, the AAPA and TS 36.213 power control formula disclose the parameters 10log10($M_{PUSCH}$(i)). ('966 patent, Equation [1]; TS 36.213, §5.1.1.1). The expression $10 \log_{10}(M_{PUSCH}(i))$ describes the "size of the PUSCH resource assignment expressed in number of resources blocks valid for subframe *i*." ('966 patent, 4:37-39). This means that the transmit power is determined based

on the number of resources that the user equipment will use to transmit data. A POSITA would recognize that transmit power goes up as the number of resources is increased. Accordingly, transmit power calculations in LTE will take into account the number of resources that the user equipment will use to transmit data. One way the transmit resources can be used in power calculations is by the user equipment incorporating these resources in its power calculations. This is how PUSCH power calculations are done in TS 36.213. (TS 36.213, §5.1.1.1, p. 8). Alternatively, the eNB determines the resources to grant to the user equipment and sends the uplink grant to the user equipment in a random access response. (TS 36.300, §10.1.5.1, p. 49). The eNB, therefore, knows the uplink resources that the user equipment will use to transmit data to the eNB.

175. In the random access response, the eNB can also modify the transmit power used by the user equipment to transmit a message through various mechanisms, such as the power control correction value. (*See* Qualcomm, 10:16-17). The eNB can take into account the uplink resources granted to the user equipment in determining the power control correction value. (*See* Qualcomm-386, ¶¶ [0057]-[0067]). Incorporating the uplink resources in the calculation of the power control correction value has the same effect as the user equipment adjusting its transmit power based on the granted uplink resources. That effect is the transmit power of messages sent on the PUSCH is adjusted based on the uplink resources

granted to the user equipment. Thus, calculating, at the eNB, the transmit power adjustment due to the granted resources yields the predictable results of the user equipment's transmit power being adjusted due to the granted resources. The eNB knows of the resources granted to the user equipment and the eNB transmits a power control correction value to the user equipment. It is simply a design choice as to where the granted resources are used to adjust the transmit power.

176. The Qualcomm-386, whose inventors are the same as the Qualcomm patent, describes such a system where the eNB's power control adjustment can take into account the uplink resources granted to user equipment. In the Qualcomm-386, user equipment can calculate a power headroom or buffer size values that can be sent to the eNB as part of the random access preamble. (Qualcomm-386, ¶¶ [0036] and [0040]-[0041]). These values can be used to calculate both the uplink resource grant and the power control information. (Qualcomm-386, ¶¶ [0108], [0112], and [0118]).

177. As noted above, as resources required to transmit a message increase, *e.g.,* the larger the message, so does the power requirements to transmit that message. When user equipment uses more power, power control becomes more critical as increasing the transmit power can cause more interference with other user equipment and/or eNBs. This is why the Qualcomm-386 notes that the benefits of power control are greater when Message 3 is large. (Qualcomm-386, ¶

[0100]). As the benefits of power control are greater when Message 3 is large, the Qualcomm-386 teaches that the power control information takes into account the granted uplink resources, via the buffer size information. (Qualcomm-386, ¶¶ [0108], [0112], and [0118]).

178. The combination of relied upon teachings of the Qualcomm-386 with the features of Qualcomm and TS 36.213 would have been obvious to a POSITA. First, all three references are related to the same technical subject, *e.g.,* LTE system access. These references also focus on the same system access messaging used to access an LTE system. The Qualcomm power control function, *e.g.*, Equation (4), includes an adjustment based on power control information received from the eNB but does not expressly include a parameter that depends on the uplink granted resources. However, as noted in the Qualcomm-386 the benefits of power control are greater when Message 3 is large. Further, the power control information described in the Qualcomm-386 takes into account the resources granted to the user equipment. A POSITA would find the combination of using the power control information described in the Qualcomm-386 with the teachings of Qualcomm to be obvious. Specifically, a POSITA would use power control information from the Qualcomm-386 to take into account the uplink resource grant in calculating the transmit power for Message 3. Further, a POSITA would recognize the ability to use the uplink resources to adjust the PUSCH transmit

power based on TS 36.213. (TS 36.213, §5.1.1.1, p. 8). Qualcomm-386 is consistent with TS 36.213 for the same reasons as Qualcomm because Qualcomm-386 describes a way UE can access an LTE system. Accordingly, a POSITA would find it obvious to combine the teachings from LTE specifications, e.g., TS 36.213 and TS 36.300, to ensure compatibility with LTE.

179. In addition, a POSITA having the knowledge of Equation (4) of Qualcomm, which teaches the transmit power of Message 3 (PUSCH_power) can be calculated based on the preamble power, a power control correction, and a power offset from the preamble power, would find it obvious to derive Equation [5] based on Equation [1] of the '966 patent, which is reproduced from the admitted prior art TS 36.213.

180. According to the '966 patent, Equation [5] "defines the Message 3 power relative to preamble power, i.e., full path loss compensation used." ('966 patent, 8:7-11; 8:23-24 "for the case where $\alpha = 1$ full path loss compensation is used in this Message 3 power, just as for the preamble power."). In addition, as noted above, Qualcomm teaches calculating the preamble power based on the full path loss compensation. Thus, in deriving Equation [5], a POSITA would naturally set $\alpha = 1$ because full path loss compensation is used. Further, the '966 patent admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated according to Equation [3]:

**Equation [3]**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where

$P_{target}$ is the broadcasted target power;
PL is the path loss that UE estimates from DL; and
$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.

181. A POSITA would recognize and rearrange Equation [3] above to solve for PL:

**Rearrange Equation [3] and solve for PL:**

➔ **Equation [3]**: $PL = P_{preamble} - P_{target} - \Delta P_{rampup}$.

182. Further, a POSITA would set α = 1 (full path loss compensation) and substitute PL of Equation [3] into Equation [1] to obtain:

**Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i)) + P_{O\_PUSCH}(j) + \alpha \bullet PL + f(i)\}$.

**Set α = 1 (full path loss compensation) and substitute PL of Equation [3] into Equation [1]:**

➔ **Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i)) + P_{O\_PUSCH}(j) + P_{preamble} - P_{target} - \Delta P_{rampup} + f(i)\}$.

183. According to the '966 patent and its admitted prior art, TS 36.213 v8.2.0, $f(i) = \delta_{PUSCH}(i- K_{PUSCH})$ if f(*) represents current absolute value; and $\delta_{PUSCH}$ is a **UE specific correction value**, also referred to as a **TPC (transmission power control) command** and it is included in PDCCH (Message 2). (TS 36.213 v8.2.0, §5.1.1.1; '966 patent, 4:62-5:35). A POSITA would substitute $f(i) = \delta_{PUSCH}(i- K_{PUSCH})$ into Equation [1]. Also, because $\delta_{PUSCH}$ is a UE specific correction value

also known as a TPC (transmission power control) command, a POSITA would simplify the expression $\delta_{PUSCH}(i- K_{PUSCH})$ as $\Delta_{TPC}$.

**Substitute $f(i) = \delta_{PUSCH}(i- K_{PUSCH})$ into Equation [1]:**

➔ **Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i)) + P_{O\_PUSCH}(j) + P_{preamble} - P_{target} - \Delta P_{rampup} + \delta_{PUSCH}(i- K_{PUSCH})\}$;

**Rearrange Equation [1]and simplify the expression $\delta_{PUSCH}(i- K_{PUSCH})$ as $\Delta_{TPC}$:**

➔ **Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, P_{preamble} + [P_{O\_PUSCH}(j) - P_{target} - \Delta P_{rampup}] + \Delta_{TPC} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;

184. In addition, based on the teaching of Equation (4) of Qualcomm, which teaches the transmit power of Message 3 (PUSCH_power) can be calculated based on the preamble power, a power control correction, and a power offset from the preamble power, a POSITA would simplified the above equation by defining a power offset from the preamble, in the form of Power_Offset = $P_{O\_PUSCH}(j) - P_{target} - \Delta P_{rampup}$ to obtain a Modified Equation [1].

**Define Power_Offset = $P_{O\_PUSCH}(j) - P_{target} - \Delta P_{rampup}$ and substitute into Equation [1] to obtain:**

➔ **Modified Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, P_{preamble} + Power\_Offset + \Delta_{TPC} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;

**Equation [5]**: $P_{Msg3} = \min\{P_{MAX}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log 10(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;

185. A POSITA would recognize that the Modified Equation [1], which is derived from Equation [1] of the '966 patent (AAPA) and based on the teachings of Equation (4) of Qualcomm, is identical to Equation [5] of the '966 patent.

Specifically, a POSITA would recognize that the Power_Offset parameter of Modified Equation [1] is the same as the $\Delta_{0,preamble\_Msg3}$ parameter of Equation [5]. The '966 patent states that $\Delta_{0,preamble\_Msg3}$ is an offset from the preamble power (claim 5) and $\Delta_{0,preamble\_Msg3}$ is a typical power offset between a Message 3 and the preamble whose power corresponds to the detection threshold ('966 patent, 8:26-28). A POSITA would understand that the Power_Offset parameter (which equals $P_{O\_PUSCH}(j)$ - $P_{target}$ - $\Delta P_{rampup}$) represents a power offset from the preamble power because it includes parameters such as $P_{target}$ and $\Delta P_{rampup}$ for calculating the preamble power.

186. Also, a POSITA would recognize that the $\Delta_{TPC}$ parameter of Modified Equation [1] is the same as the $\Delta_{PC\_Msg3}$ parameter of Equation [5]. For example, the '966 patent states that $\Delta_{PC\_Msg3}$ is the power control command included in the preamble response (Message 2). ('966 patent, 8:32-34). The '966 patent and its admitted prior art, TS 36.213 v8.2.0, specify that $\Delta_{TPC}$ is a UE specific correction value also known as a TPC (transmission power control) command and it is included in PDCCH (Message 2). ('966 patent, 4:62-64). Thus, a POSITA would understand that the parameter, $\Delta_{TPC}$, is the same as the $\Delta_{PC\_Msg3}$ parameter described in Equation [5] of the '966 patent.

### F. Claims 6 and 15 of the '966 Patent

187. Dependent claims 6 and 15 recite features which are part of AAPA relating to existing random access procedure that is disclosed in LTE specifications, e.g., TS 36.213. Specifically, the equation recited in claims 6 and 15 is identical to Equation [1] of the '966 patent, which is reproduced from existing 3GPP specification TS 36.213. ('966 patent, 4:28-5:35; TS 36.213 v8.2.0, §5.1.1.1).

188. The '966 patent also admits that existing random access procedure discloses "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. This is needed because several simultaneous preamble transmissions can take place in the same PRACH resource and in order to detect them, their power at the eNB needs to be roughly the same to avoid the well-known near-far problem for spread spectrum transmissions. However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." ('966 patent, 2:39-49; emphasis added).

189. Dependent claims 6 and 15 include features that are related to those in claims 2 and 11. Specifically, claims 6 and 15 recite computing an updated transmit power for the shared uplink channel using fractional power control and

sending a message after Message 3 with the updated transmit power. Accordingly, the discussion regarding claims 2 and 11 are relevant to understanding how the features of claims 6 and 15 are taught in the prior art. These paragraphs are not repeated here. (*See supra* ¶¶ 155-164).

190. Different from claims 2 and 11 is the use of a specific formula to calculate the updated transmit power. The claimed formula is the exact formula from TS 36.213. (TS 36.213, §5.1.1.1, p. 8). This function, also recited verbatim in the '966 patent, is $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{O\_PUSCH}(j) + \alpha \cdot PL + \Delta_{TF}(TF(i)) + f(i)\}$ [dBm].

191. This function was also discussed regarding claims 2 and 11 in terms of how this formula teaches using "fractional power control." (*See supra* ¶¶ 160-162).

### G. Claims 7 and 16 of the '966 Patent

192. Dependent claims 7 and 16 further narrow claims 6 and 15 by setting $\alpha = 1$ for the transmission of Message 3 and all retransmissions of Message 3, and setting $\alpha < 1$ for all subsequent messages and retransmissions of Message 3 indicating fractional path loss compensation.

193. As claims 7 and 16 recite that retransmissions of Message 3 can be sent using both an $\alpha = 1$ and $\alpha < 1$, a POSITA would understand these claims to mean that Message 3 can be retransmitted with either $\alpha$ value and that the transmit

power will reflect either full path loss compensation, *i.e.,* $\alpha = 1$, or a fractional path loss compensation, *i.e.*, $\alpha < 1$.

194. As noted above with regard to claim 1, Qualcomm teaches using the full path loss compensation for calculating the initial Message 3 power. (Qualcomm, 8:37-40, 10:1-19). The Message 3 power therefore indicates a full path loss compensation. In addition, this power would be used for all retransmissions of Message 3.

195. For messages subsequent to the initial transmission of Message 3, the formula from TS 36.213 is used, which includes $\alpha < 1$or $\alpha = 1$. (TS 36.213, §5.1.1.1, p. 8). This formula would also be used for calculating retransmissions of messages after Message 3.

196. As described above with regard to claims 2 and 11, combining these teachings together would have been obvious to a POSITA. (*See supra* ¶¶ 163-165).

**H. Claims 8 and 17 of the '966 Patent**

197. Dependent claims 8 and 17 further narrow Message 3 to include an indication of a power difference between the initial transmit power using full path loss compensation and a fractional path loss computation of the initial transmit power.

198. TS 36.213 provides an example of a fractional path loss computation of the initial transmit power. (TS 36.213, §5.1.1.1, p. 8). This function is discussed

above with regard to claims 2, 6, 11, and 15. (*See supra* ¶¶ 189-191). The '966 patent acknowledges that a transmit power calculated from the TS 36.213 Equation is computed using fractional path loss. ('966 patent, 8:51-53). In some cases, the fractional path loss transmit power will simply be the maximum allowed power for the user equipment. (TS 36.213, §5.1.1.1, p. 8).

199. Qualcomm-386 teaches sending a power headroom value in Message 3. (Qualcomm-386, ¶ [0097]). The power headroom can indicate "the difference between the maximum transmit power at the UE and the transmit power used for the first message." (Qualcomm-386, ¶ [0108]). Thus, the power headroom indicates the difference between the transmit power of Message 3 that is based on full path loss compensation, *i.e.,* the PUSCH power formula from Qualcomm, and a value that corresponds with the TS 36.213 Equation, which is the fractional path loss compensation of the initial transmit power. Further, as described above the initial transmit power of Message 3, *e.g.*, the first message sent after a successful random access preamble, is calculated using full pass loss compensation, i.e., based upon the entire estimated path loss. (Qualcomm, 8:37-39).

200. Based on my review and above analysis of the prior art, it is my opinion that claims 1-17 of the '966 patent are invalid. A claim chart of my analysis is attached as **Appendix B**.

201. I declare under penalty of perjury that the foregoing is true and correct. Executed this 27th day of May, 2017.

Robert Akl

Dr. Robert Akl, D.Sc.

# APPENDIX A

# Robert Akl, D.Sc.

## Professional Summary

Dr. Akl has over 20 years of industry and academic experience. He is currently a Tenured Associate Professor at the University of North Texas and a Senior Member of IEEE. He has designed, implemented, and optimized both hardware and software aspects of several wireless communication systems for CDMA, WiFi, and sensor networks. Dr. Akl has broad expertise in wireless communication, Bluetooth, CDMA/WCDMA network optimization, GSM, LTE, VoIP, telephony, computer architecture, and computer networks. He is a very active researcher and is well published and cited. He has been awarded many research grants by leading companies in the industry and the National Science Foundation. He has developed and taught over 100 courses in his field. Dr. Akl has received several awards and commendation for his work, including the 2008 IEEE Professionalism Award and was the winner of the 2010 Tech Titan of the Future Award.

Dr. Akl has extensive experience with patents in the wireless and networking industry. In the past ten years, he has worked as a technical expert in dozens of patent related matters, involving thousands of hours of research, investigation, and study. He has repeatedly been qualified as an expert by Courts, and has provided numerous technology tutorials to Courts, and given testimony by deposition and at trial. He has worked with companies large and small, both for and against the validity and infringement of patents, and has also helped counsel and Courts to understand technology that often seems complex. In doing so, he has become familiar with, and actively worked with, the legal principles that underlie patentability and validity and claim interpretation in the wireless and networking industries.

## Areas of Expertise

2G, 3G, 4G, CDMA/WCDMA, GSM, UMTS, LTE, Ad-hoc Networks, Bluetooth, Call Admission Control, Channel Coding, Computer Architecture, Multi-cell Network Optimization, Packet-networks, Telephony, VoIP, Wi-Fi, Wireless Communication, Wireless Sensors.

## Education

| Year | College/University | Degree | GPA |
|---|---|---|---|
| 2000 | Washington University in Saint Louis | D.Sc. in Electrical Engineering | **4.0 / 4.0** |
| 1996 | Washington University in Saint Louis | M.S. in Electrical Engineering | **4.0 / 4.0** |
| 1994 | Washington University in Saint Louis | B.S. in Electrical Engineering | **4.0 / 4.0** |
| 1994 | Washington University in Saint Louis | B.S. in Computer Science | **4.0 / 4.0** |

Graduated *summa cum laude* and ranked first in undergraduate class.
Dissertation: "Cell Design to Maximize Capacity in Cellular Code Division Multiple Access (CDMA) Networks." Advisors: Dr. Manju Hegde and Dr. Paul Min.

## Litigation Support and Expert Witness Experience

L1. 2017 **Pillsbury Winthrop Shaw Pittman LLP**
Case: HTC Corp and ZTE (USA) v. Cellular Communications Equipment
IPR2017-xxx, IPR2017-xxx
Matter: *Inter Partes* Review, LTE, power control, emergency notification
Project: Two declarations to support two IPR petitions

L2. 2017 **Alston & Bird LLP**
Case: Itron, Inc. and Duke Energy Corp. v. Smart Meter Technologies
IPR2017-01199
Matter: *Inter Partes* Review, power meter
Project: Declaration to support IPR petition

L3. 2017 **Haynes and Boone, LLP**
Case: Ericsson Inc. v. Regents of the University of Minnesota
IPR2017-01186, IPR2017-01200, IPR2017-01213
Matter: *Inter Partes* Review, OFDM and MIMO
Project: Three declarations to support three IPR petitions

L4. 2017 **Quinn Emanuel Urquhart & Sullivan, LLP**
Case: GENBAND US, LLC v. Metaswitch Networks Ltd, et al.
Eastern district of Texas, Marshal division, Case No. 2:16-cv-582-JRG-RSP
Matter: Patent infringement, Internet protocols and VoIP
Project: Expert report regarding essentiality

L5. 2017 **Mayer Brown LLP**
Case: Uniloc USA, Inc. et al. v. Avaya Inc., and ShoreTel, Inc., et al.
Eastern district of Texas, Tyler division, Case Nos. 6:15-cv-1168-JRG
Matter: Patent infringement, instant messaging and conference calling
Project: Source code review, non-infringement consulting

L6. 2017 **Fish & Richardson P.C.**
Case: Nokia Solutions and Networks US LLC, et al. v. Huawei Technologies Co. Ltd., et al.
Eastern district of Texas, Marshal division, Case Nos. 2:16-cv-753-JRG-RSP, 2:16-cv-754
Matter: Patent infringement, 4G LTE
Project: Claim construction, two declarations

L7. 2017 **Rothwell Figg Ernst & Manbeck, PC**
Case: Samsung v. Rembrandt Wireless
Matter: *Ex Parte* Reexamination, Bluetooth
Project: Validity consulting

L8. 2016 **Sidley Austin LLP**

Case: Huawei Technologies Co., et al. v. Samsung Electronics Co, et al. and Samsung Research America v. Hisilicon Technologies Co, LTD
Northern district of California, San Francisco division, Case No. 3:16-cv-2787-WHO

Matter: Patent infringement, 3G/4G LTE

Project: Source code review, validity and invalidity consulting

L9. 2016 **Bragalone Conroy PC**

Case: Securus Technologies, Inc. v. Global Tel*Link Corporation
CBM2017-00034

Matter: Covered Business Method Review, call monitoring and recording

Project: Declaration to support CBM petition

L10. 2016 **Braxton, Hilton & Perrone PLLC**

Case: Biosonix, LLC. v. Hydrowave, LLC et al.
Eastern district of Texas, Case No. 2:16-cv-139-RC

Matter: Patent infringement, underwater transceivers

Project: Claim construction, Markman hearing testimony

L11. 2016 **Gray Reed & McGraw**

Case: Optis Cellular Technology, LLC and PanOptis Patent Management, LLC. v. Blackberry Corporation, et al.
Eastern district of Texas, Marshal division, Case No. 2:16-cv-59-JRG-RSP, Case No. 2:16-cv-61-JRG-RSP, Case No. 2:16-cv-62-JRG-RSP

Matter: Patent infringement, LTE

Project: Claim construction, three declarations regarding claim construction, deposition

L12. 2016 **Davidson Berquist Jackson & Gowdey**

Case: SIPCO, LLC et al v. Emerson Electric Co. et al
Eastern district of Texas, Tyler division, Case No. 6:15-cv-907
Emerson Electric Co. et al v. SIPCO, LLC et al.
Northern district of Georgia, Atlanta division, Case No. 1:15-cv-00319-AT

Matter: Patent infringement, links in wireless networks and remote monitoring

Project: Source code review, invalidity consulting

L13. 2016 **McKool Smith**

Case: Regents of University of Minnesota v. AT&T Mobility LLC, et al.
District of Minnesota, Case No. 0:14-cv-04666-JRT-TNL

Matter: Patent infringement, LTE and MIMO

Project: Non-infringement and invalidity consulting, declaration

L14. 2016 **EIP US LLP**
Case: GENBAND US, LLC et al. v. Metaswitch Networks Ltd
IPR2015-01456, IPR2015-01457
Matter: *Inter Partes* Review, media gateways
Project: Two declarations to support Patent Owner, two depositions

L15. 2016 **Haynes and Boone, LLP**
Case: Cox Communications, Inc. v. AT&T Intellectual Property I, II, LP
IPR2015-01187, IPR2015-01227, IPR2015-01273, IPR2015-01536
Matter: *Inter Partes* Review, cable networks
Project: Four declarations to support Patent Owner, four depositions

L16. 2016 **Mayer Brown LLP**
Case: Odyssey Wireless v. Motorola Mobility LLC
Eastern district of North Carolina, Western division, Case No. 5:14-cv-491-D
Southern district of California, Case No. 3:15-cv-01741-H-RBB
Matter: Patent infringement, LTE
Project: Source code review, non-infringement consulting

L17. 2016 **Cooley LLP**
Case: Saint Lawrence Comm. LLC v. Motorola Mobility LLC, ZTE (USA) Inc.
Eastern district of Texas, Marshal division, Case No. 2:15-cv-000351-JRG, Case No. 2:15-cv-000349-JRG
Matter: Patent infringement, speech coding and decoding
Project: Invalidity expert report, expert report regarding AMR-WB standard, expert report regarding Opus and Silk, supplemental expert report regarding invalidity, two-day depositions, jury trial testimony for Motorola

L18. 2015 **Sidley Austin LLP**
Case: Evolved Wireless, LLC v. Microsoft Corp, et al.
District of Delaware, Case No. 15-cv-546
Matter: Patent infringement, LTE
Project: Prior art and invalidity consulting

L19. 2015 **McKool Smith**
Case: Optis Wireless Technology, LLC and PanOptis Patent Management, LLC. v. ZTE Corporation and ZTE (USA) Inc.
Eastern district of Texas, Marshal division, Case No. 2:15-cv-300-JRG-RSP
Matter: Patent infringement, cellular messages and multimedia attachments
Project: Source code review, claim construction, declaration

L20. 2015 **Fish & Richardson, P.C.**
Case: Saint Lawrence Comm. LLC v. LG Elec., Inc. et al.
Eastern district of Texas, Marshal division, Case No. 2:14-cv-1055-JRG
Matter: Patent infringement, speech coding and decoding
Project: Invalidity expert report

L21. 2015 **Finnegan Henderson Farabow Garrett & Dunner LLP**
Case: LG Electronics, Inc. v. Cellular Communications Equipment LLC
IPR2016-00178
Matter: *Inter Partes* Review, LTE
Project: Declaration to support IPR petition

L22. 2015 **McKool Smith**
Case: AT&T, et al. v. Cox Communication, Inc., et al.
District of Delaware, Case No. 14-1106-GMS
Matter: Patent infringement, cable networks
Project: Claim construction, declaration

L23. 2015 **McKool Smith**
Case: Ericsson Inc., et al. v. TCL Communication, et al.
Eastern district of Texas, Marshal division, Case No. 2:15-cv-00011-RSP
Matter: Patent infringement, wireless devices and systems
Project: Source code review, claim construction, declaration, infringement expert report, validity expert report, two-day depositions

L24. 2015 **Foley & Lardner LLP**
Case: Kyocera Communications, Inc. v. Cellular Communications Equipment LLC
IPR2015-01559, IPR2015-01564
Matter: *Inter Partes* Review, LTE
Project: Two declarations to support two IPR petitions

L25. 2015 **Fish & Richardson, P.C.**
Case: Fairfield Industries Inc. v. Wireless Seismic, Inc.
Southern district of Texas, Case No. 4:14-cv-02972-KPE
Matter: Patent infringement, wireless sensor networks
Project: Non-infringement expert report

L26. 2015 **Quinn Emanuel Urquhart & Sullivan, LLP**
Case: GENBAND US, LLC v. Metaswitch Networks Ltd, et al.
Eastern district of Texas, Marshal division, Case No. 2:14-cv-33-JRG-RSP
Matter: Patent infringement, Internet protocols and VoIP
Project: Expert report regarding essentiality, non-infringement expert report,

rebuttal expert report regarding non-practice, supplemental rebuttal expert report, three-day depositions, jury trial testimony

L27. 2015 **Foley & Lardner LLP; Duane Morris LLP**
Case: Mobile Telecommunications Technologies, LLC v. Leap Wireless International, Cricket Communications, Inc.
Eastern district of Texas, Marshal division, Case No. 2:13-cv-00885-RSP
Matter: Patent infringement, OFDM and MIMO
Project: Non-infringement expert report, deposition

L28. 2015 **Hogan Lovells US LLP; Kenyon & Kenyon LLP**
Case: One-E-Way v. Beats Electronics, LLC, Sony Corporation, et al.
In the Matter of Certain Wireless Headsets, ITC Investigation No. 337-TA-943
Matter: Patent infringement, wireless communication
Project: Claim construction, declaration

L29. 2015 **McKool Smith**
Case: Solocron Media, LLC v. AT&T Inc., et al.
Eastern district of Texas, Marshal division, Case No. 2:13-cv-1059-JRG
Matter: Patent infringement, ringtone download
Project: Claim construction, claim invalidity expert report

L30. 2015 **EIP US LLP**
Case: Good Technology Software, Inc. v. Mobile Iron, Inc.
IPR2015-00833, IPR2015-00836, IPR2015-01090
Matter: *Inter Partes* Review, software management in wireless devices
Project: Three declarations to support three IPR petitions

L31. 2015 **McKool Smith**
Case: AirWatch LLC v. Good Technology Corp
Northern district of Georgia, Case No. 1:14-cv-02281-SCJ
Matter: Patent infringement, software management in wireless devices
Project: Claim construction, declaration

L32. 2015 **Simpson Thacher & Bartlett LLP**
Case: IXI Mobile (R&D) Ltd. et al. v. Apple Inc.
Southern district of New York, Case No. 14-cv-7594-RJS
Matter: Patent infringement, PDA and Bluetooth
Project: Invalidity consulting

L33. 2014 **Bragalone Conroy PC**

Case: Global Tel*Link Corporation v. Securus Technologies, Inc.
IPR2014-00785, IPR2014-00810, IPR2014-00824, IPR2014-00825, IPR2014-01278, IPR2014-01282, IPR2014-01283

Matter: *Inter Partes* Review, VoIP call monitoring and recording, allocating telecommunication resources and information systems

Project: Seven declarations to support seven Patent Owner's responses, five depositions

L34. 2014 **Orrick, Herrington & Sutcliffe LLP**

Case: Shopkick, Inc. v. Novitaz, Inc.
IPR2015-00277, IPR2015-00278

Matter: *Inter Partes* Review, wireless customer service management

Project: Two declarations to support two IPR petitions

L35. 2014 **Paul Hastings LLP**

Case: Cellular Communications Equipment LLC v. AT&T, et al.
Eastern district of Texas, Tyler division, Case No. 6:13-cv-507-LED (Lead Case for Consolidation)

Matter: Patent infringement, 3G cellular communication

Project: Claim construction, declaration

L36. 2014 **Baker Botts LLP**

Case: Orlando Communications LLC v. AT&T, et al.
M.D. Florida, Case No. 6:14-cv-01021

Matter: Patent infringement, 3G/4G cellular communication

Project: Non-infringement and claim construction consulting

L37. 2014 **EIP US LLP**

Case: Good Technology Software, Inc. v. AirWatch, LLC
IPR2015-00248, IPR2015-00875

Matter: *Inter Partes* Review, software management in wireless devices

Project: Two declarations to support two IPR petitions

L38. 2014 **Bragalone Conroy PC**

Case: Securus Technologies, Inc. v. Global Tel*Link Corporation
IPR2015-00153, IPR2015-00155, IPR2015-00156

Matter: *Inter Partes* Review, VoIP call monitoring and recording

Project: Three declarations to support three IPR petitions, two depositions

L39. 2014 **Andrews Kurth LLP**

Case: Sony Mobile Communications (USA) v. Adaptix Inc.
IPR2014-01524, IPR2014-01525

Matter: *Inter Partes* Review, subcarrier selection in LTE

Project: Two declarations to support two IPR petitions, deposition

L40. 2014 **Steptoe & Johnson LLP, Baker & McKenzie LLP**
Case: VTech Communications, Inc. and Uniden America Corporations v. Spherix Incorporated
IPR2014-01432
Matter: *Inter Partes* Review, IP telephony
Project: Declaration to support IPR petition, deposition, reply declaration, deposition

L41. 2014 **Steptoe & Johnson LLP, Baker & McKenzie LLP**
Case: Spherix Inc. v. VTech Telecommunications Ltd., et al.
Spherix Inc. v. Uniden Corp, et al.
Northern district of Texas, Dallas Division, Case No. 3:13-cv-3494 and 3:13-cv-3496
Matter: Patent infringement, IP telephony
Project: Claim construction, declaration, deposition

L42. 2014 **McKool Smith**
Case: Good Technology Corp. v. MobileIron, Inc.
Northern district of California, Case No. 5:12-cv-05826-PSG
Matter: Patent infringement, software management in wireless devices
Project: Claim construction, three declarations, claim invalidity expert report, non-infringement expert report, deposition, jury trial testimony

L43. 2014 **Lee & Hayes**
Case: Broadcom Corp. v. Ericsson, Inc.
IPR2013-00601, IPR2013-00602, and IPR2013-00636
Matter: *Inter Partes* Review, ARQ protocols
Project: Three declarations to support Patent Owner's Response, two declarations to support Patent Owner's Motion to Amend, deposition, two reply declarations

L44. 2014 **Sidley Austin LLP**
Case: Adaptix, Inc. v. Huawei Technologies Co., et al.
Eastern district of Texas, Case No. 6:13-cv-00438, 439, 440 and 441
Matter: Patent infringement, subcarrier selection in LTE
Project: Non-infringement consulting, source code review

L45. 2014 **Finnegan Henderson Farabow Garrett & Dunner LLP**
Case: Cell and Network Selection LLC v. Huawei Technologies Co., et al.
Eastern district of Texas, Case No. 6:13-cv-00404-LED-JDL
Matter: Patent infringement, base station selection in LTE
Project: Non-infringement consulting

L46. 2014 **Feinberg Day Alberti & Thompson LLP**
Case: DSS Technology Management, Inc. v. Apple Inc.
Eastern district of Texas, Tyler division, Case No. 6:13-cv-00919-JDL

Matter: Patent infringement, PDA and Bluetooth
Project: Claim construction and invalidity consulting

L47. 2014 **Sheppard Mullin Richter & Hampton LLP**
Case: Digcom Inc. v. ZTE (USA), Inc.
District of Nevada, Case No. 3:13-cv-00178-RCJ-WGC
Matter: Patent infringement, cellular communication
Project: Claim construction consulting

L48. 2014 **Lott & Fischer**
Case: Zenith Electronics, LLC, et al. v. Craig Electronics, Inc.
Southern district of Florida, Case No. 9:13-cv-80567-DMM/DLB
Matter: Patent infringement, HDTV transmission and reception
Project: Opening expert report regarding nonessentiality

L49. 2013 **McKool Smith**
Case: Zenith Electronics, LLC, et al. v. Curtis International Ltd.
Southern district of Florida, Case No. 9:13-cv-80568-DMM/DLB
Matter: Patent infringement, HDTV transmission and reception
Project: Claim construction, declaration, deposition

L50. 2013 **Gibson Dunn**
Case: Straight Path IP Group v. Sharp Corp. and Sharp Electronics Corp.
In the Matter of Certain Point-to-Point Network Communication Devices and Products Containing Same, ITC Investigation No. 337-TA-892
Matter: Patent infringement, point-to-point network communication
Project: Non-infringement consulting

L51. 2013 **Kilpatrick Townsend & Stockton LLP**
Case: Monec Holding AG v. Motorola Mobility LLC, et al.
District of Delaware, Case No. 1:11-cv-798-LPS-SRF
Matter: Patent infringement, displaying books on tablets
Project: Non-infringement expert report for Motorola, non-infringement expert report for HTC, deposition

L52. 2013 **Gartman Law Group**
Case: Lone Star WiFi LLC v. Legacy Stonebriar Hotel, Ltd; et al.
Eastern Dist. Of Texas, Tyler, Case No. 6:12-cv-957
Matter: Patent infringement, levels of access in Wi-Fi networks
Project: Claim validity consulting

L53. 2013 **White & Case, LLP**
Case: Nokia Corp and Nokia, Inc. v. HTC Corp and HTC America, Inc.
In the Matter of Certain Portable Electronic Communication Devices, Including Mobile Phones and Components Thereof, ITC Investigation

No. 337-TA-885
Matter: Patent infringement, App download and installation
Project: Non-infringement consulting

L54. 2013 **Heim, Payne & Chorush, LLP**
Case: Rembrandt Wireless v. Samsung Electronics Co., et al.
Eastern Dist. of Texas, Marshal, Case No. 2:13-cv-213-JRG-RSP
Matter: Patent infringement, Bluetooth
Project: Expert report regarding validity, deposition, jury trial

L55. 2013 **Davis Polk & Wardwell LLP; Baker Hostetler**
Case: Comcast v. Sprint; and Nextel Inc.
Eastern Dist. of Pennsylvania, Case No. 2:12-cv-00859-JD
Matter: Patent infringement, SMS/MMS in Cellular Networks
Project: Infringement expert report, validity expert report, reply expert report, declaration, two-day depositions, jury trial testimony

L56. 2013 **McKool Smith**
Case: Samsung Electronics America v. Ericsson Inc.
In the Matter of Certain Wireless Communications Equipment and Articles Therein, ITC Investigation No. 337-TA-866
Matter: Patent infringement, LTE uplink and downlink
Project: Prior art research, source code review, claim construction, claim invalidity expert report, non-infringement expert report, ITC hearing testimony

L57. 2012 **DLA Piper US LLP**
Case: CSR Technology Inc. v. Freescale Semiconductor, Inc.
USDC-San Francisco, Case No. 3:12-cv-02619-RS
Matter: Patent infringement, radio transceivers
Project: Claim construction, declaration

L58. 2012 **Fish & Richardson PC**
Case: GPNE Corp. v. Apple, Inc.; et al.
USDC-ND California, Case No. 5:12-cv-02885-LHK
Matter: Patent infringement, resource allocation in wireless networks
Project: Prior art research consulting

L59. 2012 **Polsinelli Shughart PC**
Case: Single Touch Interactive, Inc. v. Zoove Corporation
Northern district of California, Case No. 3:12-cv-00831-JSC
Matter: Patent infringement, abbreviated dialing, information delivery
Project: Claim construction, Markman hearing testimony, two declarations

L60. 2012 **K & L Gates**
Case: EON Corp. IP Holdings, LLC v. Novatel Wireless, Inc.; et al.

DC-Tyler, Texas, Case No. 6:11-cv-00015-LED-JDL
Matter: Patent infringement, wireless modem and 3G services
Project: Non-infringement expert report, deposition

L61. 2012 **Simpson Thacher & Bartlett LLP**
Case: CSR Technology, Inc. v. Bandspeed, Inc.
Western Dist. of Texas, Case No. 1:12-cv-297-LY
Matter: Patent infringement, packet identification in 2.4 GHz and 5 GHz
Project: Source code review, Markman hearing testimony, infringement expert report

L62. 2012 **Sheppard Mullin Richter & Hampton LLP**
Case: Wi-LAN v. HTC America, Inc., et al.
Eastern Dist. of Texas, Case No. 6:10-cv-521-LED
Matter: Patent infringement, CDMA, Orthogonal Codes
Project: Source code review, non-infringement expert report, deposition, jury trial testimony

L63. 2012 **Dechert LLP**
Case: Hitachi v. TPV and Vizio, Inc.; and Vizio v. Hitachi, LTD.
Eastern Dist. of Texas, Case No. 2:10-cv-260
Matter: Patent infringement, HD television transmission and reception
Project: Prior art research, claim invalidity consulting

L64. 2012 **Fish & Richardson PC**
Case: InterDigital Commc'n, LLC v. Huawei Tech. Co. LTD; LG Electronics, Inc.; Nokia, Inc.; and ZTE (USA) Inc.
Certain Wireless Devices With 3G Capabilities and Components Thereof, ITC Investigation No. 337-TA-800
Matter: Patent infringement, channel coding in UMTS, HSDPA
Project: Non-infringement consulting

L65. 2012 **Fish & Richardson PC**
Case: InterDigital Commc'n, LLC v. Huawei Tech. Co. LTD; LG Electronics, Inc.; Nokia, Inc.; and ZTE (USA) Inc.
Dist. of Delaware, Case No. 1:11-cv-00654-UNA
Matter: Patent infringement, channel coding in UMTS, HSDPA
Project: Non-infringement consulting

L66. 2011 **O'Melveny & Myers LLP**
Case: MobileMedia Ideas, LLC v. Apple, Inc.
Dist. of Delaware, Case No. 1:10-cv-00258-SLR-MPT
Matter: Patent infringement, voice control, call rejection in mobile phones
Project: Source code review, prior art research, declaration, claim invalidity expert report, non-infringement expert report, deposition, jury trial testimony

L67. 2011 **Wilmer Cutler Pickering Hale and Dorr**
Case: Apple, Inc. v. Samsung Electronics Co.
Northern Dist. of California, Case No. 5:11-cv-01846-LHK
Matter: Patent infringement, channel coding in CDMA, E-AGCH, TFCI
Project: Prior art research, claim construction consulting

L68. 2011 **Weil, Gotshal & Manges LLP**
Case: Vizio, Inc. v. Renesas Electronics America, Inc.
ITC Investigation No. 337-TA-789
Matter: Patent infringement, HD television transmission and reception
Project: Claim invalidity consulting

L69. 2011 **Shapiro Cohen**
Case: TenXc Wireless Inc. v. Andrew LLC
TenXc Wireless Inc. v. Mobi Antenna Technologies Ltd.
Matter: Patent infringement, antenna design, sectorized cellular network
Project: Claim validity consulting

L70. 2010 **Fish & Richardson PC**
Case: Vizio, Inc., v. LG Electronics, Inc.
ITC Investigation No. 337-TA-733
Matter: Patent infringement, HD television transmission and reception
Project: Claim charts, claim construction expert report, deposition

L71. 2010 **Fish & Richardson PC**
Case: Vizio, Inc., v. LG Electronics, Inc.
Dist. of Maryland, Case No. 1:09-cv-1481-BEL
Matter: Patent infringement, HD television transmission and reception
Project: Claim charts, claim construction expert report, deposition

L72. 2008 **Kaye Scholer LLP**
Case: eBay Inc. v. IDT.
Western Dist. of Arkansas, Case No. 4:08-cv-4015-HFB
Matter: Patent infringement, long distance communication using Internet
Project: Prior art research, claim construction consulting

L73. 2008 **Simpson Thacher & Bartlett LLP**
Case: Commil USA, LLC v. Cisco Systems, Inc.
Eastern Dist. of Texas, Case No. 2:07-cv-00341-DF-CE
Matter: Patent infringement, two-level wireless protocol
Project: Prior art research

L74. 2006 **Woodfill and Pressler**
Case: Charles Russell v. Interinsurance Exchange of the Auto Club
Harris County, Texas, Case No. 2005-19706

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|---|---|
| Matter: | House fire and insurance claim |
| Project: | Determining user location using cellular phone records, expert report, deposition, jury trial testimony |

## Consulting History

| | | |
|---|---|---|
| From: | 1/2013 | **Heim, Payne & Chorush, LLP** |
| To: | 3/2013 | Houston, TX |
| | Duties: | Analyze patents on wireless technologies. |

| | | |
|---|---|---|
| From: | 4/2007 | **Collin County Sheriff's Office** |
| To: | 5/2007 | McKinney, TX |
| | Duties: | Analyzed cellular record data and determined user location in a double-homicide investigation. |

| | | |
|---|---|---|
| From: | 4/2004 | **Allegiant Integrated Solutions** |
| To: | 5/2004 | Fort Worth, TX |
| | Duties: | Designed and developed an integrated set of tools for fast deployment of wireless networks. The tools optimize the placement of Access Points and determine their respective channel allocations to minimize interference and maximize capacity. |

| | | |
|---|---|---|
| From: | 3/2002 | **Input/Output Incorporated** |
| To: | 4/2002 | New Orleans, LA |
| | Duties: | Designed and implemented an algorithm in MATLAB for optimizing the frequency selection process used by sonar for scanning the bottom of the ocean. |

| | | |
|---|---|---|
| From: | 6/1998 | **Teleware Corporation** |
| To: | 7/1998 | Seoul, South Korea |
| | Duties: | Designed and developed a software package for analyzing the capacity in a CDMA network to maximize the number of subscribers. |

## Employment History

| | | |
|---|---|---|
| From: | 1/2015 | **University of North Texas** |
| To: | Present | Denton, TX |
| | Position: | *Associate Chair of Graduate Studies Department of Computer Science and Engineering*<br>In charge of all administrative duties related to the Masters and PhD programs in the department. |

| | | |
|---|---|---|
| From: | 5/2008 | **University of North Texas** |
| To: | Present | Denton, TX |
| | Position: | *Tenured Associate Professor Department of Computer Science and Engineering* |

Conducting research on cellular networks and wireless sensor networks. Teaching wireless communication courses. Advising graduate and undergraduate students.

From: 9/2002 **University of North Texas**
To: 5/2008 Denton, TX
Position: *Assistant Professor Department of Computer Science and Engineering*
Conducting research on WCDMA/UMTS wireless networks. Teaching wireless communication and computer architecture courses. Advising graduate and undergraduate students.

From: 1/2002 **University of New Orleans**
To: 8/2002 New Orleans, LA
Position: *Assistant Professor Department of Electrical Engineering*
Designed and taught two new courses "Computer Systems Design I and II". Developed a Computer Engineering Curriculum with strong hardware-design emphasis. Formed a wireless research group. Advised graduate and undergraduate students.

From: 10/2000 **Comspace Corporation**
To: 12/2001 Coppell, TX
Position: *Senior Systems Engineer*
Designed, coded (in Matlab), and simulated Viterbi decoding, Turbo coding, trellis coded modulation (TCM), and Reed-Muller codes. Optimized soft decision parameters and interleavers for additive white Gaussian and Rayleigh faded channels. Extended the control and trunking of push-to-talk Logic Trunked Radio (LTR) to include one-to-one and one-to-many voice and data messaging.

From: 8/1996 **MinMax Corporation**
To: 8/2000 Saint Louis, MO
Position: *Research Associate*
Designed software packages that provide the tools to flexibly allocate capacity in a CDMA network and maximize the number of subscribers. Validated, simulated (logical and timing), and developed the hardware architecture for an ATM switch capable of channel group switching.

From: 8/1994 **Washington University**
To: 8/2000 Saint Louis, MO
Position: *Research and Teaching Assistant*
Taught, consulted, and graded Circuit Analysis at the undergraduate level and Network Design at the graduate level.

## Publications

**Conference Proceedings**

C1. U. Sawant, **R. Akl**, "Evaluation of Adaptive and Non Adaptive LTE Fractional Frequency Reuse Mechanisms," *IEEE WOCC 2017 The 26th Annual Wireless and Optical Communications Conference*, April 2017, paper no. 1570341174, 6 pgs.

C2. U. Sawant, **R. Akl**, "A Novel Metric to Study the Performance of Sectorized Fractional Frequency Reuse Techniques in LTE," *IEEE WTS 2017 The 16th Annual Wireless Telecommunications Symposium*, April 2017, paper no. 1570338498, 7 pgs

C3. S. Alotaibi, **R. Akl**, "Dynamic Frequency Partitioning Scheme for LTE HetNet Networks Using Fractional Frequency Reuse," *IEEE WCNC '17 Wireless Communications and Networking Conference*, March 2017, paper no. 1570332420, 5 pgs.

C4. U. Sawant, **R. Akl**, "Performance Evaluation of Network Productivity for LTE Heterogenous Networks with Reward-Penalty Weights Assessment," *IEEE CCWC 2017 The 7th Annual Computing and Communication Workshop Conference*, January 2017, paper no. 1570328396, 6 pgs.

C5. S. Alotaibi, **R. Akl**, "Self-Adjustment Downlink Transmission Power for Femtocells in Co-Channel Deployment in Heterogeneous Networks," *IEEE CCWC 2017 The 7th Annual Computing and Communication Workshop Conference*, January 2017, paper no. 1570326815, 6 pgs.

C6. U. Sawant, **R. Akl**, "Performance Evaluation of Sectorized Fractional Frequency Reuse Techniques Using Novel Metric," *IEEE ISCC 2016 The Twenty-First IEEE Symposium on Computers and Communications*, June 2016, paper no. 1570275270, 7 pgs.

C7. R. Tidwell, S. Akumalla, S. Karlaputi, **R. Akl**, K. Kavi, and D. Struble, "Evaluating the Feasibility of EMG and Bend Sensors for Classifying Hand Gestures," *1st International Conference on Multimedia and Human Computer Interaction*, July 2013, paper no. 63, 8 pgs.

C8. **R. Akl**, K. Pasupathy, and M. Haidar, "Anchor Nodes Placement for Effective Passive Localization," *2011 IEEE International Conference on Selected Topics in Mobile and Wireless Networks (iCOST)*, October 2011, paper no. 1569490799, pp. 127 - 132.

C9. **R. Akl**, P. Kadiyala, and M. Haidar, "Non-Uniform Grid-Based Routing in Sensor Networks", *9th IEEE Malaysia International Conference on Communications*, December 2009, paper no. 1569243649, pp. 536 - 540.

C10. M. Haidar, M. Al-Rizzo, Y. Chan, **R. Akl**, M. Bouharras, "Throughput Validation of an Advanced Channel Assignment Algorithm in IEEE 802.11 WLAN", *ICCSN 2009 – International Conference on Communication Software and Networks*, February 2009, paper no. P385, pp. 801 - 806.

C11. **R. Akl** and D. Keathly, "Robocamp: Encouraging Young Women to Embrace STEM," 4th Annual TETC Best Practices Conference, February 2009, 13 pgs.

C12. M. Haidar, R. Ghimire, M. Al-Rizzo, **R. Akl**, Y. Chan, "Channel Assignment in an IEEE 802.11 WLAN Based on Signal-to-interference Ratio", *IEEE CCECE – Canadian Conference on Electrical and Computer Engineering: Communications and Networking*, May 2008, paper no. 1569092894, pp. 1169 - 1174.

C13. H. Al-Rizzo, M. Haidar, **R. Akl**, and Y. Chan, "Enhanced Channel Assignment and Load Distribution in IEEE 802.11 WLANs," *IEEE International Conference on Signal Processing and Communication*, November 2007, paper no. 1569042132, pp. 768 - 771.

C14. **R. Akl** and Y. Saravanos, "Hybrid Energy-Aware Synchronization Algorithm in Wireless Sensor Networks," *18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*, September 2007, paper no 692, 5 pgs.

C15. M. Haidar, **R. Akl**, and H. Al-Rizzo, "Channel Assignment and Load Distribution in a Power-Managed WLAN," *18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*, September 2007, paper no. 463, 5 pgs.

C16. D. Keathly and **R. Akl,** "Attracting and Retaining Women in Computer Science and Engineering: Evaluating the Results," *Proceedings of American Society for Engineering Education: ASEE Annual Conference*, June 2007, paper no. AC 2007-1229, 10 pgs.

C17. M. Haidar, **R. Akl**, H. Al-Rizzo, Y. Chan, R. Adada, "Optimal Load Distribution in Large Scale WLAN Networks Utilizing a Power Management Algorithm," *Proceedings of IEEE Sarnoff Symposium*, May 2007, 5 pgs.

C18. R. Dantu, P. Kolan, **R. Akl,** and K. Loper, "Classification of Attributes and Behavior in Risk Management Using Bayesian Networks," *Proceedings of IEEE Intelligence and Security Informatics Conference*, May 2007, pp. 71-74.

C19. **R. Akl** and A. Arepally, "Dynamic Channel Assignment in IEEE 802.11 Networks," *Proceedings of IEEE Portable 2007: International Conference on Portable Information Devices*, March 2007, pp 309-313.

C20. **R. Akl** and U. Sawant, "Grid-based Coordinated Routing in Wireless Sensor Networks," *Proceedings of IEEE CCNC 2007: Consumer Communications and Networking Conference*, January 2007, pp. 860-864.

C21. **R. Akl** and A. Arepally, "Simulation of Throughput in UMTS Networks with Different Spreading Factors," *Proceedings of IEEE VTC Fall 2006: Vehicular Technology Conference,* September 2006, pp. C1-5.

C22. A. Alhabsi, H. Al-Rizzo, and **R. Akl,** "Parity Assisted Decision Making for QAM Modulation," *International Conference on Mobile Computing and Wireless Communications*, September 2006, paper no. 1568988776, 5 pgs.

C23. **R. Akl** and R. Garlick, "Retention and Recruitment of Women in Computer Engineering," *ICEE 2006: International Conference on Engineering Education,* July 2006, paper no. 3318, 5 pgs.

C24. R. Garlick and **R. Akl,** "Intra-Class Competitive Assignments in CS2: A One-Year Study," *ICEE 2006: International Conference on Engineering Education,* July 2006, paper no. 3325, 5 pgs.

C25. **R. Akl**, D. Tummala, and X. Li, "Indoor Propagation Modeling at 2.4 GHz for IEEE 802.11 Networks," *WNET 2006: Wireless Networks and Emerging Technologies,* July 2006, paper no. 510-014, 6 pgs.

C26. P. Chen, K. Kavi, and **R. Akl,** "Performance Enhancement by Eliminating Redundant Function Execution," *Proceedings of IEEE: 39th Annual Simulation Symposium*, April 2006, pp. 143-150.

C27. **R. Akl** and S. Nguyen, "Capacity Allocation in Multi-cell UMTS Networks for Different Spreading Factors with Perfect and Imperfect Power Control," *Proceedings of IEEE CCNC 2006: Consumer Communications and Networking Conference*, January 2006, vol. 2, pp. 928-932.

C28. W. Li, K. Kavi, and **R. Akl**, "An Efficient Non-Preemptive Real-Time Scheduling," *18th International Conference on Parallel and Distributed Computing Systems*, Las Vegas, NV, September 2005, pp. 154-160.

C29. S. Nguyen and **R. Akl**, "Approximating User Distributions in WCDMA Networks Using 2-D Gaussian," *CCCC20T 05: International Conference on Computing, Communications, and Control Technologies*, July 2005, 5 pgs.

C30. **R. Akl** and S. Park, "Optimal Access Point Selection and Traffic Allocation in IEEE 802.11 Networks," *Proceedings of 9th World Multiconference on Systemics, Cybernetics and Informatics (WMSCI 2005): Communication and Network Systems, Technologies and Applications*, July 2005, vol. 8, pp. 75-79.

C31. **R. Akl**, M. Naraghi-Pour, M. Hegde, "Throughput Optimization in Multi-Cell CDMA Networks," *IEEE WCNC 2005 - Wireless Communications, and Networking Conference*, March 2005, vol. 3, pp. 1292-1297.

C32. **R. Akl**, "Subscriber Maximization in CDMA Cellular Networks," *Proceedings of CCCT 04: International Conference on Computing, Communications, and Control Technologies*, August 2004, vol. 3, pp. 234-239.

C33. **R. Akl** and A. Parvez, "Global versus Local Call Admission Control in CDMA Cellular Networks," *Proceedings of CITSA 04: Communications, Information and Control Systems, Technologies and Applications*, July 2004, vol. 2, pp. 283-288.

C34. **R. Akl** and A. Parvez, "Impact of Interference Model on Capacity in CDMA Cellular Networks," *Proceedings of SCI 04: Communication and Network Systems, Technologies and Applications*, July 2004, vol. 3, pp. 404-408. Selected as **best paper** of those presented in the session: Tele-Communication Systems, Technologies and Application II.

C35. **R.G. Akl**, M.V. Hegde, M. Naraghi-Pour, P.S. Min, "Call Admission Control Scheme for Arbitrary Traffic Distribution in CDMA Cellular Systems," *IEEE Wireless Communications and Networking Conference*, September 2000, vol. 1, pp. 465-470.

C36. **R.G. Akl**, M.V. Hegde, M. Naraghi-Pour, P.S. Min, "Cell Placement in a CDMA Network," *IEEE Wireless Communications and Networking Conference*, September 1999, vol. 2, pp. 903-907.

C37. **R.G. Akl**, M.V. Hegde, P.S. Min, "Effects of Call Arrival Rate and Mobility on Network Throughput in Multi-Cell CDMA," *IEEE International Conference on Communications*, June 1999, vol. 3, pp. 1763-1767.

C38. **R.G. Akl**, M.V. Hegde, M. Naraghi-Pour, P.S. Min, "Flexible Allocation of Capacity in Multi-Cell CDMA Networks," *IEEE Vehicular Technology Conference*, May 1999, vol. 2, pp. 1643-1647.

## Journal Publications

J1. M. Haidar, H.M. Al-Rizzo, **R. Akl**, and Z. Elbazzal, "The Effect of an Enhanced Channel Assignment Algorithm in an IEEE 802.11 WLAN," *World Scientific and Engineering Academy and Society Transactions on Communications*, WSEAS, Vol. 8, Issue 12, December 2009.

J2. **R. Akl**, P. Kadiyala, and M. Haidar, "Non-Uniform Grid-Based Coordinated Routing in Wireless Sensor Networks", *Journal of Sensors*, article ID 491349, volume 2009, 11 pages.

J3. M. Haidar, M. Al-Rizzo, Y. Chan, **R. Akl**, "User-Based Channel Assignment Algorithm in a Load-Balanced IEEE 802.11 WLAN", *International Journal of Interdisciplinary Telecommunications & Networking (IJITN)*, April-June 2009, 1(2), pp. 66-81.

J4. **R. Akl**, D. Keathly, and R. Garlick, "Strategies for Retention and Recruitment of Women and Minorities in Computer Science and Engineering," *iNEER Special Volume: Innovations 2007- World Innovations in Engineering Education and Research*, 9 pgs., 2007.

J5. R. Garlick and **R. Akl**, "Motivating and Retaining CS2 Students with a Competitive Game Programming Project," *iNEER Special Volume: Innovations 2007- World Innovations in Engineering Education and Research*, 9 pgs., 2007.

J6. **R. Akl** and S. Nguyen, "UMTS Capacity and Throughput Maximization for Different Spreading Factors," *Journal of Networks*, July 2006, vol. 1, issue 3, pp. 40-49. ISSN: 1796-2056

J7. W. Li, K. Kavi, and **R. Akl**, "A Non-preemptive Scheduling Algorithm for Soft Real-time Systems," *Journal of Computer and Electrical Engineering,* 2006, vol. 32, 18 pgs. ISSN: 0045-7906

J8. **R. Akl**, A. Parvez, and S. Nguyen, "Effects of Interference on Capacity in Multi-Cell CDMA Networks," *Journal of Systemics, Cybernetics and Informatics*, 2006, vol. 3, no. 1, p825612, 7 pgs. ISSN: 1690-4524

J9. **R.G. Akl**, M. Hegde and M. Naraghi-Pour, "Mobility-based CAC Algorithm for Arbitrary Traffic Distribution in CDMA Cellular Systems," *IEEE Transactions on Vehicular Technology,* March 2005, vol. 54, no. 2, pp. 639-651.

J10. **R.G. Akl**, M.V. Hegde, M. Naraghi-Pour, P.S. Min, "Multi-Cell CDMA Network Design," *IEEE Transactions on Vehicular Technology*, May 2001, vol. 50, no. 3, pp. 711-722.

## Technical Papers

T1. J. Williams, **R. Akl,** et al, "Flight Control Subsystem," *The Eagle Feather*, Special Section: Undergraduate Research Initiative in Engineering, University of North Texas, Vol. 7, 2010.

T2. **R.G. Akl**, M.V. Hegde, A. Chandra, P.S. Min, "CDMA Capacity Allocation and Planning," Technical Document, Washington University Department of Electrical Engineering WUEE-98, April 1998.

## Book Chapters

B1. R. Akl, Y. Saravanos, and M. Haidar, "Chapter 18: Hybrid Approach for Energy-Aware Synchronization in Sensor Networks," *Sustainable Wireless Sensor Networks*, December 2010, pgs. 413-429, ISBN: 978-953-307-297-5.

B2. K. Kavi, **R. Akl** and A. Hurson, "Real-Time Systems: An Introduction and the State-of-the-Art," *Encyclopedia of Computer Science and Engineering*, John Wiley & Sons, Volume 4, January 2009, pgs. 2369-2377.

B3. **R. Akl** and K. Kavi, "Chapter 12: Modeling and Analysis using Computational Tools," *Introduction to Queuing Theory: Modeling and Analysis*, Birkhauser Boston, December 2008, pgs. 295-320.

**Technical Presentations**

P1. "Bio-Com Project," Raytheon, Richardson TX, May 2012, (invited).

P2. "Bio-Com Project," Net-Centric Software and Systems I/UCRC Meeting, Denton TX, December 2011, (invited).

P3. "Student Outreach Report: Robocamp," College of Engineering Advisory Board Meeting, Denton TX, May 2011, (invited).

P4. "Robocamp: Encouraging Young Women to Embrace STEM," 4th Annual TETC Best Practices Conference, Austin TX, February 2009, (invited).

P5. "Self-Configuring Wireless MEMS Network (demo)," Southern Methodist University, Dallas TX, January 2008, (invited).

P6. "Energy-aware Routing and Hybrid Synchronization in Sensor Networks," *Southern Methodist University,* Dallas TX, September 2007, (invited).

P7. "Retention and Recruitment of Women in Computer Engineering," *ICEE 2006: International Conference on Engineering Education,* Puerto Rico, July 2006, (refereed).

P8. "Capacity Allocation in Multi-cell UMTS Networks for Different Spreading Factors with Perfect and Imperfect Power Control," *IEEE CCNC 2006: Consumer Communications and Networking Conference*, Las Vegas, NV, January 2006, (refereed).

P9. "Research, Teaching, and Outreach," CSE Advisory Council Meeting, *UNT Research Park,* Denton, TX, December 2005, (invited).

P10. "WiFi and WCDMA Network Design," *University of Arkansas*, Little Rock, AR, April 2005, (invited).

P11. "WiFi and WCDMA Network Design," *Southern Methodist University*, Dallas, TX, March 2005, (invited).

P12. "Current Research in Wireless at UNT," *Nortel Networks*, Richardson, TX, October 2004, (invited).

P13. "Subscriber Maximization in CDMA Cellular Networks," *International Conference on Computing, Communications, and Control Technologies*, Austin, TX, August 2004, (refereed).

P14. "Global versus Local Call Admission Control in CDMA Cellular Networks," *International Conference on Cybernetics and Information Technologies, Systems and Applications*, Orlando, FL, July 2004, (refereed).

P15. "Impact of Interference Model on Capacity in CDMA Cellular Networks," *8th World Multi-Conference on Systemics, Cybernetics, and Informatics*, Orlando, FL, July 2004, (refereed).

P16. "CDMA Network Design," IEEE Communications Society – New Orleans Chapter, New Orleans, LA, May 2002, (invited).

P17. "Cell Design to Maximize Capacity in CDMA Networks," Louisiana State University, Baton Rouge, LA, April 2002, (invited).

P18. "Call Admission Control Scheme for Arbitrary Traffic Distribution in CDMA Cellular Systems," *IEEE Wireless Communications and Networking Conference*, Chicago, IL, September 2000, (refereed).

P19. "Cell Placement in a CDMA Network," *IEEE Wireless Communications and Networking Conference*, September 1999, (refereed).

P20. "Effects of Call Arrival Rate and Mobility on Network Throughput in Multi-Cell CDMA," *IEEE International Conference on Communications*, June 1999, (refereed).

P21. "Flexible Allocation of Capacity in Multi-Cell CDMA Networks," *IEEE Vehicular Technology Conference*, May 1999, (refereed).

P22. "CCAP: A Strategic Tool for Managing Capacity of CDMA Networks," Teleware Co. Ltd., Seoul, South Korea, 1998, (invited).

## Courses Developed

- CSCE 5933: LTE Physical Layer Using MATLAB.
  Research issues in the design of LTE physical layer and simulate using MATLAB. Topics include modulation and coding, OFDM, channel modeling, MIMO, and

link adaption.

- CSCE 6590: Advanced Topics in Wireless Communications & Networks: 4G/LTE.
  Research issues in the design of next generation wireless networks: cellular systems, medium access techniques, signaling, mobility management, control and management for mobile networks, wireless data networks, Internet mobility, quality-of-service for multimedia applications, caching for wireless web access, and ad hoc networks.

- CSCE 5933: Fundamentals of VoIP.
  Fundamentals of VoIP, with emphasis on network infrastructure implementation and security. Topics include IP protocol suite, SS7, speech-coding techniques, quality of service, session initiation protocol, and security issues.

- CSCE 5540: Introduction to Sensor Networks.
  Topics include: design implications of energy (hardware and software), and otherwise resource-constrained nodes; network self-configuration; services such as routing under network dynamics, localization, time-synchronization and calibration; distributed data management, in-network aggregation and collaborative signal processing, programming tools and language support.

- CSCE 5510. Wireless Communication.
  Point-to-point signal transmission through a wireless channel, channel capacity, channel encoding, and multi-user transmissions. First, second, and third generation cellular systems, and mobility management.

- CSCE 3510. Introduction to Wireless Communication.
  Fundamentals of wireless communications and networking, with emphasis on first, second, and third generation cellular systems. Topics include point-to-point signal transmission through a wireless channel, cellular capacity, multi-user transmissions, and mobility management.

- CSCE 3020. Communications Systems.
  Introduction to the concepts of transmission of information via communication channels. Amplitude and angle modulation for the transmission of continuous-time signals. Analog-to-digital conversion and pulse code modulation. Transmission of digital data. Introduction to random signals and noise and their effects on communication. Optimum detection systems in the presence of noise.

- ENEE 3583. Computer Systems Design I (UNO).
  The design process of digital computer systems is studied from the instruction set level, system architecture level, and digital logic level. Topics include machine organization, register transfer notation, processor design, memory design, and input/output considerations. Includes semester project.

- ENEE 3584. Computer Systems Design II (UNO).
  The design and evaluation of contemporary computer systems are analyzed to compare the performance of different architectures. Topics include performance metrics, computer arithmetic, pipelining, memory hierarchies, and multiprocessor systems.

- ENEE 3514. Computer Architecture Laboratory (UNO).
  Selected experiments examining programmable logic, VHDL and logic synthesis, and including a final design project, to accompany and complement the lecture course ENEE 3584. Three hours of laboratory.

## Courses Taught

Fall 2016
- CSCE 5933.3: LTE Physical Layer Using MATLAB (4.7 / 5.0)

Spring 2016
- CSCE 5950.743: Thesis (no evaluation done)
- CSCE 6950.743: Dissertation (no evaluation done)

Fall 2015
- CSCE 3010.1: Signals and Systems (5.7 / 7.0)

Spring 2015
- CSCE 5934.743: Directed Study (no evaluation done)

Fall 2014
- CSCE 3010.1: Signals and Systems (3.32 / 4.00)
- CSCE 6590.1: Advanced Topics in Wireless Communications & Networks: 4G/LTE (3.79 / 4.00)

Spring 2014
- CSCE 3510.1: Intro to Wireless Communication (808 – Highly Effective)
- CSCE 5510.1: Wireless Communications (808 – Highly Effective)

Fall 2013
- CSCE 6590.1: Advanced Topics in Wireless Communications & Networks: 4G/LTE (804 – Highly Effective)

Spring 2013
- CSCE 4890.743: Directed Study (no evaluation done)
- CSCE 6940.743: Individual Research (no evaluation done)

Fall 2012
- CSCE 3010.1: Signals and Systems (793 – Highly Effective)
- CSCE 5540.1: Intro to Sensor Networks (814 – Highly Effective)

Spring 2012
- CSCE 3020.1: Communication Systems (809 – Highly Effective)
- CSCE 3510.1: Intro to Wireless Communication (811 – Highly Effective)
- CSCE 5510.1: Wireless Communications (817 – Highly Effective)
- EENG 3810.1: Communication Systems (801 – Highly Effective)

Fall 2011
- CSCE 3010.1: Signals and Systems (793 – Highly Effective)

- CSCE 5540.1: Intro to Sensor Networks (824 – Highly Effective)

Spring 2011

- CSCE 3020.1: Communication Systems (820 – Highly Effective)
- CSCE 3510.1: Intro to Wireless Communication (812 – Highly Effective)
- CSCE 5510.1: Wireless Communications (812 – Highly Effective)
- EENG 3810.1: Communication Systems (826 – Highly Effective)

Fall 2010

- CSCE 3010.1: Signals and Systems (857 – Highly Effective)
- CSCE 5540.1: Intro to Sensor Networks (831 – Highly Effective)

Spring 2010

- CSCE 3020.1: Communication Systems (792 – Highly Effective)
- CSCE 3510.1: Intro to Wireless Communication (793 – Highly Effective)
- CSCE 5510.1: Wireless Communications (834 – Highly Effective)
- EENG 3810.1: Communication Systems (854 – Highly Effective)

Fall 2009

- CSCE 3010.1: Signals and Systems (4.40 / 5.00)
- CSCE 5540.1: Intro to Sensor Networks (4.70 / 5.00)
- EENG 2620.1: Signals and Systems (4.40 / 5.00)

Spring 2009

- CSCE 3020.1: Communication Systems (4.87 / 5.00)
- CSCE 3510.1: Intro to Wireless Communication (4.65 / 5.00)
- CSCE 5510.1: Wireless Communications (4.79 / 5.00)

Fall 2008

- CSCE 3010.1: Signals and Systems (4.91 / 5.00)
- CSCE 5540.2: Intro to Sensor Networks (4.10 / 5.00)
- EENG 2620.3: Signals and Systems (4.91 / 5.00)

Spring 2008

- CSCE 3020.1: Communication Systems (4.68 / 5.00)
- CSCE 3510.1: Intro to Wireless Communication (3.96 / 5.00)
- CSCE 5510.1: Wireless Communications (4.75 / 5.00)

Fall 2007

- CSCE 3010.1: Signals and Systems (4.57 / 5.00)
- CSCE 5540.2: Intro to Sensor Networks (4.01 /5.00)

Summer 2007

- CSCE 3020.1: Fund. of Communication Theory (no evaluation done)
- EENG 3810.1: Communication Systems (no evaluation done)

Spring 2007

- CSCE 5510.2: Wireless Communications (4.75 / 5.00)
- CSCE 5933.6: Fundamentals of VoIP (4.70 / 5.00)

Fall 2006

- CSCE 3010.1: Signals and Systems (4.58 / 5.00)
- CSCE 5540.1: Intro to Sensor Networks (4.70 / 5.00)
- EENG 2620.1: Signals and Systems (4.58 / 5.00)

Summer 2006

- CSCE 3020.1: Fund. of Communication Theory (no evaluation done)
- CSCE 3510.21: Intro to Wireless Communications (no evaluation done)
- CSCE 5510.21: Intro to Wireless Communications (no evaluation done)
- EENG 3810.1: Communication Systems (no evaluation done)

Spring 2006

- CSCE 2610.2: Computer Organization (3.69 / 5.00)
- CSCE 3010.1: Signals and Systems (4.41 / 5.00)
- EENG 2620.1: Signals and Systems (4.41 / 5.00)

Fall 2005

- CSCE 3510.1: Intro to Wireless Communications (4.52 / 5.00)
- CSCE 5510.1: Wireless Communications (4.46 / 5.00)
- CSCE 5933.6: Intro to Sensor Networks (4.60 / 5.00)

Summer 2005

- CSCE 3010.21: Signals and Systems (no evaluation done)
- CSCE 3510.21: Intro to Wireless Communications (no evaluation done)

Spring 2005

- CSCE 3510.02: Intro to Wireless Communications (4.46 / 5.00)
- CSCI 3100.02: Computer Organization (4.14 / 5.00)

Fall 2004

- CSCE 3510.01: Intro to Wireless Communications (4.15 / 5.00)
- CSCI 4510.01: Machine Structures (4.55 / 5.00)
- CSCI 5330.02: Intro to Wireless Communications (4.05 / 5.00)

Summer 2004

- CSCI 4330.22: Intro to Wireless Communications (no evaluation done)
- CSCI 4330.23: Intro to Wireless Communications (no evaluation done)
- CSCI 5330.22: Intro to Wireless Communications (no evaluation done)

Spring 2004

- CSCI 3100: Computer Organization (4.64 / 5.00)
- CSCI 4330: Intro to Wireless Communications (4.22 / 5.00)

Fall 2003

- CSCI 4510: Machine Structures (4.49 / 5.00)
- CSCI 5330: Intro to Wireless Communications (4.83 / 5.00)

Summer 2003

- CSCI 3100: Computer Organization (no evaluation done)

Spring 2003

- CSCI 3100: Computer Organization (3.84 / 5.00)

Fall 2002

- CSCI 4510: Machine Structures (4.38 / 5.00)

## Funded Proposals

R1. "UNT GenCyber Summer Program: Inspiring the Next Generation of Cyber Stars in North Texas," National Security Agency (NSA). Requested amount is $85,000. Submitted 11/4/2016. Robert Akl (co-PI), **awarded $85,000**.

R2. "App Design Summer Camp" under Texas Higher Education Coordinating Board: Engineering Summer Program. Requested amount is $12,900. Submitted 5/6/16. Robert Akl (PI), **awarded $12,900.**

R3. "Robotics, Game and App Programming Summer Camps" under Texas Workforce Commission: Summer Merit Program. Requested amount is $63,000. Submitted 11/16/15. Robert Akl (PI), **awarded $63,000.**

R4. "App Design Summer Camp" under Texas Higher Education Coordinating Board: Engineering Summer Program. Requested amount is $13,998. Submitted 5/1/15. Robert Akl (PI), **awarded $13,988.**

R5. "App Design Summer Camp" under Texas Higher Education Coordinating Board: Engineering Summer Program. Requested amount is $12,500. Submitted 5/2/14. Robert Akl (PI), **awarded $12,500.**

R6. "Robotics, Game and App Programming Summer Camps" under Texas Workforce Commission: Summer Merit Program. Requested amount is $63,000. Submitted 12/14/12. Robert Akl (PI), **awarded $63,000.**

R7. "Bio-Com Project," funded by Raytheon under Net-Centric Software and Systems I/UCRC 2nd year. Requested amount is $30,000. Submitted 5/12/12. Krishna Kavi (PI), Robert Akl (co-PI), **awarded $30,000.**

R8. "Bio-Com Project," funded by Raytheon under Net-Centric Software and Systems I/UCRC. Requested amount is $30,000. Submitted 5/12/11. Krishna Kavi (PI), Robert Akl (co-PI), **awarded $30,000.**

R9. "Game Programming for Xbox 360 Summer Camp" under Texas Higher Education Coordinating Board: Engineering Summer Program. Requested amount is $20,000. Submitted 3/21/11. Robert Akl (PI), **awarded $20,000.**

R10. "RoboCamps and Game Programming Summer Camps" under Texas Workforce Commission: Summer Merit Program. Requested amount is $63,000. Submitted 2/17/11. Robert Akl (PI), **awarded $63,000.**

R11. "Game Programming for Xbox 360 Summer Camp" under Texas Higher Education Coordinating Board: Engineering Summer Program. Requested amount is $13,000. Submitted 2/22/10. Robert Akl (PI), **awarded $18,000.**

R12. "Robotics and Game Programming Summer Camps" under Texas Workforce Commission: Summer Merit Program. Requested amount is $63,000. Submitted 10/16/09. Robert Akl (PI), **awarded $63,000.**

R13. "Micro Air Vehicle Design: A Collaborative Undergraduate Project for Electrical Engineering, Computer Engineering, and Computer Science Students,".

under UNT Undergraduate Research Initiative. Submitted 9/25/2009. Robert Akl (co-PI), **awarded $8,000**.

R14. "Summer Merit Program" under Texas Workforce Commission. Requested amount is $42,000. Submitted 3/20/09. Robert Akl (PI), **awarded $42,000**.

R15. "Robocamp at Stewpot" under Dallas Women's Foundation. Requested amount is $20,000. Submitted 2/23/09. Robert Akl (PI), **awarded $18,600**.

R16. "Robocamp Jump Start" under Motorola Foundation Innovation Generation Grant. Requested amount is $29,852. Submitted 2/12/09. Robert Akl (PI), **awarded $30,700**.

R17. "Engineering Summer Program" under Texas Higher Education Coordinating Board. Requested amount is $7,944. Submitted 2/13/09. Robert Akl (PI), **awarded $11,111**.

R18. "Texas Youth in Technology" under Texas Workforce Commission. Requested amount is $152,393. Submitted 11/10/08. Robert Akl (PI), **awarded $152,393**.

R19. "IUCRC Center Proposal: Net-Centric Software and Systems," under NSF-07-537: Industry/University Cooperative Research Centers. Requested amount is $349,482. Submitted 9/26/08. Krishna Kavi (PI), Robert Akl (co-PI), **awarded $60,000 per year for 5 years**.

R20. "Robocamp and Beyond" under Motorola Foundation Innovation Generation Grant. Requested amount is $30,000. Submitted 6/20/08. Robert Akl (PI), **awarded $30,000**.

R21. Texas Youth in Technology" under Texas Workforce Commission. Requested amount is $30,000. Submitted 2/27/08. Robert Akl (PI), **awarded $31,500**.

R22. "Robocamp Program for Young Women" under RGK foundation. Requested amount is $30,000. Submitted 11/5/07. Robert Akl (PI), **awarded $15,000**.

R23. "Texas Youth in Technology" under Texas Workforce Commission. Requested amount is $102,514. Submitted 10/22/07. Robert Akl (PI), **awarded $102,514**.

R24. "Women Art Technology" under Hispanic and Global Studies Initiatives Fund. Requested amount is $14,125. Submitted 9/30/07. Jennifer Way (PI), Robert Akl (co-PI), **awarded $12,785**.

R25. "Robocamp Mobile Unit" under Motorola Foundation Innovation Generation Grant. Requested amount is $35,000. Submitted 6/20/07. Robert Akl (PI), **awarded $30,000**.

R26. "ICER: UNT Engineering Challenge Camps" under NSF 0547299. Requested amount is $35,000. Submitted 4/27/07. Oscar Garcia (PI), Robert Akl (senior personnel), **awarded $32,792.**

R27. "IUCRC-Planning Proposal: UNT Research Site Proposal to join Embedded Systems I/UCRC," under NSF-01-116: Industry/University Cooperative Research Centers. Requested amount is $10,000. Submitted 3/31/07. Krishna Kavi (PI), Robert Akl (co-PI), **awarded $10,000.**

R28. "High-assurance NCCS: Ultra Dependability Integration Engineering," Department of Defense. Requested amount is $20,000. Submitted 3/12/07. Krishna Kavi (PI), Robert Akl (co-PI), **awarded $20,000.**

R29. "Recruiting and Retention Strategies for Computer Science at UNT" under Texas Technology Workforce Development Grant Program – 2005. Requested amount is $163,322. Submitted 3/17/05. Robert Akl (PI), **awarded $125,322.**

R30. UNT Faculty Research Grant for Fall 2003, Robert Akl (PI), $5,000, **awarded $4,000.**

R31. UNT Junior Faculty Summer Research Fellowship for Summer 2003, Robert Akl (PI), $5,000, **awarded $5,000.**

## Professional Associations and Achievements

### Membership in Professional Organizations

- Senior Member IEEE
- Member, Federation Council of North Texas Universities
- Member, Eta Kappa Nu Electrical Engineering Honor Society
- Member, Golden Key National Honor Society
- Member, Tau Beta Pi Engineering Honor Society

### Offices and Committee Assignments in Professional Organizations

- Technical Program Committee Member, IEEE Wireless Communications and Networking Conference, IEEE WCNC
- Technical Program Committee Member, International Wireless Symposium, IWS
- Technical Program Committee Member, IEEE International Conference on Computational Science, IEEE ICCS
- Technical Program Committee Member, IASTED International Conference on Wireless Communications, WC
- Technical Program Committee Member, WTS Wireless Telecommunications Symposium
- Technical Program Committee Member, Mosharaka International Conference on Computer Science and Engineering, Amman

- Invitation to serve as an NSF reviewer/panelist for Engineering Research Centers (ERC) proposals
- Technical Program Committee Member, 18th IEEE International Symposium on Personal, Indoor and Mobile Radio Communication, Greece
- International Program Committee, IASTED International Conference on Wireless and Optical Communication, Canada
- Program Committee Member, Fifth Annual Wireless Telecommunications Symposium, CA
- Technical Publications Chair, IEEE Vehicular Technology Conference, Dallas TX
- Session Chair, International Conference on Computing, Commun. and Control Tech., Austin TX
- Session Chair, International Conference on Cybernetics and Information Technologies, Orlando FL
- Session Chair, 8th World Multi Conference on Systemics, Cybernetic, and Informatics, Orlando FL

## Additional Responsibilities and Activities

- Reviewer, *Wireless Communications and Mobile Computing*, 2012 – present
- Reviewer, *Journal of Sensor and Actuator Networks*, 2012 – present
- Reviewer, *IEEE Transactions on Vehicular Technology*, 2011 – present
- Reviewer, *Elsevier Journal of Computers & Electrical Engineering*, 2008 – present
- Reviewer, *IEEE Globecom*, 2007 – present
- Reviewer, *IEEE International Conference on Advanced Networks and Telecommunication Systems (ANTS)*, 2008 – present
- Reviewer, *The International Wireless Communications and Mobile Computing Conference*, 2007 – present
- Reviewer, *Journal on Wireless Communications and Networking*, 2007 – present
- Reviewer, *IEEE Transactions on Communications*, 2007 - present
- Reviewer, *International Journal of Communication Systems*, 2007 – present
- Reviewer, *IEEE Communications Magazine*, 2005 – present
- Reviewer, *Journal of Wireless Networks*, 2004 – present
- Reviewer, *IEEE Transactions on Mobile Computing*, 2004 – present
- Reviewer, *IEEE Transactions on Wireless Communications*, 2004 – present
- Reviewer, *ACM Crossroads*, 2004 – present

## Honors and Awards

- Who's Who in America, 2012 Edition
- Winner of Tech Titan of the Future – University Level Award for UNT Robocamps for Girls, Metroplex Technology Business Council, 2010 with **$15,000 cash prize.**
- IEEE Professionalism Award, Ft Worth Chapter, 2008
- UNT College of Engineering Outstanding Teacher Award, 2008

- Certificate of Appreciation: IEEE Vehicular Technology Conference, Dallas, TX, 2005
- Certificate of Appreciation: Denton County Boosting Engineering, Science and Technology (BEST) Robotics Competition, 2004
- Summa Cum Laude Graduate, Ranked First in Undergraduate Class
- The Computer Science Departmental Award for Academic Excellence, Washington University, 1993
- The Dual Degree Engineering Award for Outstanding Senior, Washington University, 1993
- The 1992 Technical Writing Competition Award, The Society for Technical Communication

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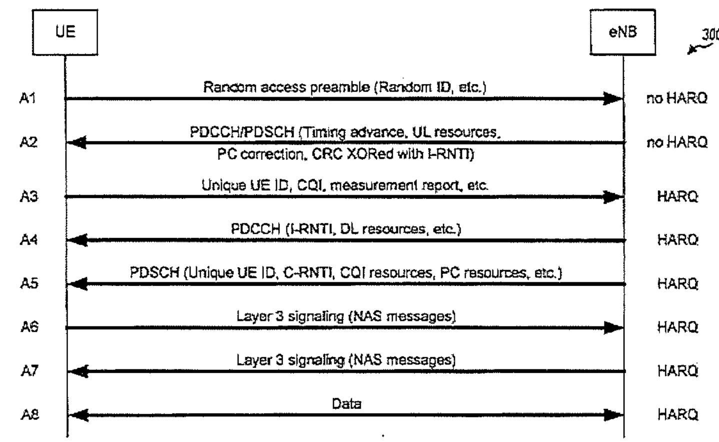
# Appendix B

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| **1[preamble]** A method comprising:<br><br>**9[preamble]** A computer readable memory storing a computer program that when executed by a processor results in actions comprising:<br><br>**10[preamble]** An apparatus comprising: a processor; and a memory storing a computer program; in which the processor is configured with the memory and the computer program to cause the apparatus to: | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>"FIGS. 3 through 5 show some example random access procedures that may be used for initial system access, system access while idle, and system access for handover. Other random access procedures may also be used for system access." Qualcomm, 7:63-67.<br><br>"The steps of a method or algorithm described in connection with the disclosure herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal." Qualcomm,14:37-51.<br><br>"Controllers/processors **730** and **770** may direct the operation at eNB **110** and UE **120**, respectively. Memories **732** and **772** may store data and program codes for eNB **110** and UE 120, respectively. A scheduler 734 may schedule UEs for downlink and/or uplink transmission and may provide assignments of resources for the scheduled UEs."<br>Qualcomm, 12:41-46. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
| --- | --- |
| | "The modules in FIGS. 9 and 11 may comprise processors, electronics devices, hardware devices, electronics components, logical circuits, memories, etc., or any combination thereof." Qualcomm, 13:61-64; *see also* Figs. 9-11.   FIG. 3 Qualcomm, Fig. 3 |

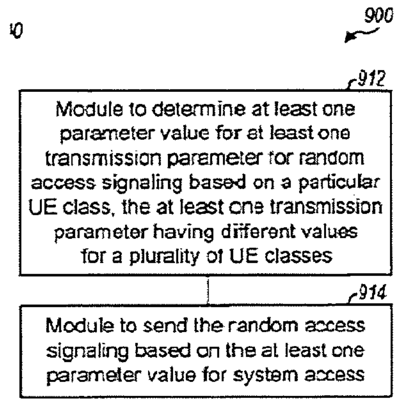
<table>
<tr><th>‘966 claim</th><th>Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)</th></tr>
<tr><td></td><td>



FIG. 9

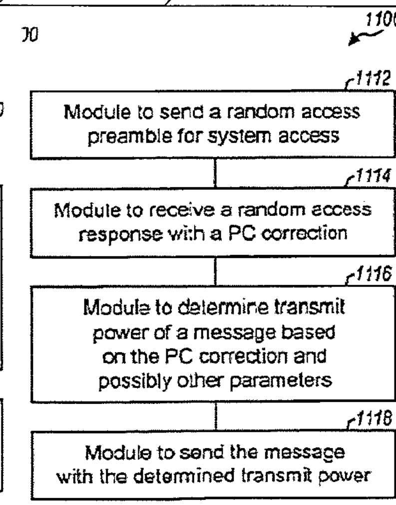
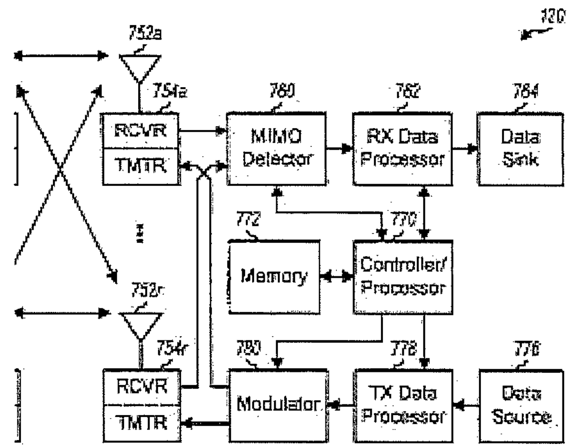



FIG. 11

“The various illustrative logical blocks, modules, and circuits described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.” Qualcomm, 14:21-36.</td></tr>
</table>

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
| --- | --- |
| | <br>FIG. 7<br><br>Qualcomm, Fig. 7<br><br>"TX data processor 778." Qualcomm, 12:32-36. |
| **1[a]** using a processor to initialize for i=0 a first power control adjustment state g(i) for an uplink control channel and a second power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error;<br><br>**9[a]** initializing for i=0 a first power control adjustment state g(i) for an uplink control channel and a second accumulation power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>*See* citations above for **1[preamble]**; *see also* citations below for **1[b]**.<br><br>Claims 1, 9, and 10 recite initializing a first power control adjustment state g(0), but do not define the formula g(0) or the general formula g(i). Dependent claims 3 and 12 though do provide an example of g(0) in the form of $P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$. The AAPA of the '966 patent also provide that $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can be equal to 0. (*Akl Decl.* ¶¶ 152-153). Accordingly, initializing for i = 0 a first power control adjustment state g(i) and a second power control adjustment state f(i) leads to $g(0) = f(0) = \Delta P_{PC} + \Delta P_{rampup}$. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| error;<br><br>**10[a]** initialize for i=0 a first power control adjustment state g(i) for an uplink control channel and a second accumulation power control adjustment state f(i) for an uplink shared channel to each reflect an open loop power control error, and | The parameters f(i) and g(i) are disclosed in the AAPA and TS 36.213 as "power control adjustment state." ('966 patent, 4:65-5:35, 6:1-17; TS 36.213, §5.1.1.1, §5.1.2.1). The parameter f(i) is the power control adjustment state relevant to messages sent on the uplink shared channel; the parameter g(i) is the power control adjustment state relevant to messages sent on the uplink control channel. The Qualcomm reference does not expressly show these power control adjustment states using the same terminology.<br><br>A POSITA, however, would understand that Qualcomm teaches these states and/or would look at least to TS 36.213 in regards to the two claimed power control adjustment states. As the claims only require that g(0) is initialized and that f(0) can be equal to g(0), Qualcomm teaches initializing both f(0) and g(0). TS 36.213 makes explicit what a POSITA would have known, i.e., that f(i) exists for use in calculating power for a shared channel and that g(i) exists for use in calculating power for a control channel. (TS 36.213, §5.1.1.1, p. 9; and §5.1.2.1, p. 10).<br><br>The teachings of Qualcomm combined with the teachings of TS 36.213 allow UE to "efficiently transmit the random access preamble and signaling for system access," while maintaining compatibility with the LTE standards such as TS 36.213. (Qualcomm, 1:45-47). Such a combination, therefore, would be obvious to a POSITA in creating a more efficient random access signaling that is compliant with the LTE specifications.<br><br>As described below, when calculating the transmit power of Message 3, the value f(0) is initialized and calculated. Because f(0) and g(0) can be the exact same formula and were both disclosed in TS 36.213, calculating f(0) also calculates g(0). Accordingly, Qualcomm discloses initializing for i = 0 a first power control adjustment state g(i) and a second power control adjustment state f(i) as $f(0) = g(0) = \Delta P_{PC} + \Delta P_{rampup}$. (*Akl Decl.* ¶¶ 102-118). |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| **1[b]** using the processor to compute an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0); and<br><br>**9[b]** computing an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0); and<br><br>**10[b]** compute an initial transmit power for the uplink shared channel using full path loss compensation, wherein the initial transmit power depends on a preamble power of a first message sent on an access channel and the second power control adjustment state f(0); and | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>*See* citations above for **1[preamble]**.<br><br>Claims 1, 9, and 10 state the initial transmit power for a third message (Message 3), which is sent on an uplink shared channel (e.g., PUSCH), depends on "the preamble power of a first message" and "the second power control adjustment state f(0)." In addition, the initial transmit power is computed "using full path loss compensation."<br><br>Qualcomm teaches calculating the "initial transmit power", which is the transmit power for Message 3, in the form of PUSCH_power. (Qualcomm, 10:1-19 ("PUSCH_power is the transmit power of the message sent on the PUSCH" and is "the transmit power of the first uplink message sent after successful transmission of the random access preamble")). Qualcomm teaches the PUSCH transmit power depends on both the preamble power of the first message sent on a random access channel and the power control adjustment state f(0). For example, Qualcomm discloses "FIG. 10 shows a design of a process 1000 for transmitting a message for system access. A random access preamble may be sent for system access (block 1012). A random access response with a PC correction may be received (block 1014). The transmit power of a message may be determined **based on the PC correction** and possibly other parameters (block 1016). For example, the transmit power of the message may be determined further **based on the transmit power of the random access preamble**, a power offset between a first channel used to send the random access preamble and a second channel used to send the message, etc. The message may be sent with the determined transmit power (block 1018)." (Qualcomm, 13:34-45; emphasis added).<br><br>**"the initial transmit power depends on a preamble power of a first** |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | **message sent on an access channel"**<br><br>Qualcomm discloses a formula for calculating the transmit power for Message 3 (PUSCH_power) in Equation (4): "PUSCH_power = RACH_power + PC_correction + PUSCH_RACH_power_offset." (Qualcomm, 10:1-19).<br><br>The parameter RACH_power "is the transmit power of the successful transmission of the random access preamble on the RACH [random access channel]." (Qualcomm, 10:12-13). The initial transmit power (PUSCH_power), therefore, depends on the preamble power of the first message, *i.e.,* the transmit power of the random access preamble (RACH_power).<br><br>**"the initial transmit power depends on ... power control adjustment state f(0)"**<br><br>As noted above, Equation [4a] of the '966 patent can be rewritten as f(0) = $\Delta P_{PC} + \Delta P_{rampup}$. (*Akl Decl.* ¶ 81). Qualcomm discloses that initial transmit power (PUSCH_power) depends on both $\Delta P_{PC}$ and $\Delta P_{rampup}$. For example, TX_power (the transmit power for the random access preamble, or RACH_power; 8:37-9:36) is defined in units of decibels in Equation (2) of Qualcomm. As shown below, TX_power (or RACH_power) depends on the power_ramp_up parameter.<br><br>Equation (2): **TX_power = RACH_power** = -RX_power + interference_correction + offset_power + added_correction + **power_ramp_up**.<br><br>The power_ramp_up parameter describes the increase in the user equipment's transmit power for subsequent transmissions of the random |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | access preamble. (Qualcomm, 9:45-49). It is used to increase the transmit power of a subsequent random access preamble that is sent when the UE does not receive a response from the eNB from an earlier sent random access preamble. The power_ramp_up parameter is the same as "a ramp-up power for preamble transmissions," *i.e.*, $\Delta P_{rampup}$ of claims 1, 9, and 10 of the '966 patent.<br><br>Further, the PUSCH_power described in Equation (4) of Qualcomm can be rewritten by substituting the parameter RACH_power with Qualcomm's Equation (2), which describes the transmit power of the preamble. As shown below, after this substitution, the Modified Equation (4) of Qualcomm shows that PUSCH_power depends on power_ramp_up + PC_correction:<br><br>Equation (4): PUSCH_power = RACH_power + PC_correction + PUSCH_RACH_power_offset.<br><br>Equation (2): TX_power = RACH_power = -RX_power + interference_correction + offset_power + added_correction + power_ramp_up.<br><br>**<u>Substituting Equation (2) into Equation (4) to obtain:</u>**<br>Modified Equation (4): **PUSCH_power** = -RX_power + interference_correction + offset_power + added_correction + **power_ramp_up** + **PC_correction** + PUSCH_RACH_power_offset.<br><br>**<u>Rearranging Modified Equation (4) to obtain:</u>**<br>Modified Equation (4): **PUSCH_power** = **power_ramp_up** + **PC_correction** - RX_power + interference_correction + offset_power + added_correction + PUSCH_RACH_power_offset.<br><br>Qualcomm describes that PC_correction "indicates an amount of increase or decrease in transmit power" and it "is the PC correction received in the |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | random access response" (Qualcomm, 10:20-21; 10:16-17). The random access response (which is Message 2) is the response sent by the eNB after receiving the random access preamble. As noted above, in the '966 patent the UE receives a power control command, $\Delta P_{PC}$, in the preamble response from the eNB, which is Message 2. ('966 patent, 6:58-60). $\Delta P_{PC}$ indicates if the user equipment should increase or decrease its transmit power. Thus, PC_correction is "a power control command indicated in a second message that is received in response to sending the first message," *i.e.*, $\Delta P_{PC}$ of claims 1, 9, and 10 of the '966 patent. Accordingly, the initial transmit power (PUSCH_power) described in Qualcomm also depends on f(0), *i.e.* $\Delta P_{PC} + \Delta P_{rampup}$.<br><br>As described in the '966 patent, the open loop power control error is "the sum of the UE specific power control constants ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and the power control initial states (f(0) and g(0)) ... taking into account the preamble power ramp-up." ('966 patent, 7:1-5). Specifically, $\Delta P_{PC}$ reflects the open loop power control error. (*Akl Decl.* ¶ 82). The PC_correction of Qualcomm may be based on a received signal quality of the random access preamble at the eNB, thus reflecting an open loop power control error. (Qualcomm, 13:46-47). Therefore, calculating a transmit power or any formula that includes $\Delta P_{PC}$ or PC_correction reflects an "open loop power control error."<br><br>In addition, it would have been obvious to a POSITA to come up with Equation [4a] based on AAPA of the '966 patent. For example, TS 36.213 discloses an equation for PUSCH transmit power, which is Equation [1] of AAPA:<br><br>**Equation [1]**: $P_{PUSCH}(i) = \min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{0\_PUSCH}(j) + \alpha \cdot PL + \Delta_{TF}(i))(TF(i)) + f(i)\}$ [dBm]. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | ('966 patent, 4:28-5:35; TS 36.213, §5.1.1.1, p. 8).<br>According to AAPA of the '966 patent, the variable $P_{O\_PUSCH}(j)$ is a parameter composed of the sum of two other parameters:<br><br>$\mathbf{P_{O\_PUSCH}(j) = P_{0\_NOMINAL\_PUSCH}(j) + P_{0\_UE\_PUSCH}(j)}$; where,<br>$P_{0\_NOMINAL\_PUSCH}(j)$ is an 8-bit cell specific nominal component signaled from higher layers for j=0 and 1 in the range of [-126, 24] dBm with 1 dB resolution;<br><br>$P_{0\_UE\_PUSCH}(j)$ is a 4-bit **<u>UE specific component</u>** configured by RRC for j=0 and 1 in the range of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7] dB;<br><br>j = 0 for PUSCH (re)transmissions corresponding to a configured scheduling grant; and<br><br>j = 1 for PUSCH (re)transmissions corresponding to a received PDCCH with DCI format 0 associated with a new packet transmission.<br><br>(Emphasis added; TS 36.213, §5.1.1.1; '966 patent, 4:40-50).<br><br>A POSITA would understand that Equation [1] can be rewritten by expanding $P_{O\_PUSCH}(j)$ and rearranging the terms to obtain:<br>**<u>Expand</u>** $P_{O\_PUSCH}(j)$ **<u>and rearrange the terms of Equation [1] to obtain:</u>**<br><br>➔ **Equation [1]**: $P_{PUSCH}(i) = \min\{P_{MAX}, [10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))] + P_{0\_NOMINAL\_PUSCH}(j) + \alpha \bullet PL + \mathbf{P_{0\_UE\_PUSCH}(j) + f(i)}\}$;<br><br>As shown above, a POSITA would understand Equation [1] is dependent on UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(i). According to the AAPA of the '966 patent, f(i) is dependent on a parameter, $\delta_{PUSCH}$, which is a **UE specific correction value**, also referred to as a **TPC [transmission power control]** |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | **command**, and it is included in PDCCH [Message 2]. (TS 36.213, §5.1.1.1; '966 patent, 4:62-5:35).<br><br>A POSITA would understand when the UE first sends data on the PUSCH, there is no previous subframe and so i = 0. By substituting i = 0 for initial subframe, Equation [1] becomes:<br><br>**<u>Substitute i = 0 for initial subframe, Equation [1] becomes:</u>**<br>→ **Equation [1]**: $P_{PUSCH}(0) = \min\{P_{MAX}, [10\log_{10}(M_{PUSCH}(0)) + \Delta_{TF}(TF(0))] + \alpha \bullet PL + P_{0\_NOMINAL\_PUSCH}(j) + \mathbf{P_{0\_UE\_PUSCH}(j) + f(0)}\}$.<br><br>The '966 patent admits that except for the UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), "**Other parameters of equation [1] are known**: $M_{PUSCH}(i)$ is known from the UE's resource allocation it gets in Message 2; the nominal portion $P_{0\_NOMINAL\_PUSCH}(j)$ of $P_{O\_PUSCH}(j)$ is received in a broadcast in the cell, as is α and $K_S$ from which $\Delta_{TF}(TF(i))$ is calculated; and PL is estimated by the UE itself such as from Message 2. If the UE has started the Random Access procedure in order to make a handover, it has received the parameters $P_{0\_NOMINAL\_PUSCH}(j)$ and α in the handover command. **Similar holds true for equation [2] and PUCCH.**" ('966 patent, 10:11-20; emphasis added).<br><br>Thus, a POSITA would have been motivated to use other parameters relevant to the Random Access Procedure in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to initialize Equation [1]. Specifically, a POSITA would have been motivated to use parameters that are known to the UE and that allow for transmit power changes. For example, a POSITA would have been motivated to look to TS 36.321, which describes the Random Access preamble transmission power. Indeed, the AAPA of the '966 patent admits "Reference can also be made to 3GPP TS 36.321, V8.0.0 (2007-12), 3rd Generation Partnership Project; Technical Specification |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification (Release 8)." ('966 patent, 2:13-17).<br><br>TS 36.321 §5.1.3 specifies that during Random Access Procedure the UE sends Message 1 with a preamble power determined by the following formula:<br><br>PREAMBLE_TRANSMISSION_POWER = PREAMBLE_INITIAL_POWER + POWER_RAMP_STEP.<br><br>The PREAMBLE_INITIAL_POWER is the target power level the eNB would like to receive for a random access. A POSITA would understand that PREAMBLE_INITIAL_POWER is equivalent to the $P_{target}$ parameter described in the '966 patent. The POWER_RAMP_STEP is the incremental power to be used every time the random access is attempted again. A POSITA would also understand that POWER_RAMP_STEP of AAPA is equivalent to the $\Delta P_{rampup}$ parameter described in the '966 patent. (*Akl Decl.* ¶¶ 59-61, 68-72 related to 3GPP Draft Proposals R1-080612 and R1-070870).<br><br>A POSITA would understand this description of preamble power in TS 36.321 §5.1.3 is similar to Equation [3] of the AAPA of the '966 patent, which admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated based on a path loss and a power ramp-up for retransmission:<br><br>**Equation [3] of AAPA**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where<br>$P_{target}$ is the broadcasted target power;<br>PL is the path loss that UE estimates from DL; and |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | $\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.<br><br>Accordingly, a POSITA would have been motivated to use a parameter known to the UE and that allows for transmit power change, such as the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), to calculate Equation [1].<br><br>Besides the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, a POSITA would also have been motivated to look to the power control command, $\delta_{PUSCH}$, which is sent to the UE via the Random Access Response or Message 2, to replace the unknown UE specific parameters in calculating Equation [1]. According to the '966 patent, "the UE receives a power control command (e.g., $\Delta P_{PC}$) in the preamble response from the eNB, which is Message 2." ('966 patent, 6:58-60). A POSITA would understand that $\delta_{PUSCH}$ of the AAPA is equivalent to the $\Delta P_{PC}$ parameter described in the '966 patent.<br><br>The UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access Response, which is Message 2. Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. Accordingly, Equation [4a] of the '966 patent simply uses two parameters, $\Delta P_{PC}$ and $\Delta P_{rampup}$, known to the UE in place of the unknown UE specific parameters, $P_{0\_UE\_PUSCH}$ and f(0), for calculating $P_{PUSCH}(0)$.<br><br>**"depends on"**<br><br>In the context of the '966 patent, the claim term "depends on" means both |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | direct dependency and indirect dependency. That is to say, the initial transmit power can depend directly on a parameter or depend indirectly on a parameter. This reading of "depends on" is consistent with the claims and the specification of the '966 patent.<br><br>For example, dependent claims 5 and 14, which depend from claims 1 and 10, provide an equation (which is Equation [5] of the '966 patent) for the initial transmit power:<br><br>**Equation [5]**: $P_{Msg3} = \min\{P_{MAX}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10 \log10(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$<br><br>Claims 1 and 10 recite "wherein the initial transmit power depends on **a preamble power** of a first message sent on an access channel and the second power control adjustment state **f(0)**." (emphasis added) Because claims 5 and 14 are dependent claims, they must include the limitations of their independent claims; e.g., the limitation that an initial transmit power depends on the preamble power and f(0). Equation [5] shows an initial transmit power that directly depends on $P_{preamble}$ ("the preamble power of the first message") and $\Delta_{PC\_Msg3}$, which is "a power control command received at the receiver," *i.e.*, $\Delta P_{PC}$. (*Akl Decl.* ¶¶ 87).<br><br>However, Equation [5] does not show an initial transmit power that directly depends on f(0), which is $\Delta P_{rampup} + \Delta P_{PC}$. Specifically, Equation [5] does not include the $\Delta P_{rampup}$ parameter. The $\Delta P_{rampup}$ parameter, however, is part of the preamble transmission power equation: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$. (Equation [3] '966 patent). No other parameter in Equation [5] has a relationship with $\Delta P_{rampup}$. Rewriting Equation [5], by expanding the $P_{preamble}$ term and substituting $\Delta P_{PC}$ for $\Delta_{PC\_Msg3}$, shows that the initial transmit power does depend on f(0) where $f(0) = \Delta P_{rampup} + \Delta P_{PC}$: |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | **Modified Equation [5]**: $P_{Msg3} = \min\{P_{MAX}, P_{target} + PL + \mathbf{\Delta P_{rampup}} + \mathbf{\Delta P_{PC}}$ $\Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log10(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;<br><br>Thus, exactly as described in Qualcomm, Equation [5] of the '966 patent "depends on" the $\Delta P_{rampup}$ parameter as part of both the preamble power and the f(0) component. Such a reading is consistent with independent claims 1 and 10. Any other definition of "depends" would cause an inconsistency between claims 1 and 10 and their respective dependent claims; *i.e.,* Equation [5] would otherwise not depend on $\Delta P_{rampup}$.<br><br>As discussed above, PUSCH_power as described in Qualcomm depends on both the preamble power, *i.e.,* RACH_power, and f(0), *i.e.,* $\Delta P_{PC} + \Delta P_{rampup}$ or PC_correction + power_ramp_up. The power_ramp_up parameter is part of both the preamble power and f(0). In this manner, the initial transmit power (PUSCH_power) of Qualcomm depends directly on a preamble power and depends indirectly on the power_ramp_up parameter.<br><br>"**compute/computing an initial transmit power for the uplink shared channel using full path loss compensation**"<br><br>In the context of the '966 patent, the terms "path loss", "pathloss", and "PL" are used interchangeably and they all refer to the downlink path loss estimate calculated by the UE. Specifically, the '966 patent states "PL is the downlink pathloss estimate calculated in the UE" ('966 patent, 4:53) and "PL is the path loss that UE estimates from DL." ('966 patent, 6:24).<br><br>In addition, the term "full path loss compensation" means that the entire estimated PL (as opposed to a fractional portion of estimated PL) is used in the power control calculation. In the '966 patent, the preamble power (Equation [3]) is calculated using the entire path loss (PL), i.e., with an α value equal to 1. ('966 patent, 6:18-22; compare Equation [3] with Equation [1] of the '966 patent). The '966 patent admits that "RACH preambles are |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | transmitted by the UEs using a full path-loss compensation PC formula." ('966 patent, 2:39-40). The '966 patent further describes the existing preamble power control formula in Equation [3]: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$. Thus, Equation [3] is described as using a "full path loss compensation" because it uses the entire estimated value of "PL" and not just a fractional portion of estimated "PL".<br><br>The initial transmit power (PUSCH_power) in Equation (4) of Qualcomm also uses full path loss compensation because it uses the entire value of "PL" in the power control formula. The preamble power described in Qualcomm is based on the entire path loss. First, the preamble power is calculated using an open loop method. (Qualcomm, 8:37-39). The '966 patent admits that preamble power is calculated using full path loss compensation in an open loop method. ('966 patent, 2:39-40; 6:60-62; 7:3-4). In contrast, a closed loop method implies that the power is determined based on a feedback parameter; e.g., a power correction value. (*Akl Decl.* ¶¶ 57).<br><br>As discussed above, path loss (PL) is the difference or ratio between transmit power and the receive power of a signal. (*Akl Decl.* ¶¶ 51-53). And in the context of the '966 patent, "path loss" or "PL" refers to the downlink path loss estimate calculated by the UE. The parameter PL does not expressly appear in Qualcomm Equation (1), but its components, *i.e.* transmit power of a reference signal ($P_{TX}^{eNB}$) and the received power of the reference signal ($P_{RX}^{UE}$), are disclosed. According to Equation (1) of Qualcomm, $P_{TX}^{eNB}$ "is the transmit power of the reference signal from the recipient eNB" and $P_{RX}^{UE}$ "is the received power at the UE for time-frequency slots used for a reference signal (*e.g.*, a pilot signal) from the recipient eNB." (Qualcomm, 8:49-51; 8:58-59). Thus, the path loss for the downlink reference signal can be calculated at the UE as $PL = P_{TX}^{eNB} / P_{RX}^{UE}$, or the difference of the power values in the logarithm domain. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | As shown in Qualcomm, Equation (2) of the preamble power includes both $P_{TX}^{eNB}$ and $P_{RX}^{UE}$. The parameter RX_power is $P_{RX}^{UE}$ written in the logarithm domain. The parameter offset_power parameter includes $P_{TX}^{eNB}$ in the logarithm domain. Accordingly, rewriting Equation (2) with the RX_power and offset_power values expanded and rearranging the terms:<br><br>**Modifiled Equation (2)**: TX_power = $[10\log_{10}(\mathbf{P_{TX}^{eNB}}) - 10\log_{10}(\mathbf{P_{RX}^{UE}})]$ + interference_correction + $10\log_{10}(SNR_{target}) + 10\log_{10}(N_0+I_{oc}^{eNB})$ + added_correction + power_ramp_up.<br><br>The path loss in Modified Equation (2) is $PL = [10\log_{10}(P_{TX}^{eNB}) - 10\log_{10}(P_{RX}^{UE})]$. The entire path loss is used ($\alpha = 1$) because there is no fractional portion in the equation, so the preamble power uses full path loss compensation. Because the transmit power of Message 3, which is Equation (4) in Qualcomm, uses the preamble power, the transmit power of Message 3 is also calculated using full path loss compensation. |
| **1[c]** sending from a transmitter a third message on the uplink shared channel at the initial transmit power;<br><br>**9[c]** outputting the initial transmit power for transmission of a third message on the uplink shared channel;<br><br>**10[c]** compile a third message to be sent on the uplink shared channel at the initial transmit power; | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Qualcomm discloses calculating a "transmit power of the first uplink message sent after successful transmission of the random access preamble…" (Qualcomm, 10:1-3). Equation (4) of Qualcomm defines the variable PUSCH_power as "the transmit power of the message sent on the PUSCH." (Qualcomm, 10:14-15). PUSCH is a physical uplink shared channel. (Qualcomm, Table 1; 4:24-25). Qualcomm, therefore, teaches sending a third message on an uplink shared channel at the calculated transmit power, as claimed.<br><br>As described in Qualcomm, the invention can be implemented using various technologies such as software, computer-readable media, processors, |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | methods, etc. (Qualcomm, 14:6-10; 37-44; 52-60). Accordingly, the transmit power calculation for Message 3 described in Qualcomm could be implemented as a method, computer-readable medium, or an apparatus.<br><br>Qualcomm describes that its disclosed inventions can be used in an LTE system. (Qualcomm, 3:3-10). Further, Qualcomm relies on LTE terminology and examples in describing the disclosed inventions. (Qualcomm, 3:10-14). In reviewing Qualcomm, a POSITA would also be familiar with or reference the LTE specifications available on the 3GPP website. The LTE specifications define how equipment, such as user equipment, operates to be compatible with LTE. Accordingly, a POSITA reading about the random access procedure described in Qualcomm that can be used in an LTE system would naturally be familiar with and look to LTE specifications, such as 3GPP TS 36.213 and TS 36.300. Combining teachings from Qualcomm and AAPA would achieve rational and expected results, user equipment that is compliant with and can successfully operate in an LTE system.<br><br>Based on the above, Qualcomm and TS 36.213 disclose, suggest, or teach the features of independent Claims 1, 9, and 10. Specifically, Qualcomm provides the claim features added to the independent claims during prosecution to overcome the prior art rejections, namely addition of the equation: P0_UE_PUSCH +f(0)=ΔPPC +ΔPrampup. Equation (4) of Qualcomm defines a transmit power for Message 3 that depends on a preamble transmit power, a PC correction (which is ΔPPC in the claimed equation as defined in the claim) and a power_ramp_up value (which is ΔPrampup in the claimed equation). Thus, Qualcomm and TS 36.213 disclose, suggest, or teach the claimed features of Claims 1, 9, and 10, including the same equation added by Patent Owner during prosecution to overcome prior art rejections. |
| **1[d]** wherein the second power control | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213,** |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| adjustment state f(i) for i=0 is initialized as:<br>$P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup}$;<br>in which:<br>• $P_{0\_UE\_PUSCH}$ is a power control constant for the uplink shared channel that is specific for a user equipment executing the method;<br>• $\Delta P_{rampup}$ is a ramp-up power for preamble transmissions; and<br>• $\Delta P_{PC}$ is a power control command indicated in a second message that is received in response to sending the first message.<br><br>**9[d]** wherein the second accumulation power control adjustment state f(i) for i=0 is initialized as:<br>$P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup}$;<br>in which:<br>• $P_{0\_UE\_PUSCH}$ is a power control constant for the uplink shared channel that is specific for a user equipment which sends the first and third messages;<br>• $\Delta P_{rampup}$ is a ramp-up power for preamble transmissions; and<br>• $\Delta P_{PC}$ is a power control command indicated in a second message that is received in response to the first | **TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>*See* citations above for **1[b]** related to **"the initial transmit power depends on ... power control adjustment state f(0)"** |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| message.<br><br>**10[d]** wherein the second power control adjustment state f(i) for i=0 is initialized as:<br>$P_{0\_UE\_PUSCH} + f(0) = \Delta P_{PC} + \Delta P_{rampup}$;<br>in which:<br>• $P_{0\_UE\_PUSCH}$ is a power control constant for the uplink shared channel that is specific for a user equipment;<br>• $\Delta P_{rampup}$ is a ramp-up power for preamble transmissions; and<br>• $\Delta P_{PC}$ is a power control command indicated in a second message received at a receiver of the apparatus in response to the transmitter sending the first message. | |
| **2** The method according to claim 1, wherein the first message comprises a random access request message, the method further comprising:<br><br>computing the preamble power using full path loss compensation,<br><br>sending from the transmitter on the access channel the first message and<br><br>in response to receiving at a receiver a | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Claims 2 and 11 include additional features which are part of AAPA (existing random access procedure) and taught in Qualcomm and in LTE specifications, *e.g.,* TS 36.213 and TS 36.300.<br><br>Claims 2 and 11 recite the first message is a random access request message. Qualcomm teaches this. In Qualcomm the first message is referred to as a random access preamble. (Qualcomm, 8:38-40). This is also how the '966 patent and TS 36.300 refer to the first message sent from the user equipment |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| second message that comprises an allocation of resources on which the third message is sent; | in a contention based random access procedure. ('966 patent, Figure 1B and 4:1-4, TS 36.300, Fig. 10.1.5-1). |
| and after sending the third message, the method further comprises using the processor to compute an updated transmit power for the uplink shared channel using fractional power control and sending from the transmitter a subsequent message on the uplink shared channel using the updated transmit power.<br><br>**11** The apparatus according to claim 10, wherein the first message comprises a random access request message, and:<br><br>the processor is configured with the memory and the computer program to compute the preamble power using full path loss compensation, | Claims 2 and 11 further recite that the preamble power is computed using full path loss compensation. Here, preamble power refers to the random access preamble power used to transmit the RACH preamble. ('966 patent, claim 1). The '966 patent admits that existing random access procedure discloses this limitation. ('966 patent, 2:39-40 "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula."). As described above, Qualcomm teaches calculating the preamble transmit power using the full path loss, *i.e.*, the difference between the transmit power of a reference signal and the receive power at the user equipment of the reference signal. *(Akl Decl.* ¶¶ 125-129). Because the entire estimated path loss of the reference signal is used to calculate the preamble power, the preamble power is computed using full path loss compensation. |
| the apparatus further comprising a transmitter is configured to send on the access channel the first message;<br><br>the apparatus further comprising a receiver configured to receive, in response to the transmitter sending the first message, a second message that comprises an allocation of resources on | Claims 2 and 11 also recite transmitting the first message on an access channel and in response receiving the second message that includes an allocation of resources that are used to transmit Message 3. The random access preamble of Qualcomm is sent on a random access channel (RACH). (Qualcomm, 4:19-20 and 13:16-20). The '966 patent admits that existing random access procedure discloses "the UE transmits a **random access preamble** and expects a response from the eNB in the form of a so-called **Message 2** (e.g., Random Access Response at FIGS. 1B and 1C). Message 2 is transmitted on a DL [downlink] shared channel DL-SCH (PDSCH, the PDCCH) and **allocates resources** on an UL-SCH (PUSCH). The **resource allocation of Message 2** is addressed with an identity RA-RNTI that is associated with the frequency and time resources of a PRACH, but is common for different preamble sequences. The Message 2 contains **UL [uplink] allocations for the transmissions of a Message 3** in the UL (e.g., step 3 of the Contention Based Random Access Procedure at FIG. 1B)." |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| which the third message is sent;<br><br>the processor with the memory and the computer program is configured, after the transmitter sends the third message, to compute an updated transmit power for the uplink shared channel using fractional power control;<br><br>and the transmitter is configured to send a subsequent message on the uplink shared channel using the updated transmit power. | ('966 patent, 2:27-38; emphasis added).<br><br>Qualcomm describes that an eNB responds to receiving a random access preamble by sending a random access response. (Qualcomm, 6:16-18). This message can include "UL [uplink] resources" that "indicate resources granted to the UE for uplink transmission." (Qualcomm, 6:26-27; *See also* TS 36.300, §10.1.5.1, p. 49 (initial UL grant)). Message 3 is an uplink transmission and these UL resources would be used to transmit Message 3. (TS 36.300, §10.1.5.1, p. 49 (transport blocks depends on the UL grant conveyed in step 2)). The uplink resources mentioned in Qualcomm are the same as those from TS 36.300. They are both received by the user equipment in a random access response message sent by an eNB that has successfully received a random access preamble from the user equipment. While Qualcomm mentions that the uplink resources are "for uplink transmission," TS 36.300 specifically notes that one such uplink transmission is the transmission of Message 3. (TS 36.300, §10.1.5.1, p. 49).<br><br>Finally, claims 2 and 11 recite that an updated transmit power for the uplink shared channel using fractional power control is computed and that a message after Message 3 is sent on the uplink shared channel using the updated transmit power. The '966 patent admits that existing random access procedure discloses "RACH preambles are transmitted by the UEs using a **full path-loss compensation PC** formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. *** However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." ('966 patent, 2:39-49; emphasis added).<br><br>Also, these last two elements of claims 2 and 11 are simply a verbal description of the TS 36.213 PUSCH transmit power function. (TS 36.213, §5.1.1.1, p. 8). This function, also recited verbatim in the '966 patent, is |

| ‘966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
| --- | --- |
| | $P_{PUSCH}(i) = \min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{0\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(i))(TF(i)) + f(i)\}$ [dBm].<br><br>The term α, which can be a value less than 1 represents the fractional power control element. Fractional power control as used in the ‘966 patent is when some amount less than the entire estimated path loss is used. (‘966 patent, 7:54-57 and 8:50-53). The ‘966 patent admits that Equation [1], *i.e.,* the $P_{PUSCH}$ Equation from TS 36.213, can use “fractional” path loss rather than “full path loss.” (‘966 patent, 7:47-53). The fractional component described in the prior art $P_{PUSCH}$ Equation is *α. As* α can be less than 1, $\alpha \bullet PL$ represents calculating the power for messages that are transmitted subsequent to Message 3 on the shared uplink channel, PUSCH, with a fractional power control.<br><br>The $P_{PUSCH}$ Equation in TS 36.213 describes the power used to transmit message on a shared uplink channel, PUSCH. (TS 36.213, §5.1.1.1). Qualcomm, however, describes an enhancement to TS 36.213 where the transmit power of Message 3 is based on the preamble power, a power control correction, and a power offset, similar to Equation [5] of the ‘966 patent. Qualcomm, however, is silent on the transmission power for messages sent after Message 3. A POSITA would recognize, based at least on Qualcomm’s disclosure, that the PUSCH formula as described in TS 36.213, §5.1.1.1, would be used to calculate the transmit power for messages sent after Message 3. The techniques described in Qualcomm can be used in a 3GPP LTE system. (Qualcomm, 3:3-10). Further, Qualcomm relies on system access in LTE to explain the disclosed embodiments. (Qualcomm, 3:12-14). Accordingly, specifications related to LTE would be highly relevant to anyone implementing the embodiments disclosed in Qualcomm.<br><br>For example, to determine transmit power for uplink messages subsequently sent after Message 3 in an LTE system, a POSITA would turn to the 3GPP |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | LTE documentation; specifically, a POSITA would reference the TS 36.213 and TS 36.300 specifications that describe the physical layer procedures and the power used to transmit messages over the physical layer. Using TS 36.213 to calculate the transmission power for messages sent after Message 3 would ensure that the UE operated consistently with TS 36.213. Further, TS 36.300 simply makes explicit what is implied in Qualcomm. The uplink resources that are granted to the user equipment as described in Qualcomm are used in transmitting Message 3. (TS 36.300, p. 49; Qualcomm, 6:26-27). Qualcomm and TS 36.300 are consistent in that the uplink resources are received by the user equipment in a random access response. (*Id.*). While Qualcomm only notes that the uplink resources are "for uplink transmission," TS 36.300 makes explicit that the uplink resources are used in transmitting Message 3. (*Id.*).<br><br>Qualcomm describes that its disclosed inventions can be used in an LTE system. (Qualcomm, 3:3-10). Further, Qualcomm relies on LTE terminology and examples in describing the disclosed inventions. (Qualcomm, 3:10-14). Because Qualcomm is silent on how to calculate the transmit power for messages after Message 3, a POSITA would have to look to other sources for calculating the transmit power for subsequent messages. A POSITA would naturally turn to the 3GPP specifications for an LTE system. Combining the transmit power calculation of Message 3 with the transmit power for subsequent messages described in the LTE specifications would be obvious to a POSITA. The teachings of Qualcomm combined with the teachings of TS 36.213 and TS 36.300 allow user equipment to "efficiently transmit the random access preamble and signaling for system access," while maintaining compatibility with the LTE standards such as TS 36.213 and TS 36.300. (Qualcomm, 1:45-47). Such a combination, therefore, would be obvious to a POSITA in creating a more efficient random access signaling that is compliant with the LTE specifications. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| **3.** The method according to claim 1, wherein the first power control adjustment state g(i) for i=0 is initialized as:<br><br>$P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$;<br><br>wherein: $P_{0\_UE\_PUCCH}$ is a power control constant for the uplink control channel power that is specific for a user equipment executing the method.<br><br>**12.** The apparatus according to claim 10, wherein the first power control adjustment state g(i) for i=0 is initialized as:<br><br>$P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$;<br><br>wherein: $P_{0\_UE\_PUCCH}$ is a power control constant for the uplink control channel that is specific for a user equipment. | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Claims 3 and 12 include features which are taught in Qualcomm and in LTE specifications, *e.g.,* TS 36.213. Claims 3 and 12 initialize the first power control adjustment state g(0) as $P_{0\_UE\_PUCCH} + g(0) = \Delta P_{PC} + \Delta P_{rampup}$. The '966 patent admits that calculation of power control adjustment states f(i) and g(i) can use the same formula. ('966 patent, 5:1-3 and 6:1-3). Specifically, Equations [1] and [2] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.1.1, disclose $f(i) = f(i\text{-}1) + \delta_{PUSCH}(i\text{-} K_{PUSCH})$ where f(0) = 0, and $g(i) = g(i\text{-}1) + \Delta_{PUCCH}(i\text{-} K_{PUCCH})$ where g(0) = 0 ( *Id.*)<br><br>As described above for claims 1, 9 and 10, calculating the initial transmit power includes initializing f(0). As $P_{0\_UE\_PUSCH}$ and $P_{0\_UE\_PUCCH}$ can be equal to zero, the Equations f(0) and g(0) can be equal to one another, *i.e.* $f(0) = g(0) = \Delta P_{PC} + \Delta P_{rampup}$. (*See* claims 4 and 13). Accordingly, calculating f(0) as $\Delta P_{PC} + \Delta P_{rampup}$ also teaches calculating the initial state of g(0) as $\Delta P_{PC} + \Delta P_{rampup}$.<br><br>In addition, it would have been obvious to a POSITA to come up with Equation [4b] based on AAPA of the '966 patent. For example, TS 36.213 discloses an equation for PUSCH transmit power, which is Equation [2] of AAPA:<br><br>**Equation [2]**: $P_{PUCCH}(i) = \min\{P_{MAX}, P_{O\_PUCCH} + PL + \Delta_{TF\_PUCCH}(TF) + g(i)\}$ [dBm].<br><br>('966 patent, 5:39-40; TS 36.213, §5.1.2.1).<br><br>According to AAPA of the '966 patent, the variable $P_{O\_PUCCH}$ is a parameter composed of the sum of two other parameters: |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | $\mathbf{P}_{O\_PUCCH} = \mathbf{P}_{0\_NOMINAL\_PUCCH} + \mathbf{P}_{0\_UE\_PUCCH}$; where,<br>$P_{0\_NOMINAL\_PUCCH}$ is a 5-bit cell specific parameter provided by higher layers in the range of [-127, -96] dBm with 1 dB resolution;<br><br>$P_{0\_UE\_PUCCH}$ is a **<u>UE specific component</u>** configured by RRC in the range of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7] dB.<br><br>(TS 36.213, §5.1.2.1; '966 patent, 5:48-54).<br><br>A POSITA would understand that Equation [2] can be rewritten by expanding $P_{O\_PUCCH}$ and rearranging the terms to obtain:<br>**<u>Expand</u>** $P_{O\_PUCCH}$ **<u>and rearrange the terms of Equation [2] to obtain:</u>**<br><br>→ **Equation [2]**: $P_{PUCCH}(i) = \min\{P_{MAX}, P_{0\_NOMINAL\_PUCCH} + PL + \Delta_{TF\_PUCCH}(TF) + \mathbf{P}_{0\_UE\_PUCCH} + \mathbf{g(i)}\}$.<br><br>As shown above, a POSITA would understand Equation [2] is dependent on UE specific parameters, $P_{0\_UE\_PUCCH} + g(i)$. According to the AAPA of the '966 patent, g(i) is dependent on a parameter, $\delta_{PUCCH}$ or $\Delta_{PUCCH}$, which is a **UE specific correction value**, also referred to as a **TPC [transmission power control] command**, and it is included in PDCCH [Message 2]. (TS 36.213, §5.1.2.1; '966 patent, 5:54-6:17).<br><br>A POSITA would understand when the UE first sends data on the PUCCH, there is no previous subframe and so i = 0. By substituting i = 0 for initial subframe, Equation [2] becomes:<br><br>**<u>Substitute i = 0 for initial subframe, Equation [2] becomes:</u>**<br>→ **<u>Equation [2]</u>**: $P_{PUCCH}(0) = \min\{P_{MAX}, P_{0\_NOMINAL\_PUCCH} + PL +$ |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
| --- | --- |
| | $\Delta_{TF\_PUCCH}(TF)$ + $\mathbf{P_{0\_UE\_PUCCH} + g(0)}$}.<br><br>The '966 patent admits that except for the UE specific parameters, $P_{0\_UE\_PUCCH}$ + g(0), **"Other parameters of equation [1] are known**: $M_{PUSCH}(i)$ is known from the UE's resource allocation it gets in Message 2; the nominal portion $P_{0\_NOMINAL\_PUSCH}(j)$ of $P_{O\_PUSCH}(j)$ is received in a broadcast in the cell, as is α and $K_S$ from which $\Delta_{TF}(TF(i))$ is calculated; and PL is estimated by the UE itself such as from Message 2. If the UE has started the Random Access procedure in order to make a handover, it has received the parameters $P_{0\_NOMINAL\_PUSCH}(j)$ and α in the handover command. **Similar holds true for equation [2] and PUCCH**." ('966 patent, 10:11-20; emphasis added).<br><br>Thus, a POSITA would have been motivated to use other parameters relevant to the Random Access Procedure in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH}$ + g(0), to initialize Equation [2]. Specifically, a POSITA would have been motivated to use parameters that are known to the UE and that allow for transmit power changes. For example, a POSITA would have been motivated to look to TS 36.321, which describes the Random Access preamble transmission power. Indeed, the AAPA of the '966 patent admits "Reference can also be made to 3GPP TS 36.321, V8.0.0 (2007-12), 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) Medium Access Control (MAC) protocol specification (Release 8)." ('966 patent, 2:13-17).<br><br>TS 36.321 §5.1.3 specifies that during Random Access Procedure the UE sends Message 1 with a preamble power determined by the following formula:<br>PREAMBLE_TRANSMISSION_POWER = |

| ‘966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | PREAMBLE_INITIAL_POWER + POWER_RAMP_STEP<br><br>The PREAMBLE_INITIAL_POWER is the target power level the eNB would like to receive for a random access. A POSITA would understand that PREAMBLE_INITIAL_POWER is equivalent to the $P_{target}$ parameter described in the ‘966 patent. The POWER_RAMP_STEP is the incremental power to be used every time the random access is attempted again. A POSITA would also understand that POWER_RAMP_STEP of AAPA is equivalent to the $\Delta P_{rampup}$ parameter described in the ‘966 patent. (*Akl Decl.* ¶¶ 59-61, 68-72 related to 3GPP Draft Proposals R1-080612 and R1-070870).<br><br>A POSITA would understand this description of preamble power in TS 36.321 §5.1.3 is similar to Equation [3] of the AAPA of the ‘966 patent, which admits that prior art preamble power control formula for the UE’s transmission on the Random Access Channel is calculated based on a path loss and a power ramp-up for retransmission:<br><br>**Equation [3] of AAPA**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where<br>$P_{target}$ is the broadcasted target power;<br>PL is the path loss that UE estimates from DL; and<br>$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.<br><br>Accordingly, a POSITA would have been motivated to use a parameter known to the UE and allows for transmit power change, such as the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH} + g(0)$, to initialize and calculate Equation [2].<br><br>Besides the POWER_RAMP_STEP or $\Delta P_{rampup}$ parameter, a POSITA would also have been motivated to look to the power control command, $\delta_{PUCCH}$ or |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | $\Delta_{PUCCH}$, which is sent to the UE via the Random Access Response or Message 2, to replace the unknown UE specific parameters in calculating Equation [1]. According to the '966 patent, "the UE receives a power control command (e.g., $\Delta P_{PC}$) in the preamble response from the eNB, which is Message 2." ('966 patent, 6:58-60). A POSITA would understand that $\delta_{PUSCH}$ of the AAPA is equivalent to the $\Delta P_{PC}$ parameter described in the '966 patent.<br><br>The UE receives information for $\Delta P_{rampup}$ before the preamble transmission, and the UE receives the power control command, $\Delta P_{PC}$, in the Random Access Response, which is Message 2. Therefore, both $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters are known to the UE before the transmission of Message 3. Once the UE has information for $\Delta P_{rampup}$ and $\Delta P_{PC}$, it would have been obvious to a POSITA to use the known $\Delta P_{rampup}$ and $\Delta P_{PC}$ parameters in place of the unknown UE specific parameters, ($P_{0\_UE\_PUSCH}$ or $P_{0\_UE\_PUCCH}$) and (f(0) or g(0)), to calculate the transmission powers of $P_{PUSCH}(0)$ and $P_{PUCCH}(0)$. Accordingly, Equation [4b] of the '966 patent simply uses two parameters, $\Delta P_{PC}$ and $\Delta P_{rampup}$, known to the UE in place of the unknown UE specific parameters, $P_{0\_UE\_PUCCH} + g(0)$, for calculating $P_{PUCCH}(0)$. |
| **4** The method according to claim 3, wherein $P_{0\_UE\_PUSCH} = P_{0\_UE\_PUCCH} = 0$ when computing initial values at i=0 of power control states for the respective shared and control channels.<br><br>**13** The apparatus according to claim 12, wherein $P_{0\_UE\_PUSCH} = P_{0\_UE\_PUCCH} = 0$ when the processor computes initial values at i=0 of power control states for the respective shared and control | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Claims 4 and 13 recite features which are part of applicant admitted prior art (AAPA) relating to existing random access procedure that is disclosed in LTE specifications, e.g., TS 36.213.<br><br>Claim 1 provides that f(0) depends on $P_{0\_UE\_PUSCH}$ and claim 3 provides that g(0) depends on $P_{0\_UE\_PUCCH}$. The '966 patent admits that both of these values can be 0. ('966 patent, 7:16-18). Equation [1] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.1.1, discloses $P_{0\_UE\_PUSCH}(j)$ |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| channels. | is a 4-bit UE specific component configured by RRC for j=0 and 1 in the range of [-8, 7] dB with 1 dB resolution; i.e., a range of [-8, -7, -6, -5, -4, -3, -2, -1, **0**, 1, 2, 3, 4, 5, 6, 7] dB. ('966 patent, 4:40-50).<br><br>Equation [2] (AAPA) of the '966 patent, which is reproduced from TS 36.213 v8.2.0 §5.1.2.1, discloses $P_{0\_UE\_PUCCH}(j)$ is a UE specific component configured by RRC in the range of [-8, 7] dB with 1 dB resolution; *i.e.*, a range of [-8, -7, -6, -5, -4, -3, -2, -1, **0**, 1, 2, 3, 4, 5, 6, 7] dB. ('966 patent, 5:48-53).<br><br>Accordingly, the recited features of claims 4 and 13 are disclosed in the AAPA; specifically, TS 36.213 §5.1.1.1 and §5.1.2.1. |
| **5** The method according to claim 1, wherein the initial transmit power $P_{Msg3}$ of the third message for i=0 is equal to:<br><br>$P_{Msg3}=\min\{P_{max}, P_{preamble}+\Delta 0_{,preamble\_Msg3}+\Delta_{PC\_Msg3}+10\log10(M_{PUSCH}(i))+\Delta_{TF}(TF(i))\}$;<br><br>in which:<br>• $P_{MAX}$ is a maximum allowed transmission power;<br>• $P_{preamble}$ is the preamble power of the first message;<br>• $M_{PUSCH(i)}$ is determined from an uplink resource allocation of a second message received in response to sending the first message; | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Claims 5-8 and 14-17 include additional features that are taught in Qualcomm, TS 36.213, and the Qualcomm-386. Dependent claims 5 and 14 recite a specific function, *i.e.,* Equation [5] for calculating the transmit power for Message 3. (*See* '966 patent, 8:15-17).<br><br>**Equation [5]**: $P_{Msg3} = \min\{P_{max}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$.<br><br>**"$P_{max}$"**<br><br>$P_{max}$ refers to "the maximum allowed power that depends on the UE power class." ('966 patent, 4:35-36). The idea of ensuring that the Message 3 transmit power does not exceed $P_{max}$ is well known in the telecommunications world. As one example, TS 36.213 includes a similar check to ensure that the transmit power cannot exceed $P_{max}$. (TS 36.213, §5.1.1.1, p. 8). |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| • $\Delta_{TF}$(TF(i)) is calculated from received signaling;<br>• $\Delta_{PC\_Msg3}$ is indicated by a power control command received at the receiver; and<br>• $\Delta_{0,preamble\_Msg3}$ is an offset from the preamble power.<br><br>**14** The apparatus according to claim 10, wherein the initial transmit power $P_{Msg3}$ for i=0 is equal to:<br><br>$P_{Msg3}=\min\{P_{max}, P_{preamble}+\Delta 0_{,preamble\_Msg3}+\Delta_{PC\_Msg3}+10\log10(M_{PUSCH}(i))+\Delta_{TF}(TF(i))\}$;<br><br>in which:<br><br>• $P_{MAX}$ is a maximum allowed transmission power;<br>• $P_{preamble}$ is the preamble power of the first message;<br>• $M_{PUSCH(i)}$ is determined from an uplink resource allocation of a second message received in response to sending the first message;<br>• $\Delta_{TF}$(TF(i)) is calculated from received signaling;<br>• $\Delta_{PC\_Msg3}$ is indicated by a power control command received at the | **"$\Delta_{TF}$(TF(i))"**<br><br>The parameters 10 log10($M_{PUSCH}$(i)) + $\Delta_{TF}$(TF(i)) are also directly from the TS 36.213 transmit power formula. (TS 36.213, §5.1.1.1, p. 8). As noted by TS 36.213 and acknowledged by the '966 patent, $\Delta_{TF}$(TF(i)) can be equal to zero. (*See* '966 patent, 4:54-56; 8:18-19). This effectively removes $\Delta_{TF}$(TF(i)) from the Equation. The claimed formula, therefore, can be rewritten as<br><br>**Equation [5]**: $P_{Msg3} = \min\{P_{max}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log_{10}(M_{PUSCH}(i))\}$.<br><br>As detailed below, the disclosures of Qualcomm, TS 36.213 and the Qualcomm-386 teach the claimed $P_{Msg3}$ formula in Equation [5] of the '966 patent.<br><br>**"$P_{preamble}$"**<br><br>Equation (4) of Qualcomm teaches the transmit power of Message 3 (PUSCH_power) is calculated based on RACH_power parameter, which is transmit power of a successfully received random access preamble. (Qualcomm, 10:12-13). This RACH_power parameter is the same as the claimed $P_{preamble}$. (*See* '966 patent, 6:18-21).<br><br>**"$\Delta_{PC\_Msg3}$"**<br><br>The '966 patent Equation [5] includes parameter $\Delta_{PC\_Msg3}$, which "is the power control command included in the preamble response (*e.g.*, Message 2)." ('966 patent, 8:32-35). Similarly, the parameter PC_correction used in |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| receiver; and<br>• $\Delta_{0,preamble\_Msg3}$ is an offset from the preamble power. | Qualcomm's Equation (4) "is the PC correction received in the random access response." (Qualcomm, 10:16-17). Accordingly, the PC_correction parameter is the same as the $\Delta_{PC\_Msg3}$ parameter. *Akl Decl.* ¶ 87 (discussing $\Delta_{PC\_Msg3} = \Delta_{PC}$).<br><br>"**$\Delta_{0,preamble\_Msg3}$**"<br><br>The '966 patent Equation [5] includes parameter $\Delta_{0,preambie\_Msg3}$ which is "an offset from the preamble power" (claim 5) and "corresponds to a typical power offset between a Message 3 and the preamble whose power corresponds to the detection threshold." ('966 patent, 8:26-28). The parameter PUSCH_RACH_power_offset used in Qualcomm's Equation (4) "is a power offset between the PUSCH and RACH." (Qualcomm, 10:18-19). The random access preamble is sent on a random access channel (RACH). (Qualcomm, 4:19-20; 4:3841; and 6:14-15). PUSCH is a physical uplink shared channel and is used to transmit Message 3. (Qualcomm, 4:24-25, 10:14-15). Thus, PUSCH_RACH_power_offset as used in Qualcomm corresponds to a power offset between a message sent on a PUSCH, *e.g.*, Message 3, and a power used to transmit a successful random access preamble. Accordingly, the parameter PUSCH_RACH_power_offset in Qualcomm is the same as the claimed parameter $\Delta_{0,preamble\_Msg3}$.<br><br>**"$10\log_{10}(M_{PUSCH}(i))$"**<br><br>Equation (4) from Qualcomm does not expressly include the $10\log_{10}(M_{PUSCH}(i))$ expression. The $10\log_{10}(M_{PUSCH}(i))$ expression, however, is still present in Equation (4) as part of the PC_correction parameter.<br><br>As noted above, the AAPA and TS 36.213 power control formula disclose the parameters 10log10($M_{PUSCH}$(i)). ('966 patent, Equation [1]; TS 36.213, §5.1.1.1). The expression $10 \log_{10}(M_{PUSCH}(i))$ describes the "size of the |

| ‘966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | PUSCH resource assignment expressed in number of resources blocks valid for subframe *i*.” (‘966 patent, 4:37-39). This means that the transmit power is determined based on the number of resources that the user equipment will use to transmit data. A POSITA would recognize that transmit power goes up as the number of resources is increased. Accordingly, transmit power calculations in LTE will take into account the number of resources that the user equipment will use to transmit data. One way the transmit resources can be used in power calculations is by the user equipment incorporating these resources in its power calculations. This is how PUSCH power calculations are done in TS 36.213. (TS 36.213, §5.1.1.1, p. 8). Alternatively, the eNB determines the resources to grant to the user equipment and sends the uplink grant to the user equipment in a random access response. (TS 36.300, §10.1.5.1, p. 49). The eNB, therefore, knows the uplink resources that the user equipment will use to transmit data to the eNB.<br>In the random access response, the eNB can also modify the transmit power used by the user equipment to transmit a message through various mechanisms, such as the power control correction value. (*See* Qualcomm, 10:1617). The eNB can take into account the uplink resources granted to the user equipment in determining the power control correction value. (*See* Qualcomm-386, ¶¶ [0057]-[0067]). Incorporating the uplink resources in the calculation of the power control correction value has the same effect as the user equipment adjusting its transmit power based on the granted uplink resources. That effect is the transmit power of messages sent on the PUSCH is adjusted based on the uplink resources granted to the user equipment. Thus, calculating, at the eNB, the transmit power adjustment due to the granted resources yields the predictable results of the user equipment’s transmit power being adjusted due to the granted resources. The eNB knows of the resources granted to the user equipment and the eNB transmits a power control correction value to the user equipment. It is simply a design choice as to where the granted resources are used to adjust the transmit power. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
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| | The Qualcomm-386, whose inventors are the same as the Qualcomm patent, describes such a system where the eNB's power control adjustment can take into account the uplink resources granted to user equipment. In the Qualcomm-386, user equipment can calculate a power headroom or buffer size values that can be sent to the eNB as part of the random access preamble. (Qualcomm-386, ¶¶ [0036] and [0040]-[0041]). These values can be used to calculate both the uplink resource grant and the power control information. (Qualcomm-386, ¶¶ [0108], [0112], and [0118]).<br><br>As noted above, as resources required to transmit a message increase, *e.g.*, the larger the message, so does the power requirements to transmit that message. When user equipment uses more power, power control becomes more critical as increasing the transmit power can cause more interference with other user equipment and/or eNBs. This is why the Qualcomm-386 notes that the benefits of power control are greater when Message 3 is large. (Qualcomm-386, ¶ [0100]). As the benefits of power control are greater when Message 3 is large, the Qualcomm-386 teaches that the power control information takes into account the granted uplink resources, via the buffer size information. (Qualcomm-386, ¶¶ [0108], [0112], and [0118]).<br><br>The combination of relied upon teachings of the Qualcomm-386 with the features of Qualcomm and TS 36.213 would have been obvious to a POSITA. First, all three references are related to the same technical subject, *e.g.,* LTE system access. These references also focus on the same system access messaging used to access an LTE system. The Qualcomm power control function, *e.g.*, Equation (4), includes an adjustment based on power control information received from the eNB but does not expressly include a parameter that depends on the uplink granted resources. However, as noted in the Qualcomm-386 the benefits of power control are greater when Message 3 is large. Further, the power control information described in the |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | Qualcomm-386 takes into account the resources granted to the user equipment. A POSITA would find the combination of using the power control information described in the Qualcomm-386 with the teachings of Qualcomm to be obvious. Specifically, a POSITA would use power control information from the Qualcomm-386 to take into account the uplink resource grant in calculating the transmit power for Message 3. Further, a POSITA would recognize the ability to use the uplink resources to adjust the PUSCH transmit power based on TS 36.213. (TS 36.213, §5.1.1.1, p. 8). Qualcomm-386 is consistent with TS 36.213 for the same reasons as Qualcomm because Qualcomm-386 describes a way UE can access an LTE system. Accordingly, a POSITA would find it obvious to combine the teachings from LTE specifications, e.g., TS 36.213 and TS 36.300, to ensure compatibility with LTE.<br><br>In addition, a POSITA having the knowledge of Equation (4) of Qualcomm, which teaches the transmit power of Message 3 (PUSCH_power) can be calculated based on the preamble power, a power control correction, and a power offset from the preamble power, would find it obvious to derive Equation [5] based on Equation [1] of the '966 patent, which is reproduced from the admitted prior art TS 36.213.<br><br>According to the '966 patent, Equation [5] "defines the Message 3 power relative to preamble power, i.e., full path loss compensation used." ('966 patent, 8:7-11; 8:23-24 "for the case where $\alpha = 1$ full path loss compensation is used in this Message 3 power, just as for the preamble power."). In addition, as noted above, Qualcomm teaches calculating the preamble power based on the full path loss compensation. Thus, in deriving Equation [5], a POSITA would naturally set $\alpha = 1$ because full path loss compensation is used. Further, the '966 patent admits that prior art preamble power control formula for the UE's transmission on the Random Access Channel is calculated according to Equation [3]: |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | **Equation [3]**: $P_{preamble} = P_{target} + PL + \Delta P_{rampup}$; where<br>$P_{target}$ is the broadcasted target power;<br>PL is the path loss that UE estimates from DL; and<br>$\Delta P_{rampup}$ is the power ramp-up applied for preamble retransmissions.<br><br>A POSITA would recognize and rearrange Equation [3] above to solve for PL:<br><br>**<u>Rearrange Equation [3] and solve for PL:</u>**<br>→ **Equation [3]**: $PL = P_{preamble} - P_{target} - \Delta P_{rampup}$.<br><br>Further, a POSITA would set $\alpha = 1$ (full path loss compensation) and substitute PL of Equation [3] into Equation [1] to obtain:<br>**Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i)) + P_{O\_PUSCH}(j) + \alpha \bullet PL + f(i)\}$.<br>**<u>Set $\alpha = 1$ (full path loss compensation) and substitute PL of Equation [3] into Equation [1]:</u>**<br><br>→ **Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i)) + P_{O\_PUSCH}(j) + P_{preamble} - P_{target} - \Delta P_{rampup} + f(i)\}$.<br><br>According to the '966 patent and its admitted prior art, TS 36.213 v8.2.0, $f(i) = \delta_{PUSCH}(i - K_{PUSCH})$ if f(*) represents current absolute value; and $\delta_{PUSCH}$ is a **UE specific correction value**, also referred to as a **TPC (transmission power control) command** and it is included in PDCCH (Message 2). (TS 36.213 v8.2.0, §5.1.1.1; '966 patent, 4:62-5:35). A POSITA would substitute $f(i) = \delta_{PUSCH}(i - K_{PUSCH})$ into Equation [1]. Also, because $\delta_{PUSCH}$ is a UE specific correction value also known as a TPC (transmission power control) command, a POSITA would simplify the expression $\delta_{PUSCH}(i - K_{PUSCH})$ as $\Delta_{TPC}$. |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | **<u>Substitute $f(i) = \delta_{PUSCH}(i - K_{PUSCH})$ into Equation [1]:</u>**<br>➔ **Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i)) + P_{O\_PUSCH}(j) + P_{preamble} - P_{target} - \Delta P_{rampup} + \delta_{PUSCH}(i- K_{PUSCH})\}$;<br><br>**<u>Rearrange Equation [1]and simplify the expression $\delta_{PUSCH}(i- K_{PUSCH})$ as $\Delta_{TPC}$:</u>**<br>➔ **Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, P_{preamble} + [P_{O\_PUSCH}(j) - P_{target} - \Delta P_{rampup}] + \Delta_{TPC} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;<br><br>In addition, based on the teaching of Equation (4) of Qualcomm, which teaches the transmit power of Message 3 (PUSCH_power) can be calculated based on the preamble power, a power control correction, and a power offset from the preamble power, a POSITA would simplified the above equation by defining a power offset from the preamble, in the form of Power_Offset = $P_{O\_PUSCH}(j) - P_{target} - \Delta P_{rampup}$ to obtain a Modified Equation [1].<br><br>**<u>Define Power_Offset = $P_{O\_PUSCH}(j) - P_{target} - \Delta P_{rampup}$ and substitute into Equation [1] to obtain:</u>**<br>➔ **Modified Equation [1]**: $P_{PUSCH}(i)=\min\{P_{MAX}, P_{preamble} + Power\_Offset + \Delta_{TPC} + 10\log_{10}(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;<br><br>**Equation [5]**: $P_{Msg3} = \min\{P_{MAX}, P_{preamble} + \Delta 0_{,preamble\_Msg3} + \Delta_{PC\_Msg3} + 10\log10(M_{PUSCH}(i)) + \Delta_{TF}(TF(i))\}$;<br><br>A POSITA would recognize that the Modified Equation [1], which is derived from Equation [1] of the '966 patent (AAPA) and based on the teachings of Equation (4) of Qualcomm, is identical to Equation [5] of the '966 patent. Specifically, a POSITA would recognize that the Power_Offset parameter of Modified Equation [1] is the same as the $\Delta_{0,preamble\_Msg3}$ parameter of Equation |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| | [5]. The '966 patent states that $\Delta_{0,preamble\_Msg3}$ is an offset from the preamble power (claim 5) and $\Delta_{0,preamble\_Msg3}$ is a typical power offset between a Message 3 and the preamble whose power corresponds to the detection threshold ('966 patent, 8:26-28). A POSITA would understand that the Power_Offset parameter (which equals $P_{O\_PUSCH}(j)$ - $P_{target}$ - $\Delta P_{rampup}$) represents a power offset from the preamble power because it includes parameters such as $P_{target}$ and $\Delta P_{rampup}$ for calculating the preamble power. Also, a POSITA would recognize that the $\Delta_{TPC}$ parameter of Modified Equation [1] is the same as the $\Delta_{PC\_Msg3}$ parameter of Equation [5]. For example, the '966 patent states that $\Delta_{PC\_Msg3}$ is the power control command included in the preamble response (Message 2). ('966 patent, 8:32-34). The '966 patent and its admitted prior art, TS 36.213 v8.2.0, specify that $\Delta_{TPC}$ is a UE specific correction value also known as a TPC (transmission power control) command and it is included in PDCCH (Message 2). ('966 patent, 4:62-64). Thus, a POSITA would understand that the parameter, $\Delta_{TPC}$, is the same as the $\Delta_{PC\_Msg3}$ parameter described in Equation [5] of the '966 patent. |
| **6** A method according to claim 5, further comprising, after sending the third message, using the processor to compute an updated transmit power for the shared uplink channel using fractional power control and sending from the transmitter a subsequent message on the uplink shared channel using the updated transmit power, wherein the updated transmit power $P_{PUSCH}(i)$ is equal to:<br><br>$P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i) + P_{O\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(TF(i) + f(i)\}$;<br><br>wherein: | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Dependent claims 6 and 15 recite features which are part of AAPA relating to existing random access procedure that is disclosed in LTE specifications, e.g., TS 36.213. Specifically, the equation recited in claims 6 and 15 is identical to Equation [1] of the '966 patent, which is reproduced from existing 3GPP specification TS 36.213. ('966 patent, 4:28-5:35; TS 36.213 v8.2.0, §5.1.1.1).<br><br>The '966 patent also admits that existing random access procedure discloses "RACH preambles are transmitted by the UEs using a full path-loss compensation PC formula. The target is that reception RX level of those preambles at the eNB is the same, and so independent of path-loss. This is |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| • $P_{O\_PUSCH\,(j)}$ is calculated from received signaling,<br>• α or an indication of α is received in signaling, and<br>• PL is path loss that is estimated from received signaling. | needed because several simultaneous preamble transmissions can take place in the same PRACH resource and in order to detect them, their power at the eNB needs to be roughly the same to avoid the well-known near-far problem for spread spectrum transmissions. However subsequent uplink transmissions on the PUSCH are orthogonal, and so called **fractional power control** can be used." ('966 patent, 2:39-49; emphasis added). |
| **15** The apparatus according to claim 14, wherein the processor is configured with the memory and the computer program to compute an updated transmit power for the shared uplink channel using fractional power control and the transmitter is configured to send from the transmitter a subsequent message on the uplink shared channel using the updated transmit power, wherein the updated transmit power PPUSCH(i) is equal to:<br><br>$P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i) + P_{O\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(TF(i) + f(i)\}$;<br><br>wherein:<br>• $P_{O\_PUSCH\,(j)}$ is calculated from received signaling,<br>• α or an indication of α is received in signaling, and<br>• PL is path loss that is estimated from received signaling. | Dependent claims 6 and 15 include features that are related to those in claims 2 and 11. Specifically, claims 6 and 15 recite computing an updated transmit power for the shared uplink channel using fractional power control and sending a message after Message 3 with the updated transmit power. Accordingly, the discussion regarding claims 2 and 11 are relevant to understanding how the features of claims 6 and 15 are taught in the prior art. These paragraphs are not repeated here. (*See Akl Decl.* ¶¶ 155-164).<br><br>Different from claims 2 and 11 is the use of a specific formula to calculate the updated transmit power. The claimed formula is the exact formula from TS 36.213. (TS 36.213, §5.1.1.1, p. 8). This function, also recited verbatim in the '966 patent, is $P_{PUSCH}(i)=\min\{P_{MAX}, 10\log_{10}(M_{PUSCH}(i)) + P_{O\_PUSCH}(j) + \alpha \bullet PL + \Delta_{TF}(TF(i)) + f(i)\}$[dBm].<br><br>This function was also discussed regarding claims 2 and 11 in terms of how this formula teaches using "fractional power control." (*See Akl Decl.* ¶¶ 160-162). |
| 7 The method according to claim 6, | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213,** |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| wherein $\alpha = 1$ for the third message and for all retransmissions of the third message indicating full path loss compensation, and $\alpha < 1$ for messages after the third message and all retransmissions of the third message indicating fractional path loss compensation.<br><br>**16** The apparatus according to claim 15, wherein $\alpha = 1$ for the third message and for all retransmissions of the third message indicating full path loss compensation, and $\alpha < 1$ for messages after the third message and all retransmissions of the third message indicating fractional path loss compensation. | **TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Dependent claims 7 and 16 further narrow claims 6 and 15 by setting $\alpha = 1$ for the transmission of Message 3 and all retransmissions of Message 3, and setting $\alpha < 1$ for all subsequent messages and retransmissions of Message 3 indicating fractional path loss compensation.<br><br>As claims 7 and 16 recite that retransmissions of Message 3 can be sent using both an $\alpha = 1$ and $\alpha < 1$, a POSITA would understand these claims to mean that Message 3 can be retransmitted with either $\alpha$ value and that the transmit power will reflect either full path loss compensation, *i.e.,* $\alpha = 1$, or a fractional path loss compensation, *i.e.*, $\alpha < 1$.<br><br>As noted above with regard to claim 1, Qualcomm teaches using the full path loss compensation for calculating the initial Message 3 power. (Qualcomm, 8:37-40, 10:1-19). The Message 3 power therefore indicates a full path loss compensation. In addition, this power would be used for all retransmissions of Message 3.<br><br>For messages subsequent to the initial transmission of Message 3, the formula from TS 36.213 is used, which includes $\alpha < 1$or $\alpha = 1$. (TS 36.213, §5.1.1.1, p. 8). This formula would also be used for calculating retransmissions of messages after Message 3.<br><br>As described above with regard to claims 2 and 11, combining these teachings together would have been obvious to a POSITA. (*See Akl Decl.* ¶¶ 163-165). |
| **8** The method according to claim 7, executed by a user equipment; and wherein the third message comprises an indication of a power difference between | **Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321)** disclose these limitations. *See e.g.*:<br><br>Dependent claims 8 and 17 further narrow Message 3 to include an |

| '966 claim | Qualcomm, Qualcomm-386, and/or AAPA (including 3GPP TS 36.213, TS 36.300, TS 36.321) |
|---|---|
| the initial transmit power which is computed using full path loss compensation and a fractional path loss computation of the initial transmit power. | indication of a power difference between the initial transmit power using full path loss compensation and a fractional path loss computation of the initial transmit power.<br><br>TS 36.213 provides an example of a fractional path loss computation of the initial transmit power. (TS 36.213, §5.1.1.1, p. 8). This function is discussed above with regard to claims 2, 6, 11, and 15. (*See Akl Decl.* ¶¶ 189-191). The '966 patent acknowledges that a transmit power calculated from the TS 36.213 Equation is computed using fractional path loss. ('966 patent, 8:51-53). In some cases, the fractional path loss transmit power will simply be the maximum allowed power for the user equipment. (TS 36.213, §5.1.1.1, p. 8).<br><br>Qualcomm-386 teaches sending a power headroom value in Message 3. (Qualcomm-386, ¶ [0097]). The power headroom can indicate "the difference between the maximum transmit power at the UE and the transmit power used for the first message." (Qualcomm-386, ¶ [0108]). Thus, the power headroom indicates the difference between the transmit power of Message 3 that is based on full path loss compensation, *i.e.,* the PUSCH power formula from Qualcomm, and a value that corresponds with the TS 36.213 Equation, which is the fractional path loss compensation of the initial transmit power. Further, as described above the initial transmit power of Message 3, *e.g.*, the first message sent after a successful random access preamble, is calculated using full pass loss compensation, i.e., based upon the entire estimated path loss. (Qualcomm, 8:37-39). |
| **17** The apparatus according to claim 15, in which the apparatus comprises a user equipment, and wherein the third message comprises an indication of a power difference between the initial transmit power which is computed using full path loss compensation and a fractional path loss computation of the initial transmit power. | |

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(12) **United States Patent**
**Damnjanovic et al.**

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(54) **RANDOM ACCESS SIGNALING TRANSMISSION FOR SYSTEM ACCESS IN WIRELESS COMMUNICATION**

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(52) **U.S. Cl.**
USPC ........... **370/252**; 370/278; 370/311; 455/522; 455/69; 455/127.1

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USPC ......... 370/329, 335, 418, 330, 336, 282, 278, 370/252, 311; 455/522, 69, 63.1
See application file for complete search history.

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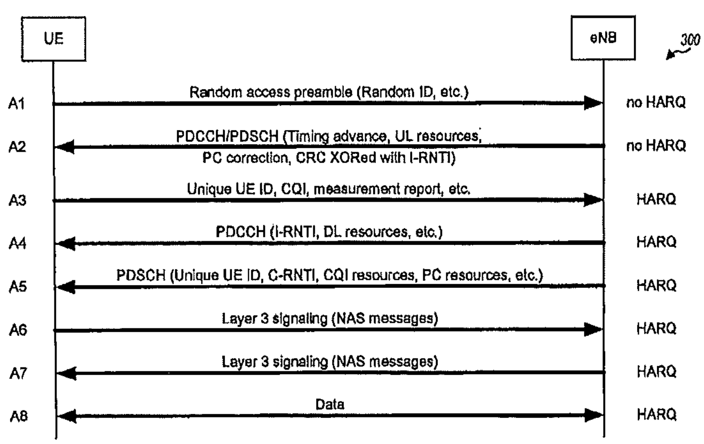
(74) *Attorney, Agent, or Firm* — Ashish L. Patel

(57) **ABSTRACT**

Techniques for transmitting random access signaling for system access are described. In an aspect, random access signaling may be sent based on at least one transmission parameter having different values for different user equipment (UE) classes. At least one parameter value may be determined based on a particular UE class, and the random access signaling may be sent based on the determined parameter value(s). The random access signaling may be a random access preamble, and the at least one transmission parameter may include a target SNR, a backoff time, and/or a power ramp. The random access preamble may then be sent based on a target SNR value, a power ramp value, and/or a backoff time value for the particular UE class. In another aspect, a message for system access may be sent based on a power control correction received in a random access response for the random access preamble.

**33 Claims, 8 Drawing Sheets**



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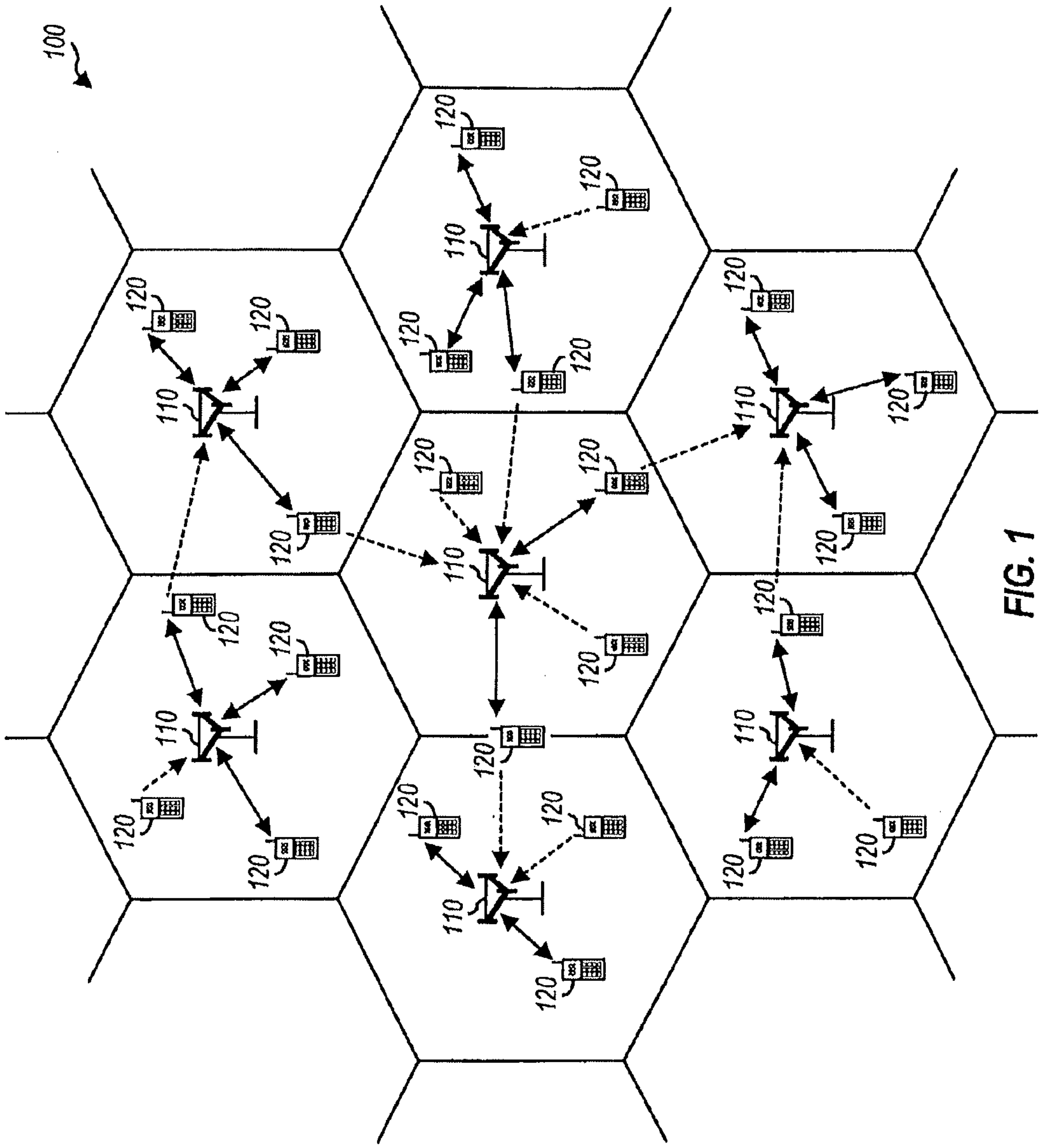



FIG. 1

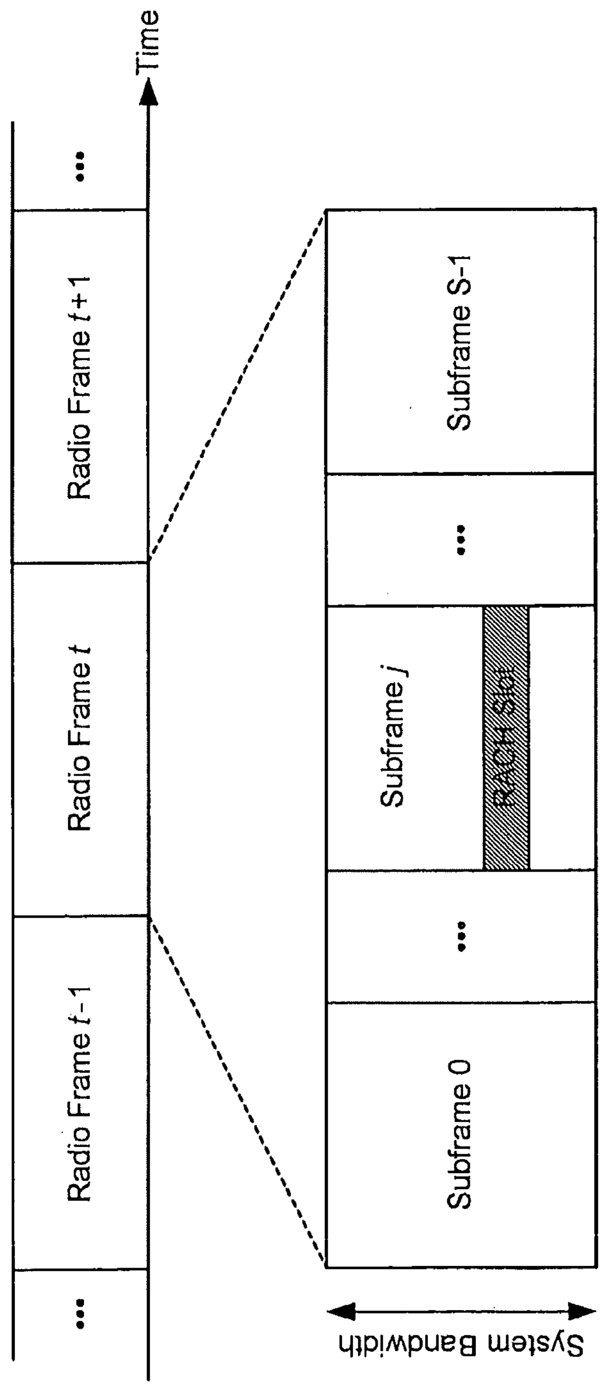

Time
Radio Frame t-1
Radio Frame t
Radio Frame t+1
Subframe 0
Subframe j
RACH Slot
Subframe S-1
System Bandwidth

FIG. 2

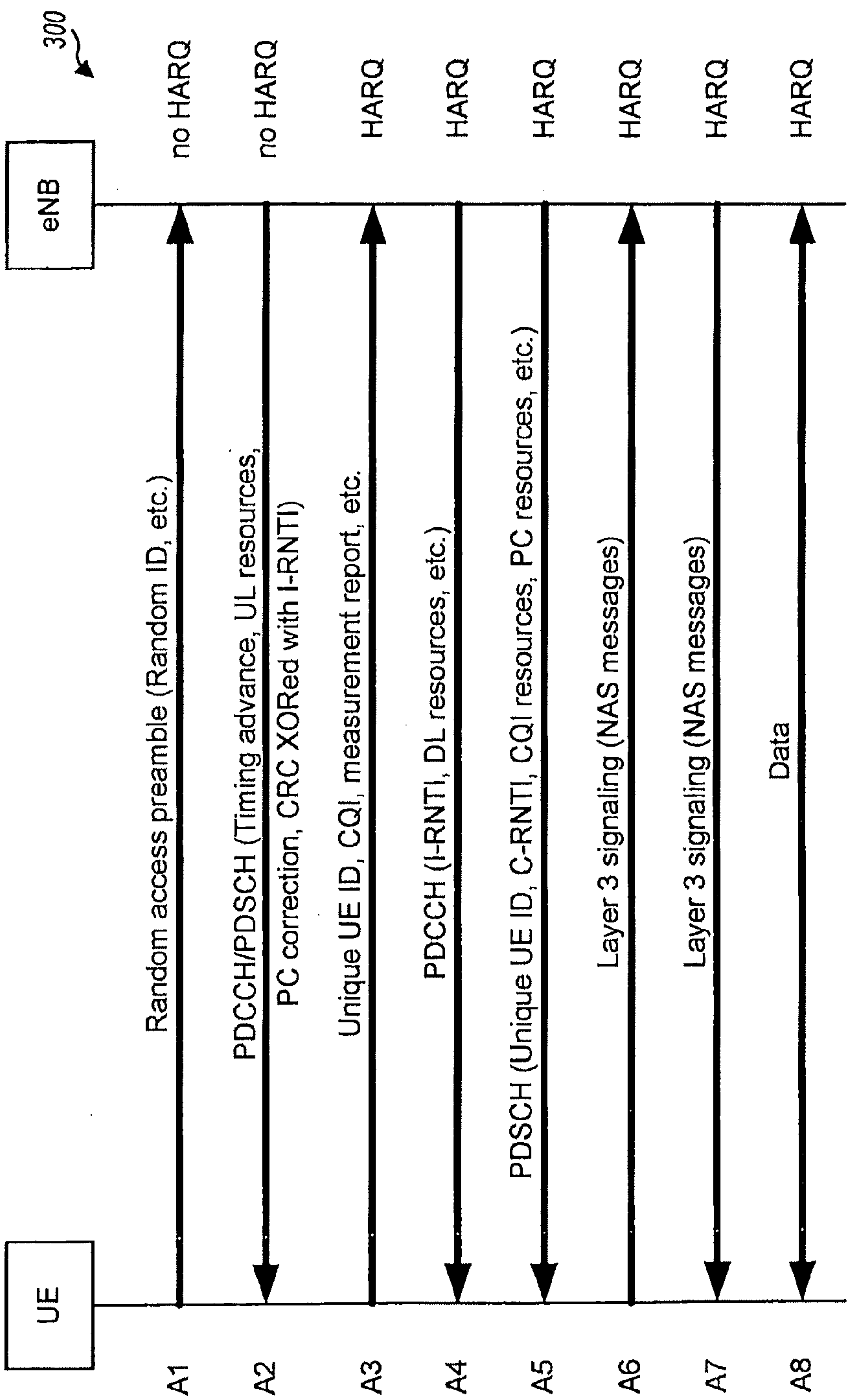

300
UE
eNB
A1
Random access preamble (Random ID, etc.)
no HARQ
A2
PDCCH/PDSCH (Timing advance, UL resources,
PC correction, CRC XORed with I-RNTI)
no HARQ
A3
Unique UE ID, CQI, measurement report, etc.
HARQ
A4
PDCCH (I-RNTI, DL resources, etc.)
HARQ
A5
PDSCH (Unique UE ID, C-RNTI, CQI resources, PC resources, etc.)
HARQ
A6
Layer 3 signaling (NAS messages)
HARQ
A7
Layer 3 signaling (NAS messages)
HARQ
A8
Data
HARQ

*FIG. 3*

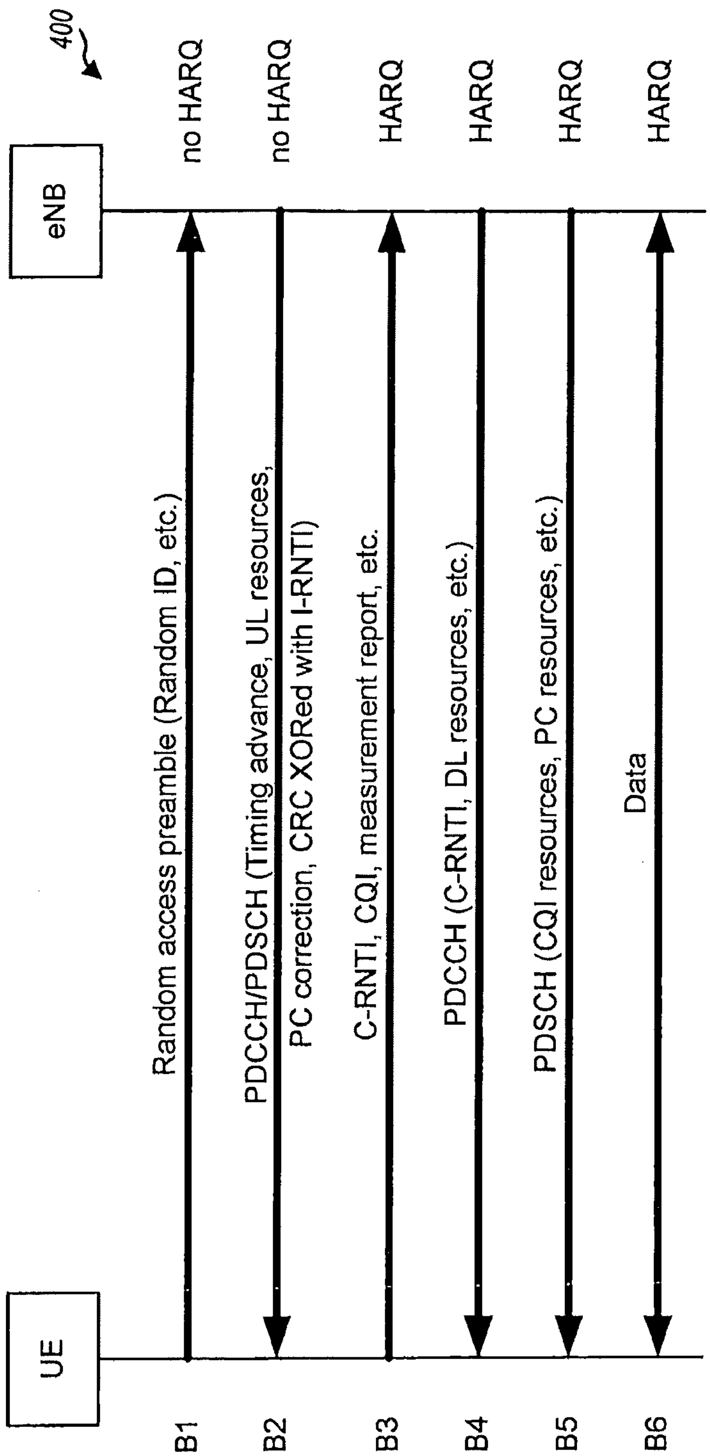

400
UE
eNB
B1
Random access preamble (Random ID, etc.)
no HARQ
B2
PDCCH/PDSCH (Timing advance, UL resources,
PC correction, CRC XORed with I-RNTI)
no HARQ
B3
C-RNTI, CQI, measurement report, etc.
HARQ
B4
PDCCH (C-RNTI, DL resources, etc.)
HARQ
B5
PDSCH (CQI resources, PC resources, etc.)
HARQ
B6
Data
HARQ

*FIG. 4*

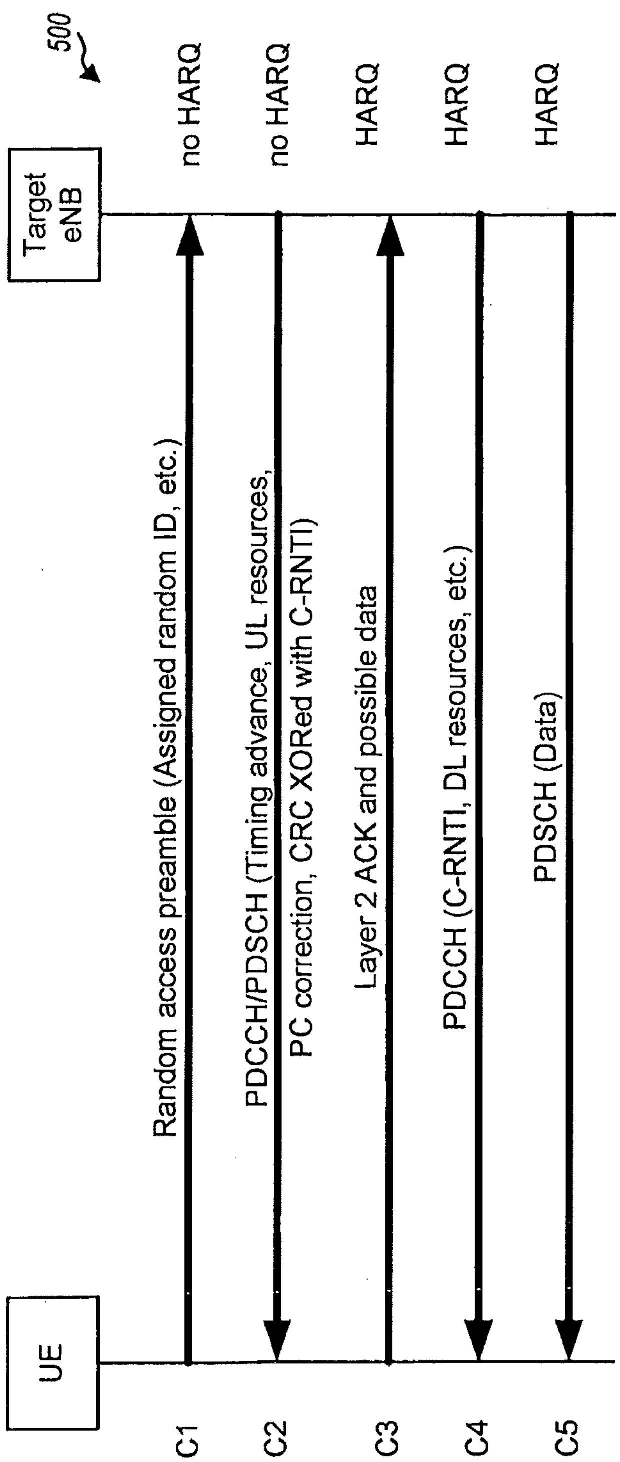

500
UE
Target eNB
C1
Random access preamble (Assigned random ID, etc.)
no HARQ
C2
PDCCH/PDSCH (Timing advance, UL resources, PC correction, CRC XORed with C-RNTI)
no HARQ
C3
Layer 2 ACK and possible data
HARQ
C4
PDCCH (C-RNTI, DL resources, etc.)
HARQ
C5
PDSCH (Data)
HARQ

*FIG. 5*

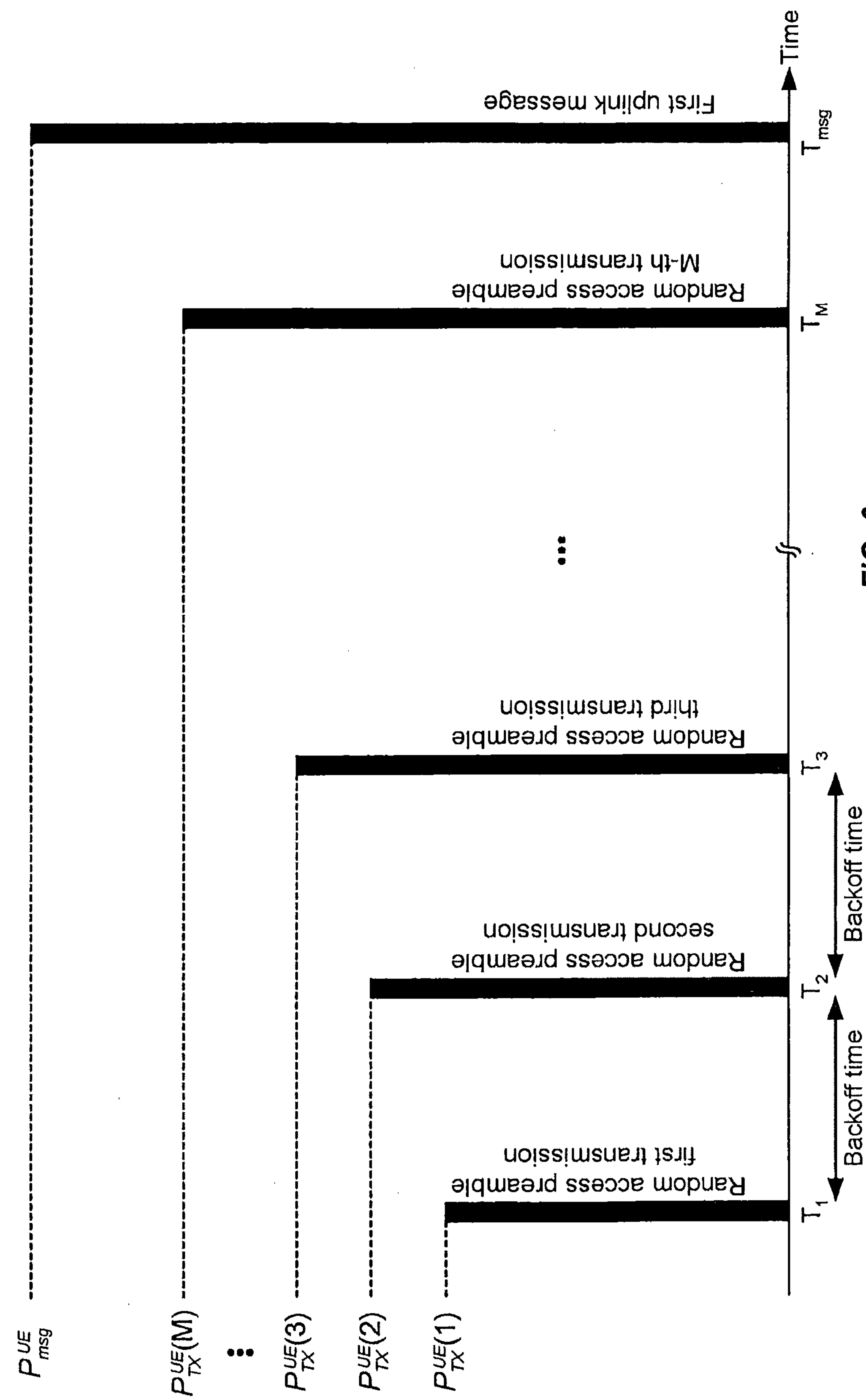
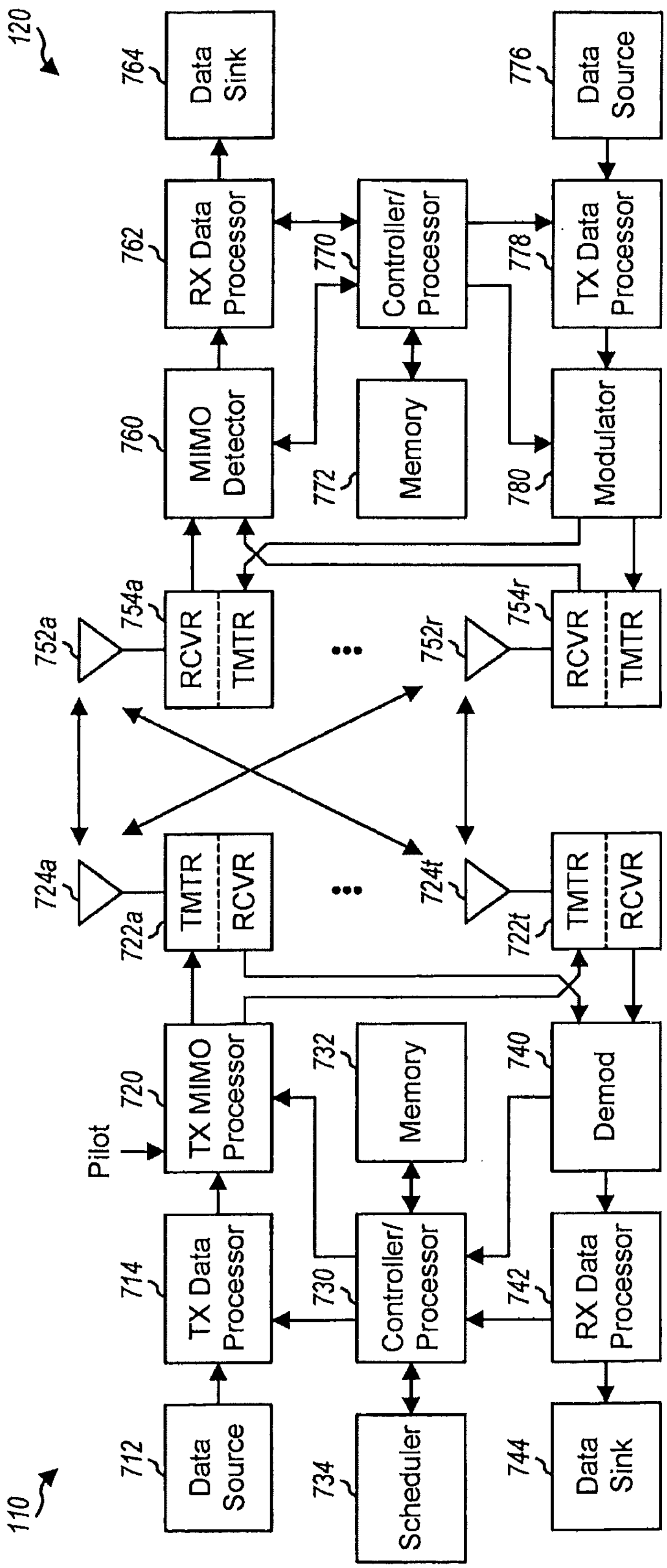

Time
First uplink message
$T_{msg}$
Random access preamble
M-th transmission
$T_M$
Random access preamble
third transmission
$T_3$
Backoff time
Random access preamble
second transmission
$T_2$
Backoff time
Random access preamble
first transmission
$T_1$
$P_{msg}^{UE}$
$P_{TX}^{UE}(M)$
•••
$P_{TX}^{UE}(3)$
$P_{TX}^{UE}(2)$
$P_{TX}^{UE}(1)$

*FIG. 6*



120
110
Data Source
712
TX Data Processor
714
TX MIMO Processor
720
Pilot
TMTR
RCVR
722a
722t
724a
724t
Controller/ Processor
730
Memory
732
Scheduler
734
Demod
740
RX Data Processor
742
Data Sink
744
752a
752r
RCVR
TMTR
754a
754r
MIMO Detector
760
RX Data Processor
762
Data Sink
764
Controller/ Processor
770
Memory
772
Data Source
776
TX Data Processor
778
Modulator
780


FIG. 7

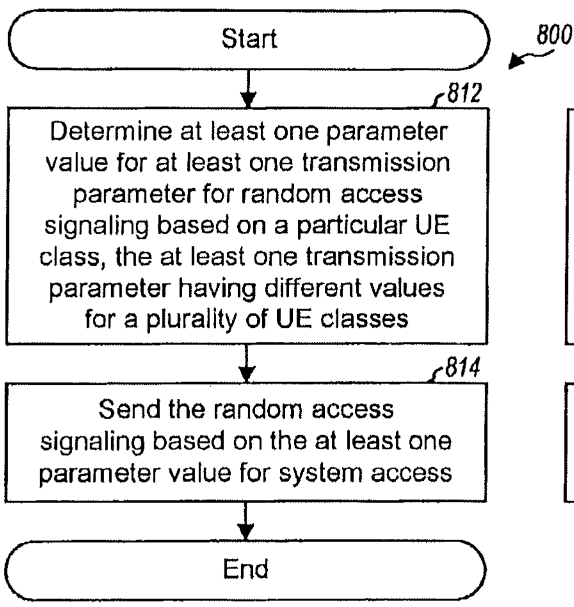



FIG. 8

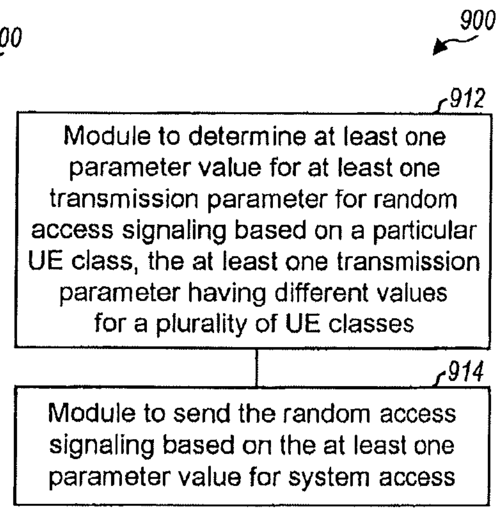



FIG. 9

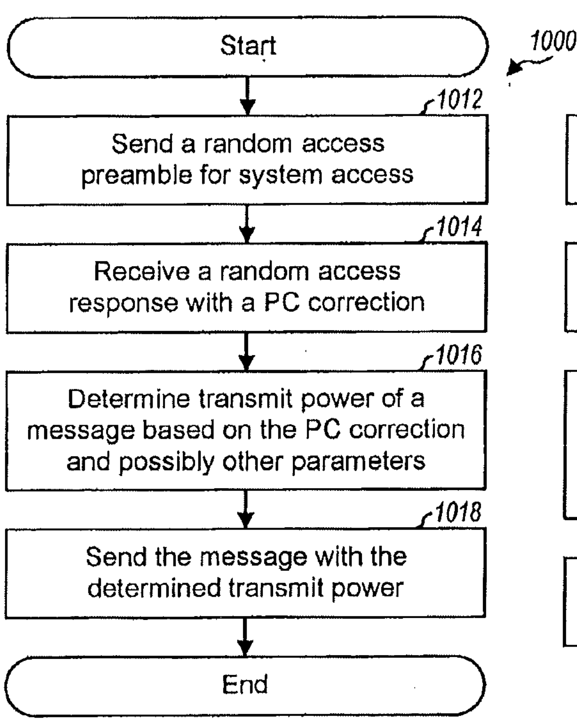



FIG. 10

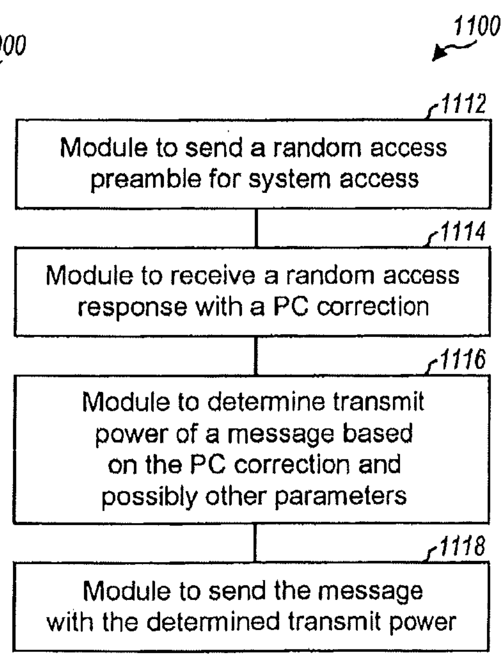



FIG. 11

# RANDOM ACCESS SIGNALING TRANSMISSION FOR SYSTEM ACCESS IN WIRELESS COMMUNICATION

The present application claims priority to provisional U.S. Application Ser. No. 60/828,058, filed Oct. 3, 2006, and assigned to the assignee hereof and incorporated herein by reference.

## BACKGROUND

I. Field

The present disclosure relates generally to communication, and more specifically to techniques for accessing a wireless communication system.

II. Background

Wireless communication systems are widely deployed to provide various communication content such as voice, video, packet data, messaging, broadcast, etc. These wireless systems may be multiple-access systems capable of supporting multiple users by sharing the available system resources. Examples of such multiple-access systems include Code Division Multiple Access (CDMA) systems, Time Division Multiple Access (TDMA) systems, Frequency Division Multiple Access (FDMA) systems, Orthogonal FDMA (OFDMA) systems, and Single-Carrier FDMA (SC-FDMA) systems.

A wireless communication system may include any number of base stations that can support communication for any number of user equipments (UEs). Each UE may communicate with one or more base stations via transmissions on the downlink and uplink. The downlink (or forward link) refers to the communication link from the base stations to the UEs, and the uplink (or reverse link) refers to the communication link from the UEs to the base stations.

A UE may transmit a random access preamble (or an access probe) on the uplink when the UE desires to gain access to the system. A base station may receive the random access preamble and respond with a random access response (or an access grant) that may contain pertinent information for the UE. Uplink resources are consumed to transmit the random access preamble, and downlink resources are consumed to transmit the random access response. Furthermore, the random access preamble and other signaling sent for system access may cause interference on the uplink. There is therefore a need in the art for techniques to efficiently transmit the random access preamble and signaling for system access.

## SUMMARY

Techniques for efficiently transmitting random access signaling for system access are described herein. In an aspect, a UE may send random access signaling based on at least one transmission parameter having different values for different UE classes, which may provide certain advantages described below. At least one parameter value for the at least one transmission parameter may be determined based on a particular UE class. The random access signaling may then be sent based on the at least one parameter value for system access.

In one design, the random access signaling may be a random access preamble, which is signaling sent first for system access. The at least one transmission parameter may comprise a target signal-to-noise ratio (SNR) for the random access preamble. The transmit power of the random access preamble may be determined based on a target SNR value for the particular UE class and other parameters. The random access preamble may then be sent with the determined transmit power. In another design, the at least one transmission parameter may comprise a backoff time, and the amount of time to wait between successive transmissions of the random access preamble may be determined based on a backoff time value for the particular UE class. In yet another design, the at least one transmission parameter may comprise a power ramp, and the transmit power for successive transmissions of the random access preamble may be determined based on a power ramp value for the particular UE class.

In another design, the random access signaling may be a message sent after receiving a random access response for the random access preamble. The at least one transmission parameter may comprise a power offset between a first channel used to send the random access preamble and a second channel used to send the message. The transmit power of the message may be determined based on a power offset value for the particular UE class, and the message may be sent with the determined transmit power.

In another aspect, a message for system access may be sent based on a power control (PC) correction. A random access preamble may be sent for system access, and a random access response with a PC correction may be received. The transmit power of the message may be determined based on the PC correction and other parameters such as the power offset between the channels used to send the random access preamble and the message. The message may then be sent with the determined transmit power.

Various aspects and features of the disclosure are described in further detail below.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a wireless multiple-access communication system.

FIG. **2** shows a transmission structure for the uplink.

FIG. **3** shows a message flow for initial system access.

FIG. **4** shows a message flow for system access to transition to an active state.

FIG. **5** shows a message flow for system access for handover.

FIG. **6** shows successive random access preamble transmissions with backoff.

FIG. **7** shows a block diagram of an eNB and a UE.

FIG. **8** shows a process for transmitting random access signaling.

FIG. **9** shows an apparatus for transmitting random access signaling.

FIG. **10** shows a process for transmitting a message for system access.

FIG. **11** shows an apparatus for transmitting a message for system access.

## DETAILED DESCRIPTION

The techniques described herein may be used for various wireless communication systems such as CDMA, TDMA, FDMA, OFDMA, SC-FDMA and other systems. The terms "system" and "network" are often used interchangeably. A CDMA system may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000, etc. UTRA includes Wideband-CDMA (W-CDMA) and Low Chip Rate (LCR). cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA system may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA system may implement a radio technology such as Evolved UTRA (E-UTRA), Ultra Mobile Broadband (UMB), IEEE 802.11 (Wi-Fi), IEEE 802.16

(WiMAX), IEEE 802.20, Flash-OFDM®, etc. UTRA, E-UTRA and GSM are part of Universal Mobile Telecommunication System (UMTS). 3GPP Long Term Evolution (LTE) is an upcoming release of UMTS that uses E-UTRA, which employs OFDMA on the downlink and SC-FDMA on the uplink. UTRA, E-UTRA, GSM, UMTS and LTE are described in documents from an organization named "3rd Generation Partnership Project" (3GPP). cdma2000 and UMB are described in documents from an organization named "3rd Generation Partnership Project 2" (3GPP2). These various radio technologies and standards are known in the art. For clarity, certain aspects of the techniques are described below for system access in LTE, and LTE terminology is used in much of the description below.

FIG. 1 shows a wireless multiple-access communication system **100** with multiple evolved Node Bs (eNBs) **110**. An eNB may be a fixed station used for communicating with the UEs and may also be referred to as a Node B, a base station, an access point, etc. Each eNB **110** provides communication coverage for a particular geographic area. The overall coverage area of each eNB **110** may be partitioned into multiple (e.g., three) smaller areas. In 3GPP, the term "cell" can refer to the smallest coverage area, of an eNB and/or an eNB subsystem serving this coverage area. In other systems, the term "sector" can refer to the smallest coverage area and/or the subsystem serving this coverage area. For clarity, 3GPP concept of cell is used in the description below.

UEs **120** may be dispersed throughout the system. A UE may be stationary or mobile and may also be referred to as a mobile station, a terminal, an access terminal, a subscriber unit, a station, etc. A UE may be a cellular phone, a personal digital assistant (PDA), a wireless modem, a wireless communication device, a handheld device, a laptop computer, a cordless phone, etc. A UE may communicate with one or more eNBs via transmissions on the downlink and uplink. In FIG. **1**, a solid line with double arrows indicates communication between an eNB and a UE. A broken line with a single arrow indicates a UE attempting to access the system.

FIG. **2** shows an example transmission structure for the uplink. The transmission timeline may be partitioned into units of radio frames. Each radio frame may be partitioned into multiple (S) subframes, and each subframe may include multiple symbol periods. In one design, each radio frame has a duration of 10 milliseconds (ms) and is partitioned into 10 subframes, and each subframe has a duration of 1 ms and includes 12 or 14 symbol periods. The radio frames may also be partitioned in other manners.

The time-frequency resources available for the uplink may be allocated for different types of transmission such as traffic data, signaling/control information, etc. In one design, one or more Random Access Channel (RACH) slots may be defined in each radio frame and may be used by the UEs for system access. In general, any number of RACH slots may be defined. Each RACH slot may have any time-frequency dimension and may be located anywhere within a radio frame. In one design that is shown in FIG. **2**, a RACH slot spans one subframe and covers a predetermined bandwidth of 1.25 MHz. The RACH slot location (e.g., the specific subframe and portion of the system bandwidth used for the RACH slot) may be conveyed in system information that is broadcast on a Broadcast Channel (BCH) by each cell. Other parameters for the RACH slot (e.g., signature sequences being used) may be fixed or conveyed via the system information.

The system may support one set of transport channels for the downlink and another set of transport channels for the uplink. These transport channels may be used to provide information transfer services to Medium Access Control (MAC) and higher layers. The transport channels may be described by how and with what characteristics information is sent over a radio link. The transport channels may be mapped to physical channels, which may be defined by various attributes such as modulation and coding, mapping of data to resource blocks, etc. Table 1 lists some physical channels used for the downlink (DL) and uplink (UL) in LTE in accordance with one design.

TABLE 1

| Link | Channel | Channel Name | Description |
|---|---|---|---|
| DL | PBCH | Physical Broadcast Channel | Carry system information broadcast over a cell. |
| DL | PDCCH | Physical Downlink Control Channel | Carry UE-specific control information for the PDSCH. |
| DL | PDSCH | Physical Downlink Shared Channel | Carry data for UEs in a shared manner. |
| UL | PRACH | Physical Random Access Channel | Carry random access preambles from UEs attempting to access the system. |
| UL | PUCCH | Physical Uplink Control Channel | Carry control information from UEs such as CQI, ACK/NAK, resource requests, etc. |
| UL | PUSCH | Physical Uplink Shared Channel | Carry data sent by a UE on uplink resources assigned to the UE. |

The physical channels in Table 1 may also be referred to by other names. For example, the PDCCH may also be referred to as a Shared Downlink Control Channel (SDCCH), Layer 1/Layer 2 (L1/L2) control, etc. The PDSCH may also be referred to as a downlink PDSCH (DL-PDSCH). The PUSCH may also be referred to as an uplink PDSCH (UL-PDSCH).

The transport channels may include a Downlink Shared Channel (DL-SCH) used to send data to the UEs, an Uplink Shared Channel (UL-SCH) used to send data by the UEs, a RACH used by the UEs to access the system, etc. The DL-SCH may be mapped to the PDSCH and may also be referred to as a Downlink Shared Data Channel (DL-SDCH). The UL-SCH may be mapped to the PUSCH and may also be referred to as an Uplink Shared Data Channel (UL-SDCH). The RACH may be mapped to the PRACH.

A UE may operate in one of several states such as LTE Detached, LTE Idle and LTE Active states, which may be associated with RRC_NULL, RRC_IDLE and RRC_CONNECTED states, respectively. Radio Resource Control (RRC) may perform various functions for establishment, maintenance and termination of calls. In the LTE Detached state, the UE has not accessed the system and is not known by the system. The UE may power up in the LTE Detached state and may operate in the RRC_NULL state. The UE may transition to either the LTE Idle state or LTE Active state upon accessing the system and performing registration. In the LTE Idle state, the UE may have registered with the system but may not have any data to exchange on the downlink or uplink. The UE may thus be idle and operate in the RRC_IDLE state. In the LTE Idle state, the UE and the system may have pertinent context information to allow the UE to quickly transition to the LTE Active state. The UE may transition to the LTE Active state when there is data to send or receive. In the LTE Active state, the UE may actively communicate with the system on the downlink and/or uplink and may operate in the RRC_CONNECTED state.

The UE may transmit a random access preamble on the uplink whenever the UE desires to access the system, e.g., at power up, if the UE has data to send, if the UE is paged by the system, etc. A random access preamble is signaling that is sent first for system access and may also be referred to as an access signature, an access probe, a random access probe, a signature sequence, a RACH signature sequence, etc. The random access preamble may include various types of information and may be sent in various manners, as described below. An eNB may receive the random access preamble and may respond by sending a random access response to the UE. A random access response may also be referred to as an access grant, an access response, etc. The random access response may carry various types of information and may be sent in various manners, as described below. The UE and eNB may further exchange signaling to set up a radio connection and may thereafter exchange data.

FIG. **3** shows a message flow for a design of a random access procedure **300**. In this design, the UE may be in the RRC_NULL or RRC_IDLE state and may access the system by sending a random access preamble (step **A1**). The random access preamble may include L bits of information, where L may be any integer value. An access sequence may be selected from a pool of $2^L$ available access sequences and sent for the random access preamble. In one design, the random access preamble includes L=6 bits of information, and one access sequence is selected from a pool of 64 access sequences. The $2^L$ access sequences may be of any length and may be designed to have good detection properties. For example, 64 access sequences may be defined based on different cyclic shifts of a Zardoff-Chu sequence of a suitable length.

The random access preamble may include a random identifier (ID) that may be pseudo-randomly selected by the UE and used to identify the random access preamble from the UE. The random access preamble may also include one or more additional bits for downlink channel quality indicator (CQI) and/or other information. The downlink CQI may be indicative of the downlink channel quality as measured by the UE and may be used to send subsequent downlink transmission to the UE and/or to assign uplink resources to the UE. In one design, a 6-bit random access preamble may include a 4-bit random ID and a 2-bit CQI. In another design, a 6-bit random access preamble may include a 5-bit random ID and a 1-bit CQI. The random access preamble may also include different and/or additional information.

The UE may determine an Implicit Radio Network Temporary Identifier (I-RNTI) that may be used as a temporary ID for the UE during system access. The UE may be identified by the I-RNTI until a more permanent ID such as a Cell RNTI (C-RNTI) is assigned to the UE. In one design, the I-RNTI may include the following:

System time (8 bits)—time when the access sequence is sent by the UE, and

RA-preamble identifier (6 bits)—index of the access sequence sent by the UE.

The I-RNTI may have a fixed length (e.g., 16 bits) and may be padded with a sufficient number of zeros (e.g., 2 zeros) to achieve the fixed length. The system time may be given in units of radio frames, and an 8-bit system time may be unambiguous over 256 radio frames or 2560 ms. In another design, the I-RNTI is composed of 4-bit system time, 6-bit RA-preamble identifier, and padding bits (if needed). In general, the I-RNTI may be formed with any information that may (i) allow the UE or random access preamble to be individually addressed and (ii) reduce the likelihood of collision with another UE using the same I-RNTI. The lifetime of the I-RNTI may be selected based on the maximum expected response time for an asynchronous response to the random access preamble. The I-RNTI may also include system time and a pattern (e.g., 000 . . . 0 in front of system time) to indicate that the RNTI addresses the RACH.

In another design, multiple RACHs may be available, and the UE may randomly select one of the available RACHs. Each RACH may be associated with a different Random Access RNTI (RA-RNTI). The UE may be identified by a combination of the RA-preamble identifier and the RA-RNTI of the selected RACH during the system access. An I-RNTI may be defined based on any combination of the RA-preamble identifier, RA-RNTI, and system time, e.g., the RA-preamble identifier and RA-RNTI, or the RA-RNTI and system time, etc. System time may be beneficial for asynchronous response to the random access preamble. If the I-RNTI is formed based on the RA-RNTI and system time, then the UE may be identified based on the RA-preamble identifier sent separately, e.g., on the PDSCH. The UE may send the random access preamble on the selected RACH.

An eNB may receive the random access preamble from the UE and may respond by sending a random access response on the PDCCH and/or PDSCH to the UE (step **A2**). The eNB may determine the I-RNTI of the UE in the same manner as the UE. The eNB may asynchronously respond to the random access preamble from the UE within the lifetime of the I-RNTI. In one design, the PDCCH/PDSCH may carry the following:

Timing advance—indicate adjustment to the transmit timing of the UE,

UL resources—indicate resources granted to the UE for uplink transmission,

PC correction—indicate adjustment to the transmit power of the UE, and

I-RNTI—identify the UE or access attempt for which the access grant is sent.

A cyclic redundancy check (CRC) may be generated based on all information being sent on the PDCCH/PDSCH. The CRC may be exclusive ORed (XORed) with the I-RNTI (as shown in FIG. **3**), the RA-preamble identifier, the RA-RNTI, and/or other information to identify the UE being addressed. Different and/or other information may also be sent on the PDCCH/PDSCH in step **A2**.

The UE may then respond with a unique UE ID in order to resolve possible collision (step **A3**). The unique UE ID may be an International Mobile Subscriber Identity (IMSI), a Temporary Mobile Subscriber Identity (TMSI), another random ID, etc. The unique UE ID may also be a registration area ID if the UE has already registered in a given area. The UE may also send downlink CQI, pilot measurement report, etc., along with the unique UE ID.

The eNB may receive a unique "handle" or pointer to the unique UE ID. The eNB may then assign a C-RNTI and control channel resources to the UE. The eNB may send a response on the PDCCH and PDSCH (steps **A4** and **A5**). In one design, the PDCCH may carry a message containing the I-RNTI and DL resources indicating where remaining information is sent on the PDSCH to the UE. In one design, the PDSCH may carry a message containing the unique UE ID, the C-RNTI (if assigned), CQI resources used by the UE to send downlink CQI, PC resources used to send PC corrections to the UE, etc. The messages sent on the PDCCH and PDSCH may also carry different and/or other information.

The UE may decode the messages sent on the PDCCH and PDSCH to the UE. After decoding these two messages, the UE has sufficient resources configured and can exchange Layer 3 signaling with the eNB (steps **A6** and **A7**). The Layer 3 signaling may include Non-Access Stratum (NAS) messages for authentication of the UE, configuration of the radio link between the UE and eNB, connection management, etc. The UE and eNB may exchange data after completing the Layer 3 signaling (step **A8**).

FIG. 4 shows a message flow for a design of a random access procedure 400. In this design, the UE may be in the RRC_IDLE or RRC_CONNECTED state and may already have a C-RNTI assigned to the UE. The UE may access the system from the RRC_IDLE state in response to receiving data to send or from the RRC_CONNECTED state in response to a handover command. The UE may send a random access preamble, which may include a random ID and possibly one or more additional bits for downlink CQI and/or other information (step B1).

An eNB may receive the random access preamble from the UE and may respond by sending a random access response on the PDCCH and/or PDSCH to the UE (step B2). The random access response may include timing advance, UL resources, PC correction, and a CRC that may be XORed with an I-RNTI, an RA-preamble identifier, an RA-RNTI, and/or other information to identify the UE. The UE may then send its C-RNTI, downlink CQI, pilot measurement report and/or other information to the eNB (step B3). The eNB may then send a response on the PDCCH and PDSCH (steps B4 and B5). The PDCCH may carry a message containing the C-RNTI and the DL resources for the PDSCH. The PDSCH may carry a message containing the CQI resources, PC resources, etc. The UE may decode the messages sent on the PDCCH and PDSCH to the UE. Layer 3 signaling exchanges may be omitted since the UE has been authenticated prior to being assigned the C-RNTI. After step B5, the UE has sufficient resources configured and can exchange data with the eNB (step B6).

FIG. 5 shows a message flow for a design of a random access procedure 500 for handover. In this design, the UE may be communicating with a source eNB and may be handed over to a target eNB. The UE may be assigned a random ID by the source eNB for use to access the target eNB. To avoid collision, a subset of all possible random IDs may be reserved for handover, and the random ID assigned to the UE may be selected from this reserved subset. Information regarding the subset of reserved random IDs may be broadcast to all UEs.

The source eNB may inform the target eNB of the C-RNTI, random ID, CQI resources, PC resources and/or other information for the UE. Collision resolution may not be necessary due to a one-to-one mapping between the assigned random ID and the C-RNTI of the UE. The target eNB may thus have pertinent context information for the UE prior to the random access procedure. For simplicity, FIG. 5 shows the random access procedure between the UE and the target eNB.

The UE may send a random access preamble, which may include the random ID assigned to the UE and possibly other information (step C1). The target eNB may receive the random access preamble and may respond by sending a random access response on the PDCCH and/or PDSCH to the UE (step C2). The random access response may include timing advance, UL resources, PC correction, and a CRC that may be XORed with the C-RNTI of the UE. After step C2, the UE has sufficient resources configured and can exchange data with the eNB. The UE may send a Layer 2 ACK for the information received in step C2 and may also send data and/or other information (step C3). The eNB may then send data to the UE on the PDSCH (step C5) and may send signaling for the PDSCH on the PDCCH (step C4).

FIGS. 3 through 5 show some example random access procedures that may be used for initial system access, system access while idle, and system access for handover. Other random access procedures may also be used for system access.

As shown in FIGS. 3 through 5, hybrid automatic retransmission (HARQ) may be used for messages sent in steps A3, B3 and C3 and later. For HARQ, a transmitter may send a transmission of a message, and a receiver may send an ACK if the message is decoded correctly or a NAK if the message is decoded in error. The transmitter may send one or more retransmissions of the message, if needed, until an ACK is received for the message or the maximum number of retransmissions has been sent.

FIG. 6 shows a design of random access preamble transmission by the UE. The UE may transmit a random access preamble with an initial transmit power of $P_{TX}^{UE}(1)$ at time $T_1$ to a target eNB. The UE may then wait for a random access response from the eNB. If a random access response is not received within a predetermined time interval, then the UE may wait a particular backoff time and then retransmit the random access preamble in the next available RACH slot after the backoff time. The second transmission of the random access preamble is sent with higher transmit power of $P_{TX}^{UE}(2)$ at time $T_2$. The UE may continue to retransmit the random access preamble with progressively higher transmit power, after waiting a backoff time for each failed transmission, until either (1) a random access response is received from the eNB or (2) the maximum number of transmissions has been sent for the random access preamble. In the example shown in FIG. 6, the UE receives a random access response after M transmissions of the random access preamble, where in general M≥1.

After receiving the random access response, the UE may transmit the first uplink message (e.g., corresponding to step A3, B3 or C3 in FIG. 3, 4 or 5, respectively) with transmit power of $P_{msg}^{UE}$ at time $T_{msg}$. The transmit power $P_{msg}^{UE}$ may be selected to achieve reliable reception of the first uplink message while reducing uplink interference.

In one design, the transmit power for the m-th transmission of the random access preamble, $P_{TX}^{UE}(m)$, may be determined based on an open loop method, as follows:

$$P_{TX}^{UE}(m) = \frac{1}{P_{RX}^{UE}} \cdot SNR_{target} \cdot \left(\frac{1 + N_0 + I_{oc}^{UE}}{I_{or}}\right) \cdot P_{TX}^{eNB} \cdot (N_0 + I_{oc}^{eNB}) \cdot \delta \cdot K_{ramp}(m), \qquad \text{Eq (1)}$$

where

$P_{RX}^{UE}$ is the received power at the UE for time-frequency slots used for a reference signal (e.g., a pilot signal) from the recipient eNB,

$SNR_{target}$ is a target SNR for the random access preamble,

$N_0$ is Gaussian noise at the UE,

$I_{oc}^{UE}$ is interference from other eNBs at the UE,

$I_{or}$ is the received power for the recipient eNB at the UE,

$P_{TX}^{eNB}$ is the transmit power of the reference signal from the recipient eNB,

$N_0+I_{oc}^{eNB}$ is the RACH slot interference level at the recipient eNB,

δ is a correction factor, and

$K_{ramp}(m)$ is the amount of increase in transmit power for the m-th transmission.

In equation (1), $P_{RX}^{UE}$ is indicative of the received signal from the recipient eNB. The quantity

$$\frac{I_{or}}{N_0 + I_{oc}^{UE}}$$

is a signal-to-other-cell-interference-plus-noise ratio for the time-frequency slots used for the downlink reference signal, as measured by the UE. The correction factor δ may be used to bias the open loop algorithm. The eNB transmit power $P_{TX}^{eNB}$, the RACH slot interference level $N_0+I_{oc}^{eNB}$, the correction factor δ and/or other parameters may be broadcast on the BCH by the recipient eNB. These parameters may be used to determine the transmit power of the random access preamble. The UE may estimate this transmit power so that the SNR of the random access preamble at the recipient eNB corresponds to a target value for the $SNR_{target}$.

Equation (1) may be rewritten in logarithm domain using units of decibel (dB), as follows:

$$\text{TX\_power} = -\text{RX\_power} + \text{interference\_correction} + \text{offset\_power} + \text{added\_correction} + \text{power\_ramp\_up} \quad \text{Eq (2)}$$

where

$$\text{TX\_power} = 10\log_{10}(P_{TX}^{UE}(m)),$$

$$\text{RX\_power} = 10\log_{10}(P_{RX}^{UE}),$$

$$\text{interference\_correction} = 10\log_{10}\left(1 + \frac{N_0 + I_{oc}^{UE}}{I_{or}}\right),$$

$$\text{offset\_power} = 10\log_{10}(SNR_{target}) + 10\log_{10}(P_{TX}^{eNB}) + 10\log_{10}(N_0 + I_{oc}^{eNB}),$$

$$\text{added\_correction} = 10\log_{10}(\delta), \text{ and}$$

$$\text{power\_ramp\_up} = 10\log_{10}(K_{ramp}(m)).$$

The quantities in equation (2) are in units of dB. The receive power and the interference correction may be measured by the UE. The offset power and the added correction may be signaled by the recipient eNB on the BCH.

Since the open loop estimate may not be every accurate, the UE may increase its transmit power for subsequent transmissions of the random access preamble. In one design, the power ramp up may be defined as follows:

$$\text{power\_ramp\_up} = (m-1) \times \text{power\_step}, \quad \text{Eq (3)}$$

where power_step is the amount of increase in transmit power for each failed transmission of the random access preamble. Equation (3) linearly increases the transmit power of the random access preamble starting with power_ramp_up=0 dB for the first transmission. The transmit power may also be increased based on some other linear or non-linear function.

Equations (1) through (3) show one design of determining the transmit power of the random access preamble. The transmit power may also be determined in other manners, e.g., with different parameters than those shown in equation (1) or (2). For example, default values may be used for $P_{TX}^{eNB}$, $N_0+I_{oc}^{eNB}$,

$$\frac{I_{or}}{N_0 + I_{oc}^{UE}},$$

and/or other parameters. Alternatively, these parameters may be absorbed in the correction factor δ.

In one design, the transmit power of the first uplink message sent after successful transmission of the random access preamble may be determined as follows:

$$\text{PUSCH\_power} = \text{RACH\_power} + \text{PC\_correction} + \text{PUSCH\_RACH\_power\_offset} \quad \text{Eq (4)}$$

where

RACH_power is the transmit power of the successful transmission of the random access preamble on the RACH,

PUSCH_power is the transmit power of the message sent on the PUSCH,

PC_correction is the PC correction received in the random access response, and

PUSCH_RACH_power_offset is a power offset between the PUSCH and RACH.

In one design, the PC correction may indicate the amount of increase or decrease in transmit power and may be given with any number of bits (e.g., four bits) of resolution. In another design, the PC correction may simply indicate whether the transmit power should be increased or decreased by a predetermined amount. The PC correction may also be omitted or may be absorbed in the PUSCH to RACH power offset. The PUSCH to RACH power offset may be broadcast on the BCH by the eNB or may be provided by other means.

In one design, the same transmission parameter values and setting are used by all UEs. For example, the same target SNR and added correction may be used for the random access preamble by all UEs, and the same PUSCH to RACH power offset may be used for the first uplink message by all UEs.

In other designs, the UEs may be classified into multiple classes, and different transmission parameter values and settings may be used for different classes of UEs. The UEs may be classified in various manners. For example, the UEs may perform the random access procedure for various scenarios such as initial system access at power up, response to pages sent to the UE, data arriving at the UE, transition to active state, handover from one eNB to another eNB, etc. Different UE classes may be defined for different random access scenarios. In another design, the UEs may be classified based on their priorities, which may be determined based on service subscription and/or other factors. In yet another design, the UEs may be classified based on the types of messages being sent by these UEs. In general, any number of UE classes may be formed based on any set of factors, and each class may include any number of UEs.

In one design, different target SNR values may be used by UEs in different classes. For example, the UEs may be classified into two classes, a higher target SNR value may be used by UEs in a first class, and a lower target SNR value may be used by UEs in a second class. In general, UEs with the higher target SNR may be able to use more transmit power for their random access preambles, which may allow these random access preambles to be received with higher SNR at the eNBs. The use of different target SNR values by different classes of UEs may improve throughput of the RACH via a capture effect. For example, multiple UEs may transmit their random access preambles in the same RACH slot, which would then result in collisions of these random access preambles at an eNB. When a collision between two UEs in two classes occurs, a first random access preamble transmitted with the higher target SNR may observe less interference from a second random access preamble transmitted with the lower target SNR. Hence, the eNB may be able to correctly decode the first random access preamble and may or may not be able to decode the second random access preamble. The eNB may perform interference cancellation, estimate the interference due to the first random access preamble, cancel the estimated interference from the received signal, and then perform decoding for the second random access preamble. The likelihood of correctly decoding the second random access preamble may improve due to interference cancellation. Hence, the capture effect may allow the eNB to correctly decode all or a subset of the random access preambles transmitted in the same RACH slot. In contrast, if all UEs transmit their random access preambles with the same target SNR, then collisions between these UEs do not create the capture effect, and the eNB may not be able to correctly decode any of the random access preambles transmitted by these UEs. Consequently, all of these UEs may need to retransmit their random access preambles.

In another design, different correction factor values may be used for different classes of UEs. In yet another design, different power ramp up values may be used for different classes of UEs. For example, a higher power ramp up value may be used for one class of UEs to potentially reduce random access delay, and a lower power ramp up value may be used for another class of UEs. In yet another design, different backoff time values may be used for different classes of UEs. For example, a shorter backoff time may be used for one class of UEs to potentially reduce random access delay, and a longer backoff time may be used for another class of UEs.

In yet another design, different PUSCH to RACH power offset values may be used for different classes of UEs. This may allow the capture effect to be achieved for the first uplink messages sent by the UEs in different classes.

One or more of the parameters in equation (2) and/or (4) may have different values for different UE classes, as described above. In other designs, one or more parameters in equation (2) and/or (4) may have values that are specific for individual UEs. In one design, the target SNR and/or the correction factor $\delta$ may have UE-specific values. In this design, each UE may transmit its random access preamble with transmit power determined based on the target SNR and/or the correction factor for that UE. A default value or a broadcast value may be used for each parameter for which the UE-specific value is not available.

In another design, the PUSCH to RACH power offset may have UE-specific values. In this design, each UE may transmit its first uplink message with transmit power determined based on the PUSCH to RACH power offset value for that UE (or with a default or broadcast value if the UE-specific value is not available).

FIG. 7 shows a block diagram of a design of eNB **110** and UE **120**, which are one of the eNBs and one of the UEs in FIG. **1**. In this design, eNB **110** is equipped with T antennas **724***a* through **724***t*, and UE **120** is equipped with R antennas **752***a* through **752***r*, where in general $T \geq 1$ and $R \geq 1$.

At eNB **110**, a transmit (TX) data processor **714** may receive traffic data for one or more UEs from a data source **712**. TX data processor **714** may process (e.g., format, encode, and interleave) the traffic data for each UE based on one or more coding schemes selected for that UE to obtain coded data. TX data processor **714** may then modulate (or symbol map) the coded data for each UE based on one or more modulation schemes (e.g., BPSK, QSPK, PSK or QAM) selected for that UE to obtain modulation symbols.

A TX MIMO processor **720** may multiplex the modulation symbols for all UEs with pilot symbols using any multiplexing scheme. Pilot is typically known data that is processed in a known manner and may be used by a receiver for channel estimation and other purposes. TX MIMO processor **720** may process (e.g., precode) the multiplexed modulation symbols and pilot symbols and provide T output symbol streams to T transmitters (TMTR) **722***a* through **722***t*. In certain designs, TX MIMO processor **720** may apply beamforming weights to the modulation symbols to spatially steer these symbols. Each transmitter **722** may process a respective output symbol stream, e.g., for orthogonal frequency division multiplexing (OFDM), to obtain an output chip stream. Each transmitter **722** may further process (e.g., convert to analog, amplify, filter, and upconvert) the output chip stream to obtain a downlink signal. T downlink signals from transmitters **722***a* through **722***t* may be transmitted via T antennas **724***a* through **724***t*, respectively.

At UE **120**, antennas **752***a* through **752***r* may receive the downlink signals from eNB **110** and provide received signals to receivers (RCVR) **754***a* through **754***r*, respectively. Each receiver **754** may condition (e.g., filter, amplify, downconvert, and digitize) a respective received signal to obtain samples and may further process the samples (e.g., for OFDM) to obtain received symbols. A MIMO detector **760** may receive and process the received symbols from all R receivers **754***a* through **754***r* based on a MIMO receiver processing technique to obtain detected symbols, which are estimates of the modulation symbols transmitted by eNB **110**. A receive (RX) data processor **762** may then process (e.g., demodulate, deinterleave, and decode) the detected symbols and provide decoded data for UE **120** to a data sink **764**. In general, the processing by MIMO detector **760** and RX data processor **762** is complementary to the processing by TX MIMO processor **720** and TX data processor **714** at eNB **110**.

On the uplink, at UE **120**, traffic data from a data source **776** and signaling (e.g., random access signaling) may be processed by a TX data processor **778**, further processed by a modulator **780**, conditioned by transmitters **754***a* through **754***r*, and transmitted to eNB **110**. At eNB **110**, the uplink signals from UE **120** may be received by antennas **724**, conditioned by receivers **722**, demodulated by a demodulator **740**, and processed by an RX data processor **742** to obtain the traffic data and signaling transmitted by UE **120**.

Controllers/processors **730** and **770** may direct the operation at eNB **110** and UE **120**, respectively. Memories **732** and **772** may store data and program codes for eNB **110** and UE **120**, respectively. A scheduler **734** may schedule UEs for downlink and/or uplink transmission and may provide assignments of resources for the scheduled UEs.

FIG. **8** shows a design of a process **800** for transmitting random access signaling by a UE. At least one parameter value for at least one transmission parameter for random access signaling may be determined based on a particular UE class, with the at least one transmission parameter having different values for a plurality of UE classes (block **812**). The random access signaling may be sent based on the at least one parameter value for system access, e.g., for initial system access at power up, system access to transition to an active state, or system access for handover (block **814**). The at least one transmission parameter may comprise a target SNR, a power offset, a correction factor, etc. The transmit power of the random access signaling may be determined based on the at least one parameter value, and the random access signaling may be sent with the determined transmit power.

In one design, the random access signaling may be a random access preamble, and the at least one transmission parameter may comprise a target SNR for the random access preamble. The transmit power of the random access preamble may be determined based on a target SNR value for the particular UE class and other parameters such as received power for a reference signal, an interference level of a time-frequency slot used to send the random access preamble, a power offset, a correction factor, etc. The random access preamble may be sent with the determined transmit power. The at least one transmission parameter may comprise a backoff time, and the amount of time to wait between successive transmissions of the random access preamble may be determined based on a backoff time value for the particular UE class. The at least one transmission parameter may comprise a power ramp, and the transmit power for successive transmissions of the random access preamble may be determined based on a power ramp value for the particular UE class.

In another design, the random access signaling may be a message sent after receiving a random access response for the random access preamble. The at least one transmission parameter may comprise a power offset between a first channel (e.g., the RACH) used to send the random access preamble and a second channel (e.g., the PUSCH) used to send the message. The transmit power of the message may be determined based on a power offset value for the particular UE class and possibly other parameters such as a PC correction. The message may then be sent with the determined transmit power.

FIG. **9** shows a design of an apparatus **900** for transmitting random access signaling. Apparatus **900** includes means for determining at least one parameter value for at least one transmission parameter for random access signaling based on a particular UE class, with the at least one transmission parameter having different values for a plurality of UE classes (module **912**), and means for sending the random access signaling based on the at least one parameter value for system access (module **914**).

FIG. **10** shows a design of a process **1000** for transmitting a message for system access. A random access preamble may be sent for system access (block **1012**). A random access response with a PC correction may be received (block **1014**). The transmit power of a message may be determined based on the PC correction and possibly other parameters (block **1016**). For example, the transmit power of the message may be determined further based on the transmit power of the random access preamble, a power offset between a first channel used to send the random access preamble and a second channel used to send the message, etc. The message may be sent with the determined transmit power (block **1018**).

The PC correction may be generated based on received signal quality of the random access preamble at a base station. The PC correction may indicate the amount of increase or decrease in transmit power for the message. The PC correction may also indicate whether to increase or decrease the transmit power by a predetermined amount.

FIG. **11** shows a design of an apparatus **1100** for transmitting a message for system access. Apparatus **1100** includes means for sending a random access preamble for system access (module **1112**), means for receiving a random access response with a PC correction (module **1114**), means for determining the transmit power of a message based on the PC correction and possibly other parameters (module **1116**), and means for sending the message with the determined transmit power (module **1118**).

The modules in FIGS. **9** and **11** may comprise processors, electronics devices, hardware devices, electronics components, logical circuits, memories, etc., or any combination thereof.

Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the disclosure herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present disclosure.

The various illustrative logical blocks, modules, and circuits described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

The steps of a method or algorithm described in connection with the disclosure herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

In one or more exemplary designs, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

The previous description of the disclosure is provided to enable any person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the disclosure. Thus, the disclosure is not intended to be limited to the examples and designs described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

**1**. An apparatus for wireless communication, comprising:

at least one processor configured to determine at least one parameter value for at least one transmission parameter for random access signaling based on a particular user equipment (UE) class, the at least one transmission parameter having different values for a plurality of UE classes, and to send the random access signaling based on the at least one parameter value for system access; and

a memory coupled to the at least one processor;

wherein the at least one processor is further configured to send a random access preamble on a first channel, to receive a random access response on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI), a timing advance, uplink (UL) resources and a power control (PC) correction, and to send a message as the random access signaling on a second channel; and

wherein the at least one processor is further configured to determine a transmit power based on the at least one transmission parameter value.

**2**. The apparatus of claim **1**, wherein the at least one transmission parameter comprises at least one of a target signal-to-noise ratio (SNR), a power offset, and a correction factor.

**3**. The apparatus of claim **1**, wherein the random access signaling comprises a random access preamble sent first for system access.

**4**. The apparatus of claim **3**, wherein the at least one transmission parameter comprises a target signal-to-noise ratio (SNR) for the random access preamble, transmit power of the random access preamble is based on a target SNR value for the particular UE class, and wherein the at least one processor is further configured to send the random access preamble with the determined transmit power.

**5**. The apparatus of claim **1**, wherein transmit power of the random access preamble is based on an interference level of a time-frequency slot used to send the random access preamble.

**6**. The apparatus of claim **1**, wherein the at least one transmission parameter comprises a backoff time, and wherein the at least one processor is configured to determine amount of time to wait between successive transmissions of the random access preamble based on a backoff time value for the particular UE class.

**7**. The apparatus of claim **1**, wherein the at least one transmission parameter comprises a power ramp, and wherein transmit power for successive transmissions of the random access preamble is based on a power ramp value for the particular UE class.

**8**. The apparatus of claim **1**, wherein the at least one transmission parameter comprises a power offset between the first and second channels, and wherein transmit power of the message is based on a power offset value for the particular UE class, and wherein the at least one processor is further configured to send the message with the determined transmit power.

**9**. The apparatus of claim **1**, wherein the at least one processor is configured to send the random access signaling for initial system access at power up, or for system access to transition to an active state, or for system access for handover.

**10**. A method for wireless communication, comprising:

determining at least one parameter value for at least one transmission parameter for random access signaling based on a particular user equipment (UE) class, the at least one transmission parameter having different values for a plurality of UE classes; and

sending the random access signaling based on the at least one parameter value for system access;

wherein the step of sending the random access signaling comprises sending a random access preamble on a first channel to receive a random access response on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI), a timing advance, uplink (UL) resources and a power control (PC) correction, and sending a message as the random access signaling on a second channel; and

determining a transmit power based on the at least one transmission parameter value.

**11**. The method of claim **10**, wherein the at least one transmission parameter comprises a target signal-to-noise ratio (SNR) for the random access preamble, and wherein the sending the random access signaling comprises:

the step of determining transmit power of the random access preamble based on a target SNR value for the particular UE class, and

sending the random access preamble with the determined transmit power.

**12**. The method of claim **10**, wherein the at least one transmission parameter comprises a backoff time, and wherein the method further comprises:

determining amount of time to wait between successive transmissions of the random access preamble based on a backoff time value for the particular UE class.

**13**. The method of claim **10**, wherein the at least one transmission parameter comprises a power ramp, and wherein the method further comprises:

determining transmit power for successive transmissions of the random access preamble based on a power ramp value for the particular UE class.

**14**. The method of claim **10**, wherein the at least one transmission parameter comprises a power offset between the first and second channels, and wherein the sending the random access signaling comprises: and

further comprising:

receiving the random access response;

determining transmit power of the message based on a power offset value for the particular UE class, and

wherein sending the message comprises sending the message with the determined transmit power.

**15**. An apparatus for wireless communication, comprising:

means for determining at least one parameter value for at least one transmission parameter for random access signaling based on a particular user equipment (UE) class, the at least one transmission parameter having different values for a plurality of UE classes; and

means for sending the random access signaling based on the at least one parameter value for system access;

wherein the means for sending the random access signaling comprises a means for sending a random access preamble on a first channel to receive a random access response on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI), a timing advance, uplink (UL) resources and a power control (PC) correction, and a means for sending a message as the random access signaling on a second channel; and

a means for determining a transmit power based on the at least one transmission parameter value.

**16**. The apparatus of claim **15**, wherein the at least one transmission parameter comprises a target signal-to-noise ratio (SNR) for the random access preamble, and wherein the means for sending the random access signaling comprises:

means for determining transmit power of the random access preamble based on a target SNR value for the particular UE class, and

means for sending the random access preamble with the determined transmit power.

**17**. The apparatus of claim **15**, wherein the at least one transmission parameter comprises a backoff time, and wherein the apparatus further comprises:

means for determining amount of time to wait between successive transmissions of the random access preamble based on a backoff time value for the particular UE class.

**18**. The apparatus of claim **15**, wherein the at least one transmission parameter comprises a power ramp, and wherein the apparatus further comprises:

means for determining transmit power for successive transmissions of the random access preamble based on a power ramp value for the particular UE class.

**19**. The apparatus of claim **15**, wherein the at least one transmission parameter comprises a power offset between the first and second channels, and wherein the means for sending the random access signaling comprises: and

further comprising:

means for receiving the random access response; and

means for determining transmit power of the message based on a power offset value for the particular UE class;

wherein the means for sending the message comprises means for sending the message with the determined transmit power.

**20**. A non-transitory computer readable medium comprising instructions which, when executed by a processor, cause the processor to perform operations including:

determining at least one parameter value for at least one transmission parameter for random access signaling based on a particular user equipment (UE) class, the at least one transmission parameter having different values for a plurality of UE classes; and

sending the random access signaling based on the at least one parameter value for system access;

wherein sending the random access signaling comprises sending a random access preamble on a first channel to receive a random access response on a physical downlink control channel (PDCCH) or physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI), a timing advance, uplink (UL) resources and a power control (PC) correction, and sending a message as the random access signaling on a second channel; and

determining a transmit power based on the at least one parameter value.

**21**. An apparatus for wireless communication, comprising:

at least one processor configured to send a random access preamble for system access, to receive a random access response with a power control (PC) correction, uplink (UL) resources and a timing advance on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI), to send a message as random access signaling on a second channel, to determine transmit power of a message based on the PC correction, and to send the message with the determined transmit power; and

a memory coupled to the at least one processor.

**22**. The apparatus of claim **21**, wherein the at least one processor is configured to determine the transmit power of the message further based on transmit power of the random access preamble.

**23**. The apparatus of claim **21**, wherein the at least one processor is configured to determine the transmit power of the message further based on a power offset between a first channel used to send the random access preamble and a second channel used to send the message.

**24**. The apparatus of claim **21**, wherein the PC correction indicates an amount of increase or decrease in transmit power.

**25**. The apparatus of claim **21**, wherein the PC correction indicates whether to increase or decrease transmit power by a predetermined amount.

**26**. The apparatus of claim **21**, wherein the PC correction is generated based on received signal quality of the random access preamble at a base station.

**27**. A method for wireless communication, comprising:

sending a random access preamble for system access;

receiving a random access response with a power control (PC) correction, uplink (UL) resources and a timing advance on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI) to send a message as random access signaling on a second channel;

determining transmit power of a message based on the PC correction; and

sending the message with the determined transmit power.

**28**. The method of claim **27**, wherein the determining the transmit power of the message comprises determining the transmit power of the message further based on transmit power of the random access preamble.

**29**. The method of claim **27**, wherein the determining the transmit power of the message comprises determining the transmit power of the message further based on a power offset between a first channel used to send the random access preamble and a second channel used to send the message.

**30**. An apparatus for wireless communication, comprising:

means for sending a random access preamble for system access;

means for receiving a random access response with a power control (PC) correction, uplink (UL) resources and a timing advance on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI) to send a message as random access signaling on a second channel;

means for determining transmit power of a message based on the PC correction; and

means for sending the message with the determined transmit power.

31. The apparatus of claim 30, wherein the means for determining the transmit power of the message comprises means for determine the transmit power of the message further based on transmit power of the random access preamble.

32. The apparatus of claim 30, wherein the means for determining the transmit power of the message comprises means for determining the transmit power of the message further based on a power offset between a first channel used to send the random access preamble and a second channel used to send the message.

33. A non-transitory computer readable medium comprising instructions which, when executed by a processor, cause the processor to perform operations including:

sending a random access preamble for system access;

receiving a random access response with a power control (PC) correction, uplink (UL) resources and a timing advance on a physical downlink control channel (PDCCH) or a physical downlink shared channel (PDSCH) comprising a radio network temporary identifier (RNTI) to send a message as random access signaling on a second channel;

determining transmit power of a message based on the PC correction; and

sending the message with the determined transmit power.

* * * * *

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# Contents

# Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of this present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

1 presented to TSG for information;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document specifies and establishes the characteristics of the physicals layer procedures in the FDD and TDD modes of E-UTRA.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer – General Description"

[3] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation"

[4] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding"

[5] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements"

# 3 Definitions, symbols, and abbreviations

## 3.1 Symbols

For the purposes of the present document, the following symbols apply:

| | |
|---|---|
| $N_{\mathrm{RB}}^{\mathrm{DL}}$ | Downlink bandwidth configuration, expressed in units of $N_{\mathrm{sc}}^{\mathrm{RB}}$ as defined in [3] |
| $N_{\mathrm{RB}}^{\mathrm{UL}}$ | Uplink bandwidth configuration, expressed in units of $N_{\mathrm{sc}}^{\mathrm{RB}}$ as defined in [3] |
| $T_s$ | Basic time unit as defined in [3] |

## 3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply.

| | |
|---|---|
| ACK | Acknowledgement |
| BCH | Broadcast Channel |
| CCE | Control Channel Element |
| CQI | Channel Quality Indicator |
| CRC | Cyclic Redundancy Check |

| | |
|---|---|
| DL | Downlink |
| DTX | Discontinuous Transmission |
| EPRE | Energy Per Resource Element |
| MCS | Modulation and Coding Scheme |
| NACK | Negative Acknowledgement |
| PBCH | Physical Broadcast Channel |
| PCFICH | Physical Control Format Indicator Channel |
| PDCCH | Physical Downlink Control Channel |
| PDSCH | Physical Downlink Shared Channel |
| PHICH | Physical Hybrid ARQ Indicator Channel |
| PRACH | Physical Random Access Channel |
| PRB | Physical Resource Block |
| PUCCH | Physical Uplink Control Channel |
| PUSCH | Physical Uplink Shared Channel |
| QoS | Quality of Service |
| RBG | Resource Block Group |
| RE | Resource Element |
| RPF | Repetition Factor |
| RS | Reference Signal |
| SIR | Signal-to-Interference Ratio |
| SINR | Signal to Interference plus Noise Ratio |
| SRS | Sounding Reference Symbol |
| TA | Time alignment |
| TTI | Transmission Time Interval |
| UE | User Equipment |
| UL | Uplink |
| UL-SCH | Uplink Shared Channel |
| VRB | Virtual Resource Block |

# 4 Synchronisation procedures

## 4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

## 4.2 Timing synchronisation

### 4.2.1 Synchronisation primitives

### 4.2.2 Radio link monitoring

### 4.2.3 Inter-cell synchronisation

[For example, for cell sites with a multicast physical channel]

### 4.2.4 Transmission timing adjustments

Upon reception of a timing advance command, the UE shall adjust its uplink transmission timing. The timing advance command is expressed in multiples of $16\,T_s$ and is relative to the current uplink timing.

For a timing advance command received on subframe $n$, then corresponding adjustment occurs at the beginning of subframe $n+x$.

Editor's note: RAN1 needs to agree on x.

# 5 Power control

Downlink power control determines the energy per resource element (EPRE). The term resource element energy denotes the energy prior to CP insertion. The term resource element energy also denotes the average energy taken over all constellation points for the modulation scheme applied. Uplink power control determines the average power over a DFT-SOFDM symbol in which the physical channel is transmitted.

## 5.1 Uplink power control

Uplink power control controls the transmit power of the different uplink physical channels.

A cell wide overload indicator (OI) is exchanged over X2 for inter-cell power control. An indication X also exchanged over X2 indicates PRBs that an eNodeB scheduler allocates to cell edge UEs and that will be most sensitive to inter-cell interference.

[Note: Above lines regarding OI, X and X2 to be moved to an appropriate RAN3 spec when it becomes available]

### 5.1.1 Physical uplink shared channel

#### 5.1.1.1 UE behaviour

The setting of the UE Transmit power $P_{\mathrm{PUSCH}}$ for the physical uplink shared channel (PUSCH) transmission in subframe $i$ is defined by

$$P_{\mathrm{PUSCH}}(i) = \min\{P_{\mathrm{MAX}}, 10\log_{10}(M_{\mathrm{PUSCH}}(i)) + P_{\mathrm{O\_PUSCH}}(j) + \alpha \cdot PL + \Delta_{\mathrm{TF}}(TF(i)) + f(i)\} \text{ [dBm]}$$

where,

- $P_{\mathrm{MAX}}$ is the maximum allowed power that depends on the UE power class
- $M_{\mathrm{PUSCH}}(i)$ is the size of the PUSCH resource assignment expressed in number of resource blocks valid for subframe $i$.
- $P_{\mathrm{O\_PUSCH}}(j)$ is a parameter composed of the sum of a 8-bit cell specific nominal component $P_{\mathrm{O\_NOMINAL\_PUSCH}}(j)$ signalled from higher layers for $j=0$ and $1$ in the range of [-126,24] dBm with 1dB resolution and a 4-bit UE specific component $P_{\mathrm{O\_UE\_PUSCH}}(j)$ configured by RRC for $j=0$ and $1$ in the range of [-8, 7] dB with 1dB resolution. For PUSCH (re)transmissions corresponding to a configured scheduling grant then $j=0$ and for PUSCH (re)transmissions corresponding to a received PDCCH with DCI format 0 associated with a new packet transmission then $j=1$.
- $\alpha \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ is a 3-bit cell specific parameter provided by higher layers
- $PL$ is the downlink pathloss estimate calculated in the UE
- $\Delta_{\mathrm{TF}}(TF(i)) = 10\log_{10}(2^{MPR \cdot K_S} - 1)$ for $K_S = 1.25$ and 0 for $K_S = 0$ where $K_S$ is a cell specific parameter given by RRC
    - $TF(i)$ is the PUSCH *transport format* valid for subframe $i$
    - MPR = modulation x coding rate = $N_{\mathrm{INFO}} / N_{\mathrm{RE}}$ where $N_{\mathrm{INFO}}$ are the number of information bits and $N_{\mathrm{RE}}$ is the number of resource elements determined from $TF(i)$ and $M_{\mathrm{PUSCH}}(i)$ for subframe $i$

- $\delta_{\text{PUSCH}}$ is a UE specific correction value, also referred to as a TPC command and is included in PDCCH with DCI format 0 or jointly coded with other TPC commands in PDCCH with DCI format 3/3A. The current PUSCH power control adjustment state is given by $f(i)$ which is defined by:
    - $f(i) = f(i-1) + \delta_{PUSCH}(i - K_{PUSCH})$ if $f(*)$ represents accumulation
        - where $f(0) = 0$ and $K_{PUSCH} = 4$
        - The UE attempts to decode a PDCCH of DCI format 0 and a PDCCH of DCI format 3/3A in every subframe except when in DRX
        - $\delta_{\text{PUSCH}} = 0$ dB for a subframe where no TPC command is decoded or where DRX occurs.
        - The $\delta_{\text{PUSCH}}$ dB accumulated values signalled on PDCCH with DCI format 0 are [-1, 0, 1, 3].
        - The $\delta_{\text{PUSCH}}$ dB accumulated values signalled on PDCCH with DCI format 3/3A are one of [-1, 1] or [-1, 0, 1, 3] as semi-statically configured by higher layers.
        - If UE has reached maximum power, positive TPC commands are not accumulated
        - If UE has reached minimum power, negative TPC commands shall not be accumulated
        - UE shall reset accumulation
            - at cell-change
            - when entering/leaving RRC active state
            - when an absolute TPC command is received
            - when $P_{\text{O\_UE\_PUSCH}}(j)$ is received
            - when the UE (re)synchronizes
    - $f(i) = \delta_{\text{PUSCH}}(i - K_{\text{PUSCH}})$ if $f(*)$ represents current absolute value
        - where $\delta_{\text{PUSCH}}(i - K_{PUSCH})$ was signalled on PDCCH with DCI format 0 on subframe $i - K_{PUSCH}$
        - where $K_{PUSCH} = 4$
        - The $\delta_{\text{PUSCH}}$ dB absolute values signalled on PDCCH with DCI format 0 are [-4,-1, 1, 4].
        - $f(i) = f(i-1)$ for a subframe where no PDCCH with DCI format 0 is decoded or where DRX occurs.
    - $f(*)$ type (accumulation or current absolute) is a UE specific parameter that is given by RRC.

## 5.1.2 Physical uplink control channel

### 5.1.2.1 UE behaviour

The setting of the UE Transmit power $P_{\text{PUCCH}}$ for the physical uplink control channel (PUCCH) transmission in subframe $i$ is defined by

$$P_{\text{PUCCH}}(i) = \min\{P_{\text{MAX}},\ P_{\text{O\_PUCCH}} + PL + \Delta_{\text{TF\_PUCCH}}(TF) + g(i)\}\ \text{[dBm]}$$

where

- $\Delta_{\text{TF\_PUCCH}}(TF)$ table entries for each PUCCH transport format ($TF$) defined in Table 5.4-1 in [3] are given by RRC
    - Each signalled $\Delta_{\text{TF\_PUCCH}}(TF)$ 2-bit value corresponds to a $TF$ relative to PUCCH DCI format 0.

- $P_{\text{O\_PUCCH}}$ is a parameter composed of the sum of a 5-bit cell specific parameter $P_{\text{O\_NOMINAL\_PUCCH}}$ provided by higher layers with 1 dB resolution in the range of [-127, -96] dBm and a UE specific component $P_{\text{O\_UE\_PUCCH}}$ configured by RRC in the range of [-8, 7] dB with 1 dB resolution.
- $\delta_{\text{PUCCH}}$ is a UE specific correction value, also referred to as a TPC command, included in a PDCCH with DCI format 1A/1/2 or sent jointly coded with other UE specific PUCCH correction values on a PDCCH with DCI format 3/3A.
  - The UE attempts to decode a PDCCH with DCI format 3/3A and a PDCCH with DCI format 1A/1/2 on every subframe except when in DRX.
  - $\delta_{\text{PUCCH}}$ from a PDCCH with DCI format 1A/1/2 overrides that from a PDCCH with DCI format 3/3A when both are decoded in a given subframe.
  - $\delta_{\text{PUCCH}}=0$ dB for a subframe where no PDCCH with DCI format 1A/1/2/3/3A is decoded or where DRX occurs.
  - $g(i)=g(i-1)+\Delta_{PUCCH}(i-K_{PUCCH})$ where $g(i)$ is the current PUCCH power control adjustment state with initial condition $g(0)=0$.
    - The $\delta_{\text{PUCCH}}$ dB values signalled on PDCCH with DCI format 1A/1/2 are [-1, 0, 1, 3].
    - The $\delta_{\text{PUCCH}}$ dB values signalled on PDCCH with DCI format 3/3A are [-1,1] or [-1,0,1,3] as semi-statically configured by higher layers.
    - If UE has reached maximum power, positive TPC commands are not accumulated
    - If UE has reached minimum power, negative TPC commands shall not be accumulated
    - UE shall reset accumulation
      - at cell-change
      - when entering/leaving RRC active state
      - when $P_{\text{O\_UE\_PUCCH}}(j)$ is received
      - when the UE (re)synchronizes

## 5.1.3 Sounding Reference Symbol

### 5.1.3.1 UE behaviour

The setting of the UE Transmit power $P_{\text{SRS}}$ for the Sounding Reference Symbol transmitted on subframe *i* is defined by

$$P_{\text{SRS}}(i)=\min\{P_{\text{MAX}},\ P_{\text{SRS\_OFFSET}}+10\log_{10}(M_{\text{SRS}})+P_{\text{O\_PUSCH}}(j)+\alpha\cdot PL+f(i)\}\ \text{[dBm]}$$

where

- $P_{\text{SRS\_OFFSET}}$ is a 4-bit UE specific parameter semi-statically configured by higher layers with 1dB step size in the range [-3, 12] dB.
- $M_{\text{SRS}}$ is the bandwidth of the SRS transmission in subframe *i* expressed in number of resource blocks.
- $f(i)$ is the current power control adjustment state for the PUSCH, see Section 5.1.1.1.
- $P_{\text{O\_PUSCH}}(j)$ is a parameter as defined in Section 5.1.1.1.

## 5.2 Downlink power allocation

The eNodeB determines the downlink transmit energy per resource element.

A UE may assume downlink reference symbol EPRE is constant across the downlink system bandwidth and constant across all subframes until different RS power information is received.

For each UE, the PDSCH-to-RS EPRE ratio among REs in all the OFDM symbols containing RS is equal and is denoted by $\rho_A$.

The UE may assume that for 64 QAM or RI>1 spatial multiplexing $\rho_A$ is equal to $P_A$ which is a UE specific semi-static parameter signalled by higher layers.

For each UE, the PDSCH-to-RS EPRE ratio among REs in all the OFDM symbols not containing RS is equal and is denoted by $\rho_B$.

The cell-specific ratio $\rho_B / \rho_A$ is given by Table 5.2-1 according to cell-specific parameter $P_B$ signalled by higher layers and the number of configured eNodeB cell specific antenna ports.

**Table 5.2-1: Ratio of PDSCH-to-RS EPRE in symbols with and without reference symbols for 1, 2, or 4 cell specific antenna ports**

| $P_B$ | $\rho_B / \rho_A$ | | |
|---|---|---|---|
| | One Antenna Port | Two Antenna Ports | Four Antenna Ports |
| 000 | | | |
| 001 | | | |
| 010 | | | |
| 011 | | | |
| 100 | | | |
| 101 | | | |
| 110 | | | |
| 111 | | | |

For PMCH with 16QAM or 64QAM, the UE may assume that the PMCH-to-RS EPRE ratio is equal to 0 dB.

### 5.2.1 UE behaviour

### 5.2.2 eNodeB behaviour

### 5.2.3 Downlink channel subcarrier transmit power offset

[Definition of and restrictions on the subcarrier transmit power offset for each downlink channel type]

# 6 Random access procedure

Prior to initiation of the non-synchronized physical random access procedure, Layer 1 shall receive the following information from the higher layers:

1. Random access channel parameters (PRACH configuration, frequency position and preamble format)
2. Parameters for determining the root sequences and their cyclic shifts in the preamble sequence set for the cell (index to root sequence table, cyclic shift ( $N_{CS}$ ), and set type (normal or high-speed set))

## 6.1 Physical non-synchronized random access procedure

From the physical layer perspective, the L1 random access procedure encompasses the transmission of random access preamble and random access response. The remaining messages are scheduled for transmission by the higher layer on the shared data channel and are not considered part of the L1 random access procedure. A random access channel occupies 6 resource blocks in a subframe or set of consecutive subframes reserved for random access preamble transmissions. The eNodeB is not prohibited from scheduling data in the resource blocks reserved for random access channel preamble transmission.

The following steps are required for the L1 random access procedure:

1. Layer 1 procedure is triggered upon request of a preamble transmission by higher layers.
2. A preamble index, preamble transmission power (PREAMBLE_TRANSMISSION_POWER), associated RA-RNTI, and PRACH resource are indicated by higher layers as part of the request.
3. A preamble sequence is then selected from the preamble sequence set using the preamble index.
4. A single preamble transmission then occurs using the selected preamble sequence with transmission power PREAMBLE_TRANSMISSION_POWER on the indicated PRACH resource.
5. If no associated PDCCH with RA-RNTI is detected within the random access response window then the corresponding DL-SCH transport block is passed to higher layers.
6. If the random access response window has past then the physical random access procedure is exited.

### 6.1.1 Timing

#### 6.1.1.1 Synchronized

#### 6.1.1.2 Unsynchronized

### 6.1.2 Preamble Sequence selection

# 7 Physical downlink shared channel related procedures

## 7.1 UE procedure for receiving the physical downlink shared channel

The UE is semi-statically configured via higher layer signalling to receive the physical downlink shared channel based on one of the following transmission modes:

1. Single-antenna port
2. Transmit diversity
3. Open-loop spatial multiplexing
4. Closed-loop spatial multiplexing
5. Multi-user MIMO

### 7.1.1 Single-antenna port

In the single-antenna port mode, the UE may assume that the eNB transmits on the physical downlink shared channel according to Section 6.3.4.1 of [3]

### 7.1.2 Transmit diversity

In the transmit diversity mode, the UE may assume that the eNB transmits on the physical downlink shared channel according to Section 6.3.4.3 of [3]

### 7.1.3 Open-loop spatial multiplexing

In the open-loop spatial multiplexing transmission mode, the UE may assume, based on the rank indication (RI) obtained from the associated DCI as determined from the number of assigned transmission layers, that the eNB transmits on the physical downlink shared channel according to the following:

- RI = 1 : transmit diversity as defined in Section 6.3.4.3 of [3]
- RI > 1 : large delay CDD as defined in Section 6.3.4.2.2 of [3]

For RI>1, the operation of large delay CDD is further defined as follows:

- For 2 antenna ports, the precoder for data resource element index *i*, denoted by W(i) is selected according to $W(i) = C_1$ where $C_1$ denotes the precoding matrix corresponding to precoder index 1 in Table 6.3.4.2.3-1 of [3].
- For 4 anetnna ports, the UE may assume that the eNB cyclically assigns different precoders to different data resource elements on the physical downlink shared channel as follows. A different precoder is used every $\upsilon$ data resource elements, where $\upsilon$ denotes the number of transmission layers in the case of spatial multiplexing. In particular, the precoder for data resource element index *i*, denoted by *W(i)* is selected according to $W(i) = C_k$, where k is the precoder index given by $k = \mathrm{mod}\left(\left\lceil \frac{i}{\upsilon} \right\rceil - 1, 4\right) + 1$, where *k=1,2,...4,* and $C_1, C_2, C_3, C_4$ denote precoder matrices corresponding to precoder indices 12,13,14 and 15, respectively, in Table 6.3.4.2.3-2 of [3]. .

### 7.1.4 Closed-loop spatial multiplexing

In the closed-loop spatial multiplexing transmission mode, the UE may assume that the eNB transmits on the physical downlink shared channel according to zero/small delay CDD for all the applicable number of transmission layers as defined in Section 6.3.4.2.1 of [3].

### 7.1.5 Void

### 7.1.6 Resource allocation

The UE shall interpret the resource allocation field depending on the PDCCH DCI format detected. A resource allocation field in each PDCCH includes two parts, a type field and information consisting of the actual resource allocation. PDCCH with type 0 and type 1 resource allocation have the same format and are distinguished from each other via the single bit type field. For system bandwidth less than or equal to 10 PRBs the resource allocation field in each PDCCH contains only information of the actual resource allocation. PDCCH with DCI format 0 and 1A have a type 2 resource allocation which is a different format from PDCCH with a type 0 or type 1 resource allocation. PDCCH with a type 2 resource allocation do not have a type field.

#### 7.1.6.1 Resource allocation type 0

In resource allocations of type 0, a bitmap indicates the resource block groups (RBGs) that are allocated to the scheduled UE where a RBG is a set of consecutive physical resource blocks (PRBs). Resource block group size (*P*) is a function of the system bandwidth as shown in Table 7.1.6.1-1. The total number of RBGs ($N_{\mathrm{RBG}}$) for downlink system bandwidth of $N_{\mathrm{RB}}^{\mathrm{DL}}$ PRBs is given by $N_{RBG} = \lceil N_{\mathrm{RB}}^{\mathrm{DL}} / P \rceil$ where $\lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / P \rfloor$ of the RBGs are of size P and if $\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / P \rceil - \lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / P \rfloor > 0$ then one of the RBGs is of size $N_{\mathrm{RB}}^{\mathrm{DL}} - P \cdot \lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / P \rfloor$. The bitmap is of size $N_{\mathrm{RBG}}$ bits with one bitmap bit per RBG such that each RBG is addressable.

**Table 7.1.6.1-1: Type 0 Resource Allocation RBG Size vs. Downlink System Bandwidth**

| System Bandwidth $N_{\mathrm{RB}}^{\mathrm{DL}}$ | RBG Size (*P*) |
|---|---|
| ≤10 | 1 |
| 11 — 26 | 2 |
| 27 — 6463 | 3 |
| 64 — 110 | 4 |

### 7.1.6.2 Resource allocation type 1

In resource allocations of type 1, a bitmap of size $\left\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / P \right\rceil$ indicates to a scheduled UE the PRBs from the set of PRBs from one of *P* resource block group subsets. Also *P* is the resource block group size associated with the system bandwidth as shown in Table 7.1.6.1-1. The portion of the bitmap used to address PRBs in a selected RBG subset has size $N_{\mathrm{RB}}^{\mathrm{TYPE1}}$ and is defined as

$$N_{\mathrm{RB}}^{\mathrm{TYPE1}} = \left\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / P \right\rceil - \left\lceil \log_2(P) \right\rceil - 1$$

where $\left\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / P \right\rceil$ is the overall bitmap size and $\left\lceil \log_2(P) \right\rceil$ is the minimum number of bits needed to select one of the *P* RBG subsets and one additional bit is used to indicate whether the addressable PRBs of a selected RBG subset is left justified or is right justified (right shifted) where the shift is needed for full resource block granular addressability of all PRBs in a carrier since the number of PRBs in a RBG subset is larger than the PRB addressing portion of the bitmap as indicated by $N_{\mathrm{RB}}^{\mathrm{TYPE1}} < \left\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / P \right\rceil$. Each bit in the PRB addressing portion of the bitmap addresses a single addressable PRB in the selected RBG subset starting at the left most addressable PRB.

### 7.1.6.3 Resource allocation type 2

In resource allocations of type 2, the resource allocation information indicates to a scheduled UE a set of contiguously allocated physical or virtual resource blocks depending on the setting of a 1-bit flag carried on the associated PDCCH. PRB allocations vary from a single PRB up to a maximum number of PRBs spanning the system bandwidth. For VRB allocations .the resource allocation information consists of a starting VRB number and a number of consecutive VRBs where each VRB is mapped to multiple non-consecutive PRBs.

A type 2 resource allocation field consists of a resource indication value (*RIV*) corresponding to a starting resource block ( $RB_{start}$ ) and a length in terms of contiguously allocated resource blocks ( $L_{CRBs}$ ). The resource indication value is defined by

if $(L_{CRBs} - 1) \le \left\lfloor N_{RB}^{DL} / 2 \right\rfloor$ then

$$RIV = N_{RB}^{DL}(L_{CRBs} - 1) + RB_{start}$$

else

$$RIV = N_{RB}^{DL}(N_{RB}^{DL} - L_{CRBs} + 1) + (N_{RB}^{DL} - 1 - RB_{start})$$

# 7.2 UE procedure for reporting channel quality indication (CQI), precoding matrix indicator (PMI) and rank indication (RI)

The time and frequency resources that can be used by the UE to report CQI, PMI, and RI are controlled by the eNB. For spatial multiplexing, as given in [3], the UE shall determine a RI corresponding to the number of useful transmission layers. For transmit diversity as given in [3], RI is equal to one.

CQI, PMI, and RI reporting is periodic or aperiodic. A UE transmits CQI, PMI, and RI reporting on a PUCCH for subframes with no PUSCH allocation. A UE transmits CQI, PMI, and RI reporting on a PUSCH for those subframes with PUSCH allocation for a) scheduled PUSCH transmissions with or without an associated scheduling grant or b) PUSCH transmissions with no UL-SCH. The CQI transmissions on PUCCH and PUSCH for various scheduling modes are summarized in the following table:

**Table 7.2-1: Physical Channels for Aperiodic or Periodic CQI reporting**

| Scheduling Mode | Periodic CQI reporting channels | Aperiodic CQI reporting channel |
|---|---|---|
| Frequency non-selective | PUCCH<br>PUSCH | PUSCH |
| Frequency selective | PUCCH<br>PUSCH | PUSCH |

In case both periodic and aperiodic reporting would occur in the same subframe, the UE shall only transmit the aperiodic report in that subframe.

When reporting RI the UE reports a single instance of the number of useful transmission layers. For each RI reporting interval during closed-loop spatial multiplexing, a UE shall determine a RI from the supported set of RI values for the corresponding eNodeB and UE antenna configuration and report the number in each RI report. For each RI reporting interval during open-loop spatial multiplexing, a UE shall determine RI for the corresponding eNodeB and UE antenna configuration in each reporting interval and report the detected number in each RI report to support selection between RI=1 transmit diversity and RI>1 large delay CDD open-loop spatial multiplexing.

When reporting PMI the UE reports either a single or a multiple PMI report. The number of RBs represented by a single UE PMI report can be $N_{\mathrm{RB}}^{\mathrm{DL}}$ or a smaller subset of RBs. The number of RBs represented by a single PMI report is semi-statically configured by higher layer signalling. A UE is restricted to report PMI and RI within a precoder codebook subset specified by a bitmap configured by higher layer signalling. For a specific precoder codebook and associated transmission mode, the bitmap can specify all possible precoder codebook subsets from which the UE can assume the eNB may be using when the UE is configured in the relevant transmission mode.

The set of subbands (*S*) a UE shall evaluate for CQI reporting is semi-statically configured by higher layers. A subband is a set of *k* contiguous PRBs where *k* is also semi-statically configured by higher layers. Note the last subband in set *S* may have fewer than *k* contiguous PRBs depending on $N_{\mathrm{RB}}^{\mathrm{DL}}$ . The number of subbands for system bandwidth given by $N_{\mathrm{RB}}^{\mathrm{DL}}$ is defined by $N = \lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k \rceil$ . The term "Wideband CQI" denotes a CQI value obtained over the set *S*.

- For single-antenna port and transmit diversity, as well as open-loop spatial multiplexing, and closed-loop spatial multiplexing with RI=1 a single 4-bit wideband CQI is reported according to Table 7.2.3-1
- For RI > 1, closed-loop spatial multiplexing PUSCH based triggered reporting includes reporting a wideband CQI which comprises:
  - A 4-bit wideband CQI for codeword 1 according to Table 7.2.3-1
  - A 4-bit wideband CQI for codeword 2 according to Table 7.2.3-1

- For RI > 1, closed-loop spatial multiplexing PUCCH based reporting includes separately reporting a 4-bit wideband CQI for codeword 1 according to Table 7.2.3-1 and a wideband spatial differential CQI each with a distinct reporting period and relative subframe offset. The wideband spatial differential CQI comprises:
  - A 3-bit wideband spatial differential CQI for codeword 2 = wideband CQI index for codeword 1 – wideband CQI index for codeword 2. The set of exact offset levels is {-4, -3, -2, -1, 0, +1, +2, +3}

### 7.2.1 Aperiodic/Periodic CQI/PMI/RI Reporting using PUSCH

A UE shall perform aperiodic CQI, PMI and RI reporting using the PUSCH upon receiving an indication sent in the scheduling grant.

The aperiodic CQI report size and message format is given by RRC.

The minimum reporting interval for aperiodic reporting of CQI and PMI and RI is 1 subframe. The subband size for CQI shall be the same for transmitter-receiver configurations with and without precoding.

A UE is semi-statically configured by higher layers to feed back CQI and PMI and corresponding RI on the same PUSCH using one of the following reporting modes given in Table 7.2.1-1 and described below:

**Table 7.2.1-1: CQI and PMI Feedback Types for PUSCH reporting Modes**

| | | PMI Feedback Type | | |
|---|---|---|---|---|
| | | No PMI | Single PMI | Multiple PMI |
| PUSCH CQI Feedback Type | Wideband (wideband CQI) | | | Mode 1-2 |
| | UE Selected (subband CQI) | Mode 2-0 | Mode 2-1 | Mode 2-2 |
| | Higher Layer-configured (subband CQI) | Mode 3-0 | Mode 3-1 | Mode 3-2 |

For each of the transmission modes defined in Section 7.1, the following reporting modes are supported on PUSCH:

1. Single-antenna port : Modes 2-0, 3-0
2. Transmit diversity : Modes 2-0, 3-0
3. Open-loop spatial multiplexing : Modes 2-0, 3-0
4. Closed-loop spatial multiplexing : Modes 1-2, 2-1, 2-2, 3-1, 3-2

The selection of PMI and the calculation of CQI are both dependent on the RI value that the UE selects for the corresponding reporting instance.

- Wideband feedback
  - Mode 1-2 description:
    - For each subband a preferred precoding matrix is selected from the codebook subset assuming transmission only in the subband
    - A UE shall report one wideband CQI value per codeword which is calculated assuming the use of the corresponding selected precoding matrix in each subband and transmission on set *S* subbands.
    - The UE shall report the selected precoding matrix indicator for each set *S* subband.

   - Subband size is given by Table 7.2.1-2.

- Higher Layer-configured subband feedback
  - Mode 3-0 description:
    - A UE shall report a wideband CQI value which is calculated assuming transmission on set *S* subbands
    - The UE shall also report one subband CQI value for each set *S* subband. The subband CQI value is calculated assuming transmission only in the subband The CQI represents channel quality for the first codeword, even when RI>1.
  - Mode 3-1 description:
    - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
    - A UE shall report one subband CQI value per codeword for each set *S* subband which are calculated assuming the use of the single precoding matrix in all subbands
    - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set *S* subbands
    - The UE shall report the single selected precoding matrix indicator
  - Mode 3-2 description:
    - For each subband a preferred precoding matrix is selected from the codebook subset assuming transmission only in the subband
    - A UE shall report one subband CQI value per codeword for each set *S* subband. The subband CQI value is calculated assuming the use of the corresponding selected precoding matrix in each set S subband.
    - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the corresponding selected precoding matrix in each subband and transmission on set *S* subbands
    - A UE shall report the selected precoding matrix indicator for each set *S* subband.

  - Subband CQI for each codeword are encoded differentially with respect to their respective wideband CQI using 2-bits as defined by
    - Subband differential CQI = subband CQI index – wideband CQI index
      - Possible subband differential CQI values are {-2, 0, +1, +2}
  - Supported subband size (*k*) used and number of subbands (*M1*) in the set of subands *S* contained in a report include those given in Table 7.2.1-2. In Table 7.2.1-2 the *k* values and *M1* values are semi-statically configured by higher layers as a function of system bandwidth.
  - The payload size *P* in bits for closed loop spatial multiplexing feedback modes (3-0, 3-1, 3-2) is given by
    - Mode 3-0 or Mode 3-1/3-2 with RI=1:

$$P = R(RI) \ + \ 2N + 4 + (2+T)\cdot C \quad (PMI + CQI)$$

    - Mode 3-1/3-2 with RI>1:

$$P = R(RI) \ + \ 2\cdot(2N+4) + (2+T)\cdot C \ \ (PMI + CQI)$$

- where $T=2$ if 4 antenna ports for common reference symbols are configured, for 2 antenna ports $T=y$, while for mode 3-0 then $T=0$

Editor's note: RAN1 needs to agree on y.

- where $C=N$ for mode 3-2 else $C=1$ for mode 3-1 and $C=0$ for mode 3-0
- where $R=2$ for up to 4-layer spatial multiplexing else $R=1$ for up to 2-layer spatial multiplexing and $R=0$ otherwise

**Table 7.2.1-2: Subband Size and #Subband CQI in *S* vs. System Bandwidth**

| System Bandwidth $N_{RB}^{DL}$ | Subband Size (*k*) | #Subband CQI in *S* (*M1*) |
|---|---|---|
| 6 - 7 | (wideband CQI only) | |
| 8 - 10 | 4 | |
| 11 - 26 | 4 | |
| 27 - 63 | 6 | |
| 64 - 110 | 8 | |

- UE-selected subband feedback
  - Mode 2-0 description:
    - The UE shall select a set of *M* preferred subbands of size *k* (where *k* and *M* are given in Table 7.2.1-3 for each system bandwidth range) within the set of subbands *S*.
    - The UE shall also report one CQI value reflecting transmission only over the *M* selected subbands determined in the previous step. The CQI represents channel quality across all layers irrespective of computed or reported RI.
    - Additionally, the UE shall also report one wideband CQI value.
  - Mode 2-1 description:
    - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
    - The UE shall perform joint selection of a set of *M* preferred subbands of size *k* within the set of subbands *S* assuming the use of selected preferred precoding matrix.
    - The UE shall report one CQI value per codeword reflecting transmission only over the selected *M* preferred subbands and using the same selected preferred single precoding matrix in each of the *M* subbands
    - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single preferred precoding matrix in all subbands and transmission on set *S* subbands
    - A UE shall also report the selected single preferred precoding matrix indicator for all set S subbands
  - Mode 2-2 description:
    - The UE shall perform joint selection of the set of *M* preferred subbands of size *k* within the set of subbands *S* and a preferred single precoding matrix selected from the codebook subset that is preferred to be used for transmission over the *M* selected subbands.

- The UE shall report one CQI value per codeword reflecting transmission only over the selected *M* preferred best subbands and using the same selected single precoding matrix in each of the *M* subbands.
- The UE shall also report the selected single precoding matrix preferred for the M selected subbands.
- A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
- A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set *S* subbands
- A UE shall also report the selected single precoding matrix indicator for all set S subbands.

o For all UE-selected subband feedback modes the UE shall report the positions of the *M* selected subbands using a combinatorial index *r* defined as

- $r = \sum_{k=0}^{M-1} \left\langle \begin{matrix} N - s_k \\ M - k \end{matrix} \right\rangle$
- where the set $\{s_k\}_{k=0}^{M-1}$, $(1 \le s_k \le N, \quad s_k < s_{k+1})$ contains the *M* sorted subband indices and $\left\langle \begin{matrix} x \\ y \end{matrix} \right\rangle = \begin{cases} \binom{x}{y} & x \ge y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient, resulting in unique label $r \in \left\{ 0, \cdots, \binom{N}{M} - 1 \right\}$.

o The CQI value for the *M* selected subbands for each codeword is encoded differentially using 2-bits relative to its respective wideband CQI as defined by

- Differential CQI = best-M average index – wideband CQI index
  - Possible differential CQI values are {+1, +2, +3, +4}

o Supported subband size *k* and *M* values include those shown in Table 7.2.1-3. In Table 7.2.1-3 the *k* and *M* values are a function of system bandwidth.

o The payload size (P) in bits for closed loop spatial multiplexing feedback modes (2-0, 2-1, 2-2) is given by

- Mode 2-0 or Mode 2-1/2-2 with RI=1:

$$P = R\,(\text{RI}) \quad + 2 + L + 4 + (2 + T) \cdot C \;\; \text{(CQI+PMI)}$$

- Mode 2-1/2-2 with RI>1:

$$P = R\,(\text{RI}) \quad + 2 \cdot (2 + 4) + L + (2 + T) \cdot C \;\; \text{(CQI+PMI)}$$

- where *T=2* if 4 antenna ports for common reference symbols are configured, for 2 antenna ports *T=y,* while for mode 2-0 then *T=0*

Editor's note: RAN1 needs to agree on y.

- where *C=2* for mode 2-2 and *C=1* for mode 2-1 and *C=0* for mode 2-0
- where $L = \left\lceil \log_2 \binom{N}{M} \right\rceil$

- where R=2 for up to 4-layer spatial multiplexing else R=1 for up to 2-layer spatial multiplexing and R=0 otherwise

**Table 7.2.1-3: Subband Size (*k*) and *M* values vs. Downlink System Bandwidth**

| System Bandwidth $N_{RB}^{DL}$ | Subband Size k (RBs) | *M* |
|---|---|---|
| 6 – 7 | (wideband CQI only) | (wideband CQI only) |
| 8 – 10 | 2 | 1 |
| 11 - 26 | 2 | 3 |
| 27 - 63 | 3 | 5 |
| 64 - 110 | 4 | 6 |

## 7.2.2 Periodic CQI/PMI/RI Reporting using PUCCH

A UE is semi-statically configured by higher layers to periodically feed back different CQI, PMI, and RI on the PUCCH using the reporting modes given in Table 7.2.2-1 and described below.

For the UE-selected subband CQI, a CQI report in a certain subframe describes the channel quality in a particular part or in particular parts of the bandwidth described subsequently as bandwidth part (BP) or parts.

- There are a total of *N* subbands for a system bandwidth given by $N_{RB}^{DL}$ where $\lfloor N_{RB}^{DL}/k \rfloor$ subbands are of size *k* and if $\lceil N_{RB}^{DL}/k \rceil - \lfloor N_{RB}^{DL}/k \rfloor > 0$ then one of the subbands is of size $N_{RB}^{DL} - k \cdot \lfloor N_{RB}^{DL}/k \rfloor$.
- A bandwidth part is frequency-consecutive and consists of $N_J$ subbands where *J* bandwidth parts span *S* or $N_{RB}^{DL}$ as given in Table 7.2.2-2 and where $N_J$ is $\lceil N_{RB}^{DL}/k/J \rceil$. Given *J>1* then $N_J$ is either $\lceil N_{RB}^{DL}/k/J \rceil$ or $\lceil N_{RB}^{DL}/k/J \rceil - 1$ depending on $N_{RB}^{DL}$, *k* and *J*.
- Each bandwidth part *j* is scanned in sequential order as defined by the equation $j = \text{mod}(N_{SF}, J)$ where $N_{SF}$ is a counter that a UE increments after each subband report transmission for a bandwidth part.
- For UE selected subband feedback a single subband out of $N_J$ subbands of a bandwidth part is selected along with a corresponding *L*-bit label where $L = \lceil \log_2 N_J \rceil$ .

The CQI and PMI payload sizes of each PUCCH reporting mode are given in Table 7.2.2-3.

Three CQI/PMI and RI reporting types with distinct periods and offsets are supported for each PUCCH reporting mode as given in Table 7.2.2-3:

- Type 1 report supports CQI feedback for the UE selected sub-bands
- Type 2 report supports wideband CQI and PMI feedback.
- Type 3 report supports RI feedback
- Type 4 report supports wideband CQI

RI and wideband CQI/PMI are not reported in the same subframe (reporting instance):

- The reporting interval of the RI reporting is an integer multiple of wideband CQI/PMI period.
- The same or different offsets between RI and wideband CQI/PMI reporting instances can be configured.
- Both the reporting interval and offset are configured by higher layers. In case of collision of RI and wideband CQI/PMI the wideband CQI/PMI is dropped.

The following PUCCH formats are used:

- Format 2 as defined in section 5.4.2 in [3] when CQI/PMI or RI report is not multiplexed with ACK/NAK
- Format 2a/2b as defined in section 5.4.2 in [3] when CQI/PMI or RI report is multiplexed with ACK/NAK for normal CP

- Format 2 as defined in section 5.4.2 in [3] when CQI/PMI or RI report is multiplexed with ACK/NAK for extended CP

**Table 7.2.2-1: CQI and PMI Feedback Types for PUCCH reporting Modes**

| | | PMI Feedback Type | |
|---|---|---|---|
| | | No PMI | Single PMI |
| PUCCH CQI Feedback Type | Wideband (wideband CQI) | Mode 1-0 | Mode 1-1 |
| | UE Selected (subband CQI) | Mode 2-0 | Mode 2-1 |

For each of the transmission modes defined in Section 7.1, the following reporting modes are supported on PUCCH:

1. Single-antenna port : Modes 1-0, 2-0
2. Transmit diversity : Modes 1-0, 2-0
3. Open-loop spatial multiplexing : Modes 1-0, 2-0
4. Closed-loop spatial multiplexing : Modes 1-1, 2-1

- Wideband feedback
  - Mode 1-0 description:
    - In the subframe where RI is reported (only for open-loop spatial multiplexing):
      - A UE shall determine a RI assuming transmission on set $S$ subbands.
      - The UE shall report a type 3 report consisting of one RI.
    - In the subframe where CQI is reported:
      - A UE shall report a type 4 report consisting of one wideband CQI value which is calculated assuming transmission on set $S$ subbands. For open-loop spatial multiplexing the CQI is calculated conditioned on the last reported RI.
  - Mode 1-1 description:
    - In the subframe where RI is reported (only for closed-loop spatial multiplexing):
      - A UE shall determine a RI assuming transmission on set $S$ subbands.
      - The UE shall report a type 3 report consisting of one RI
    - In the subframe where CQI/PMI is reported:
      - A single precoding matrix is selected from the codebook subset assuming transmission on set $S$ subbands and conditioned on the last reported RI
      - A UE shall report a type 2 report on each respective successive reporting opportunity consisting of
        - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set $S$ subbands and conditioned on the last reported RI.
        - The selected single precoding matrix indicator (wideband PMI)
        - When RI>1, a 3-bit wideband spatial differential CQI.

- UE Selected subband feedback
  - Mode 2-0 description:
    - In the subframe where RI is reported (only for open-loop spatial multiplexing):
      - A UE shall determine a RI assuming transmission on set $S$ subbands.
      - The UE shall report a type 3 report consisting of one RI.
    - In the subframe where wideband CQI is reported:
      - The UE shall report a type 4 report on each respective successive reporting opportunity consisting of one wideband CQI value conditioned on the last reported RI.
    - In the subframe where CQI for the selected subbands is reported:
      - The UE shall select the preferred subband within the set of $N$ subbands in each of the $J$ bandwidth parts where $J$ is given in Table 7.2.2-2. For open-loop spatial multiplexing, the selection is conditioned on the last reported RI.
      - The UE shall report a type 1 report consisting of one CQI value reflecting transmission only over the selected subband of a bandwidth part determined in the previous step along with the corresponding best subband $L$-bit label. A type 1 report for each bandwidth part will in turn be reported in respective successive reporting opportunities. The CQI represents channel quality across all layers irrespective of the computed or reported RI. For open-loop spatial multiplexing, the selection is conditioned on the last reported RI
  - Mode 2-1 description:
    - In the subframe where RI is reported:
      - A UE shall determine a RI assuming transmission on set $S$ subbands.
      - The UE shall report a type 3 report consisting of one RI.
    - In the subframe where wideband CQI/PMI is reported:
      - A single precoding matrix is selected from the codebook subset assuming transmission on set $S$ subbands and conditioned on the last reported RI.
      - A UE shall report a type 2 report on each respective successive reporting opportunity consisting of:
        - A wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set $S$ subbands and conditioned on the last reported RI.
        - The selected single precoding matrix indicator (wideband PMI).
        - When RI>1, and additional 3-bit wideband spatial differential CQI.
    - In the subframe where CQI for the selected subbands is reported:
      - The UE shall select the preferred subband within the set of $N_j$ subbands in each of the $J$ bandwidth parts where $J$ is given in Table 7.2.2-2 conditioned on the last reported wideband PMI and RI.
      - The UE shall report a type 1 report per bandwidth part on each respective successive reporting opportunity consisting of:
        - A single CQI value 1 reflecting transmission only over the selected subband of a bandwidth part determined in the previous step along with the corresponding best subband $L$-bit label conditioned on the last reported wideband PMI and RI.

- If RI>1, an additional 3-bit spatial differential CQI represents the difference between CQI value 1 for codeword 1 and CQI value 2 for codeword 2 assuming the use of the most recently reported single precoding matrix in all subbands and transmission on set S subbands.

**Table 7.2.2-2: Subband Size (*k*) and Bandwidth Parts *(J)* vs. Downlink System Bandwidth**

| System Bandwidth $N_{RB}^{DL}$ | Subband Size k (RBs) | Bandwidth Parts (*J*) |
|---|---|---|
| 6 – 7 | (wideband CQI only) | 1 |
| 8 – 10 | 4 | 1 |
| 11 – 26 | 4 | 2 |
| 27 – 64 | 6 | 3 |
| 65 – 110 | 8 | 4 |

The corresponding periodicity parameters for the different CQI/PMI modes are defined as:

- $N_P$ is the periodicity of the sub-frame pattern allocated for the CQI reports in terms of subframes were the minimum reporting interval is $N_{PMIN}$.
- $N_{OFFSET}$ is the subframe offset

A UE with a scheduled PUSCH allocation in the same subframe as its CQI report shall use the same PUCCH-based reporting format when reporting CQI on the PUSCH unless an associated PDCCH with scheduling grant format indicates an aperiodic report is required.

**Table 7.2.2-3: PUCCH Report Type Payload size per Reporting Mode**

| PUCCH Report Type | Reported | Mode State | PUCCH Reporting Modes | | | |
|---|---|---|---|---|---|---|
| | | | Mode 1-1 (bits/BP) | Mode 2-1 (bits/BP) | Mode 1-0 (bits/BP) | Mode 2-0 (bits/BP) |
| 1 | Sub-band CQI | RI = 1 | NA | 4+L | NA | 4+L |
| | | RI > 1 | NA | 7+L | NA | 4+L |
| 2 | Wideband CQI/PMI | 2 TX Antennas RI = 1 | | | NA | NA |
| | | 4 TX Antennas RI = 1 | 8 | 8 | NA | NA |
| | | 2 TX Antennas RI > 1 | | | NA | NA |
| | | 4 TX Antennas RI > 1 | 11 | 11 | NA | NA |
| 3 | RI | 2-layer spatial multiplexing | 1 | 1 | 1 | 1 |
| | | 4-layer spatial multiplexing | 2 | 2 | 2 | 2 |
| 4 | Wideband CQI | RI = 1 | NA | NA | 4 | 4 |

## 7.2.3 Channel quality indicator (CQI) definition

The number of entries in the CQI table for a single TX antenna = 16 as given by Table 7.2.3-1.

A single CQI index corresponds to an index pointing to a value in the CQI table. The CQI index is defined in terms of a channel coding rate value and modulation scheme (QPSK, 16QAM, 64QAM),

Based on an unrestricted observation interval in time and frequency, the UE shall report the highest tabulated CQI index for which a single PDSCH sub-frame with a transport format (modulation and coding rate) and number of REs corresponding to the reported or lower CQI index that could be received in a 2-slot downlink subframe aligned, reference period ending z slots before the start of the first slot in which the reported CQI index is transmitted and for which the transport block error probability would not exceed 0.1.

Editor's note: RAN1 needs to agree on z.

The UE may assume the following in calculating the number of REs for the CQI calculation:

- 3 OFDM symbols for control signaling
- No resources reserved for P/S-SCH and P-BCH
- CP length of the non-MBSFN subframe

In deriving the CQI index, the UE may assume

- the MIMO mode (TxD or spatial multiplexing)
- the nominal measurement offset is a parameter semi-statically configurable by higher layers of the data EPRE with respect to the RS EPRE, from which the actual measurement offset of the data EPRE is derived

**Table 7.2.3-1: 4-bit CQI Table**

| CQI index | modulation | coding rate x 1024 | efficiency |
|---|---|---|---|
| 0 | out of range | | |
| 1 | QPSK | 78 | 0.1523 |
| 2 | QPSK | 120 | 0.2344 |
| 3 | QPSK | 193 | 0.3770 |
| 4 | QPSK | 308 | 0.6016 |
| 5 | QPSK | 449 | 0.8770 |
| 6 | QPSK | 602 | 1.1758 |
| 7 | 16QAM | 378 | 1.4766 |
| 8 | 16QAM | 490 | 1.9141 |
| 9 | 16QAM | 616 | 2.4063 |
| 10 | 64QAM | 466 | 2.7305 |
| 11 | 64QAM | 567 | 3.3223 |
| 12 | 64QAM | 666 | 3.9023 |
| 13 | 64QAM | 772 | 4.5234 |
| 14 | 64QAM | 873 | 5.1152 |
| 15 | 64QAM | 948 | 5.5547 |

### 7.2.4 Precoding Matrix Indicator (PMI) definition

For closed-loop spatial multiplexing transmission, precoding feedback is used for channel dependent codebook based precoding and relies on UEs reporting precoding matrix indicator (PMI). A UE shall report PMI based on the feedback modes described in 7.2.1 and 7.2.2. Each PMI value corresponds to a codebook index given in Table 6.3.4.2.3-1 or Table 6.3.4.2.3-2 of [3].

For open-loop spatial multiplexing transmission, PMI reporting is not supported.

# 8 Physical uplink shared channel related procedures

For FDD, there shall be 8 HARQ processes in the uplink. For FDD, the UE shall upon detection of a PDCCH with DCI format 0 and/or a PHICH transmission in subframe *n* intended for the UE, adjust the corresponding PUSCH transmission in subframe *n+4* according to the PDCCH and PHICH information.

For TDD, the number of HARQ processes shall be determined by the DL/UL configuration. For TDD, the UE shall upon detection of a PDCCH with DCI format 0 and/or a PHICH transmission in subframe *n* intended for the UE, adjust the corresponding PUSCH transmission in subframe *n+k*, with *k>3* according to the PDCCH and PHICH information

## 8.1 Resource Allocation for PDCCH DCI Format 0

A resource allocation field in the scheduling grant consists of a resource indication value (*RIV*) corresponding to a starting resource block ( $RB_{\mathrm{START}}$ ) and a length in terms of contiguously allocated resource blocks ( $L_{\mathrm{CRBs}}$ ). The resource indication value is defined by

if $(L_{\mathrm{CRBs}}-1)\le\lfloor N_{\mathrm{RB}}^{\mathrm{UL}}/2\rfloor$ then

$$RIV=N_{\mathrm{RB}}^{\mathrm{UL}}(L_{\mathrm{CRBs}}-1)+RB_{\mathrm{START}}$$

else

$$RIV=N_{\mathrm{RB}}^{\mathrm{UL}}(N_{\mathrm{RB}}^{\mathrm{UL}}-L_{\mathrm{CRBs}}+1)+(N_{\mathrm{RB}}^{\mathrm{UL}}-1-RB_{\mathrm{START}})$$

For the case where an odd number of resource block pairs have been configured for PUCCH transmissions and a UE's PUSCH resource allocation includes PRBs at a carrier band edge then the PRB of the allocated PUSCH band edge PRB pair occupied by the PUCCH resource slot will not be used for the PUSCH.

## 8.2 UE sounding procedure

The following Sounding Reference Symbol (SRS) parameters are UE specific semi-statically configurable by higher layer signalling:

- RPF=2 transmission comb assignment and location
- Duration of SRS transmission (valid until disabled or until the session ends)
- Periodicity of SRS transmissions: {2, 5, 10, 20, 40, 80, 160, 320} ms
- Symbol location in the subframe
- Frequency hopping

- Cyclic shift
- Bandwidth of SRS transmission which does not include the PUCCH region
    - Narrowband SRS: BW=2 RB if $N_{\mathrm{RB}}^{\mathrm{UL}} \le 6$ else BW=2, 4, or 6 RB if $N_{\mathrm{RB}}^{\mathrm{UL}} > 6$

A UE shall not transmit SRS in the case of simultaneous CQI and SRS transmission.

When a UE is RRC configured to support both A/N and SRS transmissions in the same subframe, then the UE shall transmit A/N using a shortened PUCCH format where the A/N symbol corresponding to the SRS location is punctured. When a UE is not RRC configured to support both A/N and SRS transmissions in the same subframe then the UE shall only transmit the A/N using PUCCH format 1a or 1b as defined in Section 5.4.1 of [3].

A UE shall not transmit SRS in the case of simultaneous SR and SRS transmission..

### 8.2.1 Sounding definition

## 8.3 UE ACK/NACK procedure

When A/N and SR are transmitted in the same sub-frame a UE shall transmit the A/N on its assigned ACK/NACK PUCCH resource for a negative SR transmission and transmit the A/N on its assigned SR PUCCH resource for a positive SR transmission.

When only an ACK/NACK or only a SR is transmitted a UE shall use PUCCH Format 1a or 1b for the ACK/NACK resource and PUCCH Format 1 for the SR resource as defined in section 5.4.1 in [3].

## 8.4 UE PUSCH Hopping procedure

The UE shall perform PUSCH frequency hopping if the single bit frequency hopping (FH) field in a corresponding PDCCH with DCI format 0 is set otherwise no PUSCH frequency hopping is performed.

A UE performing PUSCH frequency hopping shall determine its PUSCH resource allocation for the first slot of a subframe (*S1*) including the lowest index PRB ( $n_{PRB}^{S1}(n)$ ) in subframe *n* from a subset of the type 2 resource allocation field in a corresponding PDCCH with DCI format 0 received on subframe *n-4*. For a non-adaptive retransmission of a packet on a dynamically assigned PUSCH resource a UE shall determine its hopping type based on the last received PDCCH with DCI Format 0 associated with the packet. For a PUSCH transmission on a persistently allocated resource on subframe *n* in the absence of a corresponding PDCCH with a DCI Format 0 in subframe *n-4*, the UE shall determine its hopping type based on the hopping information in the initial grant that assigned the persistent resource allocation. The initial grant is either a PDCCH with DCI Format 0 or is higher layer signaled.

The subset of the type 2 resource allocation field excludes either 1 or 2 bits used for hopping information as indicated by Table 8.4-1 below where the number of PUSCH resource blocks is defined as $N_{\mathrm{RB}}^{\mathrm{PUSCH}} = N_{\mathrm{RB}}^{\mathrm{UL}} - N_{\mathrm{RB}}^{\mathrm{PUCCH}}$ where $N_{\mathrm{RB}}^{\mathrm{PUCCH}}$ is defined in [3]. The resource indication value (*RIV*) is defined as

$$RIV = N_{\mathrm{RB}}^{\mathrm{PUSCH}}(L_{\mathrm{CRBs}} - 1) + RB'_{\mathrm{START}} - \sum_{i=0}^{L_{\mathrm{CRBs}}-2} i \quad \text{where } RB'_{\mathrm{START}} = 0 \text{ is the first PRB after PUCCH.}$$

A UE performing PUSCH frequency hopping shall use one of two possible PUSCH frequency hopping types based on the hopping information. PUSCH hopping type 1 is described in section 8.4.1 and type 2 is described in section 8.4.2.

**Table 8.4-1: Min PUCCH BW, Max PUSCH BW, and Number of Hopping Bits vs. System Bandwidth**

| System BW $N_{RB}^{UL}$ | Minimum PUCCH BW in 1st Slot (#RBs) | Max BW assigned to a hopping User | #Hopping bits for 2nd slot RA |
|---|---|---|---|
| 6-14 | 1 | $\lfloor N_{\mathrm{RB}}^{\mathrm{PUSCH}}/2 \rfloor$ | 1 |
| 15-24 | 2 | 6 | 1 |
| 25-49 | Any | 8 | 1 |
| 50-74 | Any | 8 | 2 |
| 75-99 | Any | 12 | 2 |
| 100-110 | Any | 20 | 2 |

For either hopping type a single bit signaled by higher layers indicates whether PUSCH frequency hopping is inter-subframe only or both intra and inter-subframe.

Editor's note: RAN1 needs to determine if hopping RB-pairing must always be supported.

## 8.4.1 Type 1 PUSCH Hopping

For PUSCH hopping type 1 the hopping bit or bits indicated in Table 8.4-1 determine $\tilde{n}_{PRB}(i)$ as defined in Table 8.4-2. The lowest index PRB ($n_{PRB}^{S1}$) of the 1[st] slot RA in subframe $i$ is defined as $n_{PRB}^{S1}(i) = \tilde{n}_{PRB}^{S1}(i) + \lceil N_{RB}^{PUCCH}/2 \rceil$. The lowest index PRB ($n_{PRB}(i)$) of the 2[nd] slot RA in subframe $i$ is defined as $n_{PRB}(i) = \tilde{n}_{PRB}(i) + \lfloor N_{RB}^{PUCCH}/2 \rfloor$.

## 8.4.2 Type 2 PUSCH Hopping

PUSCH hopping type 2 uses a predefined hopping sequence (PHS) to determine $\tilde{n}_{PRB}(i)$ and the lowest index PRB ($n_{PRB}(i)$) of the 2[nd] slot RA in subframe $i$ as defined by $n_{PRB}(i) = \tilde{n}_{PRB}(i) + N_{RB}^{PUCCH}$ where the PHS and $\tilde{n}_{PRB}(i)$ are defined in [3] section 5.3.4.

**Table 8.4-2: PDCCH DCI Format 0 Hopping Bit Definition**

| System BW $N_{RB}^{UL}$ | Number of Hopping bits | Information in hopping bits | $\tilde{n}_{PRB}(i)$ |
|---|---|---|---|
| 6 – 49 | 1 | 0 | $\left(\lfloor N_{RB}^{PUSCH}/2 \rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$ , |
| | | 1 | section 5.3.4 in [3] |
| 50 – 110 | 2 | 00 | $\left(\lfloor N_{RB}^{PUSCH}/4 \rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$ |
| | | 01 | $\left(-\lfloor N_{RB}^{PUSCH}/4 \rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$ |

| | | | |
|---|---|---|---|
| | | 10 | $\left(\left\lfloor N_{RB}^{PUSCH}/2\right\rfloor+\tilde{n}_{PRB}^{S1}(i)\right)\bmod N_{RB}^{PUSCH}$ |
| | | 11 | section 5.3.4 in [3] |

## 8.5 UE Reference Symbol procedure

If UL sequence hopping is configured in the cell, it applies to all reference symbols (SRS, PUSCH and PUCCH RS).

# 9 Physical downlink control channel procedures

## 9.1 UE procedure for determining physical downlink control channel assignment

### 9.1.1 PDCCH Assignment Procedure

A UE is required to monitor a set of PDCCH candidates as often as every sub-frame. The number of candidate PDCCHs in the set and configuration of each candidate is configured by the higher layer signalling.

A UE determines the control region size to monitor in each subframe based on PCFICH which indicates the number of OFDM symbols ($l$) in the control region ($l=1, 2,$ or $3$) and PHICH symbol duration ($M$) received from the PBCH where $l \geq M$ . For unicast subframes $M=1$ or $3$ while for MBSFN subframes $M=1$ or $2$.

A UE shall monitor (perform blind decoding of) all candidate PDCCH payloads possible for each of its assigned search spaces in a given subframe control region. A search space is a set of aggregated control channel elements where aggregation size can be 1, 2, 4, or 8 control channel elements. There is one aggregation size per Search space. The candidate PDCCH locations in a search space occur every $B$ control channel elements where $B$ is the aggregation size. A UE shall be required to monitor both common and UE-specific search spaces. A common search space is monitored by all UEs in a cell and generally supports a limited number of aggregation levels, DCI format types, and blind decodes compared to the UE-specific search space. A UE-specific search space supports all aggregation levels with more blind decodes (than common search space) and for some system bandwidths only a subset of UEs in a cell monitor it. A UE-specific search space may overlap with a common search space.

### 9.1.2 PHICH Assignment Procedure

For scheduled PUSCH transmissions, a UE shall implicitly determine the corresponding PHICH resource in subframe $n$ from the lowest index PRB of the uplink resource allocation and the 3-bit uplink demodulation reference symbol (DMRS) cyclic shift both indicated in the PDCCH with DCI format 0 received on subframe $n$-4. The PHICH resource is identified by the index pair $(n_{PHICH}^{group}, n_{PHICH}^{seq})$ where $n_{PHICH}^{group}$ is the PHICH group number and $n_{PHICH}^{seq}$ is the orthogonal sequence index within the group as defined by:

$$n_{PHICH}^{group}=(I_{PRB\_RA}^{lowest\_index}+n_{DMRS})\bmod N_{PHICH}^{group}$$
$$n_{PHICH}^{seq}=(\left\lfloor I_{PRB\_RA}^{lowest\_index}/N_{PHICH}^{group}\right\rfloor+n_{DMRS})\bmod 2N_{SF}^{PHICH}$$

where

- $n_{DMRS}$ is the cyclic shift of the DMRS used in the UL transmission for which the PHICH is related.
- $N_{SF}^{PHICH}$ is the spreading factor size used for PHICH modulation as described in section 6.9.1 in [3].

- $I_{PRB\_RA}^{lowest\_index}$ is the lowest index PRB of the uplink resource allocation
- $N_{PHICH}^{group}$ is the number of PHICH groups configured

# 10 Physical uplink control channel procedures

## 10.1 UE procedure for determining physical uplink control channel assignment

The resource blocks reserved for PUCCHs in a sub-frame are semi-statically configured.

For a PDSCH transmission on subframe *n* corresponding to a PDCCH with DCI format 1A/1/2 received on subframe *n-4*, the UE shall determine the PUCCH index for ACK/NACK implicitly from the lowest CCE index used to construct the associated PDCCH.

For each PDSCH transmission corresponding to a configured scheduling assignment the UE shall use a PUCCH index for ACK/NACK previously received explicitly from higher layer signalling associated with the configured scheduling assignment. While the configured scheduling assignment is valid a UE shall continue to use the explicitly signalled PUCCH index for ACK/NACK for a PDSCH transmission on subframe *n* when no corresponding PDCCH with DCI format 1A/1/2 was received on subframe *n-4*.

## 10.2 Uplink ACK/NACK timing

For FDD, the UE shall upon detection of a PDSCH transmission in subframe *n* intended for the UE and for which an ACK/NACK shall be provided, transmit the ACK/NACK response in subframe *n+4*.

For TDD, the UE shall upon detection of a PDSCH transmission in subframe *n* intended for the UE and for which an ACK/NACK shall be provided, transmit the ACK/NACK response in UL subframe *n+k*, with *k>3*.

For TDD, the use of a single ACK/NACK response for providing HARQ feedback for multiple PDSCH transmissions is supported by performing logical AND of all the corresponding individual PDSCH transmission ACK/NACKs.

# Annex A (informative): Change history

| Change history | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 2006-09 | | | | | Draft version created | | 0.0.0 |
| 2006-10 | | | | | Endorsed by RAN1 | 0.0.0 | 0.1.0 |
| 2007-01 | | | | | Inclusion of decisions from RAN1#46bis and RAN1#47 | 0.1.0 | 0.1.1 |
| 2007-01 | | | | | Endorsed by RAN1 | 0.1.1 | 0.2.0 |
| 2007-02 | | | | | Inclusion of decisions from RAN1#47bis | 0.2.0 | 0.2.1 |
| 2007-02 | | | | | Endorsed by RAN1 | 0.2.1 | 0.3.0 |
| 2007-02 | | | | | Editor's version including decisions from RAN1#48 & RAN1#47bis | 0.3.0 | 0.3.1 |
| 2007-03 | | | | | Updated Editor's version | 0.3.1 | 0.3.2 |
| 2007-03 | RAN#35 | RP-070171 | | | For information at RAN#35 | 0.3.2 | 1.0.0 |
| 2007-03 | | | | | Random access text modified to better reflect RAN1 scope | 1.0.0 | 1.0.1 |
| 2007-03 | | | | | Updated Editor's version | 1.0.1 | 1.0.2 |
| 2007-03 | | | | | Endorsed by RAN1 | 1.0.2 | 1.1.0 |
| 2007-05 | | | | | Updated Editor's version | 1.1.0 | 1.1.1 |
| 2007-05 | | | | | Updated Editor's version | 1.1.1 | 1.1.2 |
| 2007-05 | | | | | Endorsed by RAN1 | 1.1.2 | 1.2.0 |
| 2007-08 | | | | | Updated Editor's version | 1.2.0 | 1.2.1 |
| 2007-08 | | | | | Updated Editor's version – uplink power control from RAN1#49bis | 1.2.1 | 1.2.2 |
| 2007-08 | | | | | Endorsed by RAN1 | 1.2.2 | 1.3.0 |
| 2007-09 | | | | | Updated Editor's version reflecting RAN#50 decisions | 1.3.0 | 1.3.1 |
| 2007-09 | | | | | Updated Editor's version reflecting comments | 1.3.1 | 1.3.2 |
| 2007-09 | | | | | Updated Editor's version reflecting further comments | 1.3.2 | 1.3.3 |
| 2007-09 | | | | | Updated Editor's version reflecting further comments | 1.3.3 | 1.3.4 |
| 2007-09 | | | | | Updated Edtior's version reflecting further comments | 1.3.4 | 1.3.5 |
| 2007-09 | RAN#37 | RP-070731 | | | Endorsed by RAN1 | 1.3.5 | 2.0.0 |
| 2007-09 | RAN#37 | RP-070737 | | | For approval at RAN#37 | 2.0.0 | 2.1.0 |
| 12/09/07 | RAN_37 | RP-070737 | - | - | Approved version | 2.1.0 | 8.0.0 |
| 28/11/07 | RAN_38 | RP-070949 | 0001 | 2 | Update of 36.213 | 8.0.0 | 8.1.0 |
| 05/03/08 | RAN_39 | RP-080145 | 0002 | - | Update of TS36.213 according to changes listed in cover sheet | 8.1.0 | 8.2.0 |

# ETSI TS 136 300 V8.4.0 (2008-04)

*Technical Specification*

## Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300 version 8.4.0 Release 8)

- The target eNB re-transmits and prioritizes all downlink PDCP SDUs forwarded by the source eNB (i.e. the target eNB should send data with PDCP SNs from X2 before sending data from S1), with the exception of PDCP SDUs of which the reception was acknowledged through PDCP SN based reporting by the UE.
- The UE re-transmits in the target eNB all uplink PDCP SDUs starting from the first PDCP SDU following the last consecutively confirmed PDCP SDU i.e. the oldest PDCP SDU that has not been acknowledged at RLC in the source, excluding the PDCP SDUs of which the reception was acknowledged through PDCP SN based reporting by the target.

For **RLC-UM bearers**:

- The PDCP SN and HFN are reset in the target eNB.
- No PDCP SDUs are retransmitted in the target eNB.
- The target eNB prioritize all downlink PDCP SDUs forwarded by the source eNB if any (i.e. the target eNB should send data with PDCP SNs from X2 before sending data from S1),.
- The UE PDCP entity does not attempt to retransmit any PDCP SDU in the target cell for which transmission had been completed in the source cell. Instead UE PDCP entity starts the transmission with other PDCP SDUs.

#### 10.1.2.2 Path Switch

After the downlink path is switched at the Serving GW downlink packets on the forwarding path and on the new direct path may arrive interchanged at the target eNB. The target eNodeB should first deliver all forwarded packets to the UE before delivering any of the packets received on the new direct path. The method employed in the target eNB to enforce the correct delivery order of packets is outside the scope of the standard.

In order to assist the reordering function in the target eNB, the Serving GW shall send one or more "end marker" packets on the old path immediately after switching the path for each SAE bearer of the UE. The "end marker" packet shall not contain user data. The "end marker" is indicated in the GTP header. After completing the sending of the tagged packets the GW shall not send any further user data packets via the old path.

Upon receiving the "end marker" packets, the source eNB shall, if forwarding is activated for that bearer, forward the packet toward the target eNB.

On detection of an "end marker" the target eNB shall discard the end marker packet and initiate any necessary processing to maintain in sequence delivery of user data forwarded over X2 interface and user data received from the serving GW over S1 as a result of the path switch.

#### 10.1.2.3 Data forwarding

##### 10.1.2.3.1 For RLC-AM bearers

Upon handover, the source eNB forwards in order to the target eNB all downlink PDCP SDUs with their SN that have not been acknowledged by the UE. In addition, the source eNB may forward without a PDCP SN fresh data arriving over S1 to the target eNB. In addition, the source eNB may forward fresh data arriving over S1 to the target eNB.

NOTE: Target eNB does not have to wait for the completion of forwarding from the source eNB before it begins transmitting packets to the UE.

The source eNB discards any remaining downlink RLC PDUs. Correspondingly, the source eNB does not forward the downlink RLC context to the target eNB.

NOTE: Source eNB does not need to abort on going RLC transmissions with the UE as it starts data forwarding to the target eNB.

Upon handover, the source eNB forwards uplink PDCP SDUs successfully received in-sequence to the Serving Gateway, may forward uplink PDCP SDUs with their SN received out-of-sequence to the target eNB and shall discard any remaining uplink RLC PDUs. Correspondingly, the source eNB does not forward the uplink RLC context to the target eNB.

The PDCP SN of forwarded SDUs is carried in the "PDCP PDU number" field of the GTP-U extension header. The target eNB shall use the PDCP SN if it is available in the forwarded GTP-U packet.

In-sequence delivery of upper layer PDUs during handover is based on a continuous PDCP SN and is provided by the re-ordering function at the PDCP layer, which can be activated at least during inter-eNB mobility:

- in the downlink, the re-ordering function at the UE PDCP layer guarantees in-sequence delivery of downlink PDCP SDUs;
- in the uplink, the re-ordering function at the target eNB PDCP layer guarantees in-sequence delivery of uplink PDCP SDUs.

After handover, when the UE receives a PDCP SDU from the target eNB, it can deliver it to higher layer together with all PDCP SDUs with lower SNs regardless of possible gaps.

##### 10.1.2.3.2 For RLC-UM bearers

Upon handover, the source eNB does not forward to the target eNB downlink PDCP SDUs for which transmission had been completed in the source cell. PDCP SDUs that have not been transmitted may be forwarded. In addition, the source eNB may forward fresh data arriving over S1 to the target eNB. The source eNB discards any remaining downlink RLC PDUs. Correspondingly, the source eNB does not forward the downlink RLC context to the target eNB.

Upon handover, the source eNB forwards all uplink PDCP SDUs successfully received to the Serving Gateway and discards any remaining uplink RLC PDUs. Correspondingly, the source eNB does not forward the uplink RLC context to the target eNB.

#### 10.1.2.4 Handling in eNB

#### 10.1.2.5 Handling above eNB

#### 10.1.2.6 Mobility Management Entity (MME)

#### 10.1.2.7 Timing Advance

In RRC_CONNECTED, the eNB is responsible for maintaining the timing advance. In some cases (e.g. during DRX), the timing advance is not necessarily always maintained and the MAC sublayer knows if the L1 is synchronised and which procedure to use to start transmitting in the uplink:

- as long as the L1 is non-synchronised, uplink transmission can only take place on PRACH.

For one UE, cases where the UL synchronisation status moves from "synchronised" to "non-synchronised" include:

- Expiration of a timer;
- Non-synchronised handover;
- Explicit request by MAC or RRC in the eNB (FFS);

The value of the timer is either UE specific and managed through dedicated signalling between the UE and the eNB, or cell specific and indicated via broadcast information. In both cases, the timer is always restarted whenever a new timing advance is given by the eNB:

- restarted to a UE specific value if any; or
- restarted to a cell specific value otherwise.

Upon DL data arrival, dedicated signature on PRACH can be allocated by the eNB to UE. When a dedicated signature on PRACH is allocated, the UE shall perform the corresponding random access procedure regardless of its L1 synchronisation status.

TA updates are signalled by the eNB to the UE in MAC PDUs addressed via C-RNTI, and embedded with user data or alone.

### 10.1.3 Measurements

Measurements to be performed by a UE for intra/inter-frequency mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC_IDLE state, a UE shall follow the measurement parameters defined for cell reselection specified by the E-UTRAN broadcast (as in UTRAN SIB). The use of dedicated measurement control for RRC_IDLE state is FFS. In RRC_CONNECTED state, a UE shall follow the measurement configurations specified by RRC directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

Intra-frequency neighbour (cell) measurements and inter-frequency neighbour (cell) measurements are defined as follows:

- Intra-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are intra-frequency measurements when the current and target cell operates on the same carrier frequency. The UE shall be able to carry out such measurements without measurement gaps.

- Inter-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are inter-frequency measurements when the neighbour cell operates on a different carrier frequency, compared to the current cell. The UE should not be assumed to be able to carry out such measurements without measurement gaps.

Whether a measurement is non gap assisted or gap assisted depends on the UE's capability and current operating frequency. The UE determines whether a particular cell measurement needs to be performed in a transmission/reception gap and the scheduler needs to know whether gaps are needed:

- Same carrier frequency and cell bandwidths (Scenario A): an intra-frequency scenario; not measurement gap assisted.

- Same carrier frequency, bandwidth of the target cell smaller than the bandwidth of the current cell (Scenario B): an intra-frequency scenario; not measurement gap assisted.

- Same carrier frequency, bandwidth of the target cell larger than the bandwidth of the current cell (Scenario C): FFS.

- Different carrier frequencies, bandwidth of the target cell smaller than the bandwidth of the current cell and bandwidth of the target cell within bandwidth of the current cell (Scenario D): an inter-frequency scenario; measurement gap-assisted scenario.

- Different carrier frequencies, bandwidth of the target cell larger than the bandwidth of the current cell and bandwidth of the current cell within bandwidth of the target cell (Scenario E): an inter-frequency scenario; measurement gap-assisted scenario.

- Different carrier frequencies and non-overlapping bandwidth, (Scenario F): an inter-frequency scenario; measurement gap-assisted scenario.

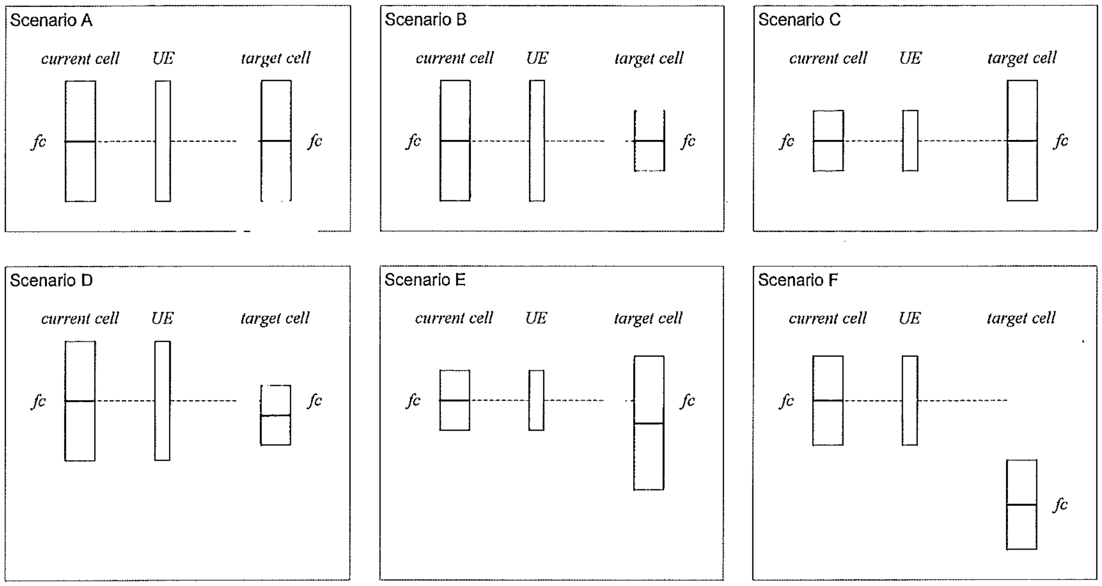


**Figure 10.1.3-1: Inter and Intra-frequency measurements scenarios**

Measurement gaps patterns are configured and activated by RRC. Measurement gaps are of higher priority than HARQ retransmissions i.e. if an HARQ retransmissions collides with a measurement gap, the HARQ retransmission does not take place.

### 10.1.3.1 Intra-frequency neighbour (cell) measurements

In a system with frequency reuse = 1, mobility within the same frequency layer (i.e. between cells with the same carrier frequency) is predominant. Good neighbour cell measurements are needed for cells that have the same carrier frequency as the serving cell in order to ensure good mobility support and easy network deployment. Search for neighbour cells with the same carrier frequency as the serving cell, and measurements of the relevant quantities for identified cells are needed.

NOTE: To avoid UE activity outside the DRX cycle, the reporting criteria for neighbour cell measurements should match the used DRX cycle.

### 10.1.3.2 Inter-frequency neighbour (cell) measurements

Regarding mobility between different frequency layers (i.e. between cells with a different carrier frequency), UE may need to perform neighbour cell measurements during DL/UL idle periods that are provided by DRX or packet scheduling (i.e. gap assisted measurements).

## 10.1.4 Paging and C-plane establishment

Paging groups (where multiple UEs can be addressed) are used on L1/L2 signalling channel:

- Precise UE identity is found on PCH;
- DRX configurable via BCCH (UE specific DRX is FFS);
- Only one subframe allocated per paging interval per UE;
- The network may divide UEs to different paging occasions in time;
- There is no grouping within paging occasion;
- One paging RNTI for PCH.

### 10.1.5 Random Access Procedure

The random access procedure is characterized by:

- Common procedure for FDD and TDD;
- One procedure irrespective of cell size;

The random access procedure is performed for the following five events:

- Initial access from RRC_IDLE;
- Initial access after radio link failure;
- Handover requiring random access procedure;
- DL data arrival during RRC_CONNECTED requiring random access procedure;
    - E.g. when UL synchronisation status is 'non-synchronised';
- UL data arrival during RRC_CONNECTED requiring random access procedure;
    - E.g. when UL synchronisation status is "non-synchronised" or there are no PUCCH resources for SR available.

Furthermore, the random access procedure takes two distinct forms:

- Contention based (applicable to all five events);
- Non-contention based (applicable to only handover and DL data arrival).

Normal DL/UL transmission can take place after the random access procedure.

#### 10.1.5.1 Contention based random access procedure

The contention based random access procedure is outlined on Figure 10.1.5.1-1 below:

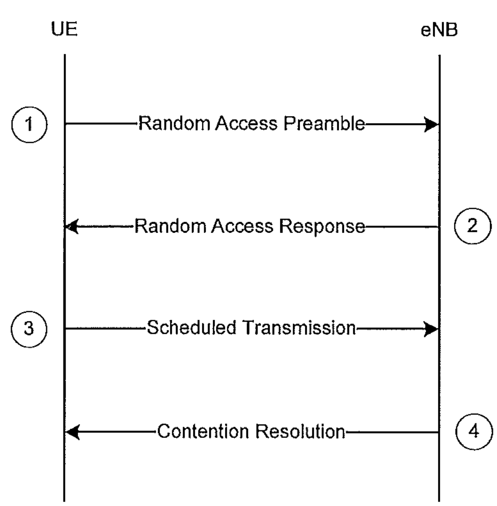


**Figure 10.1.5.1-1: Contention based Random Access Procedure**

The four steps of the contention based random access procedures are:

1) Random Access Preamble on RACH in uplink:
    - 6 bits to carry: a 5 bit random ID, and 1 bit to indicate information on size of message 3 or requested resource blocks (FFS) limited by radio conditions. The groups of signatures that are used for indicating the 1 bit information, as well as necessary thresholds are broadcast on system information.

NOTE: the total number of bits is 5 for TDD Frame Structure Type II.

2) Random Access Response generated by MAC on DL-SCH:

- Semi-synchronous (within a flexible window of which the size is one or more TTI) with message 1;
- No HARQ;
- Addressed to RA-RNTI on L1/L2 control channel;
- Conveys at least RA-preamble identifier, Timing Alignment information, initial UL grant and assignment of Temporary C-RNTI (which may or may not be made permanent upon RRC Contention Resolution);
- Intended for a variable number of UEs in one DL-SCH message.

3) First scheduled UL transmission on UL-SCH:

- Uses HARQ;
- Size of the transport blocks depends on the UL grant conveyed in step 2 and is at least 80 bits.
- For initial access:
  - Conveys the RRC Connection Request generated by the RRC layer and transmitted via CCCH;
  - Conveys at least NAS UE identifier but no NAS message;
  - RLC TM: no segmentation;
- After radio link failure:
  - Conveys the RRC Connection Re-establishment Request generated by the RRC layer and transmitted via CCCH;
  - RLC TM: no segmentation;
  - Does not contain any NAS message.
- After handover, in the target cell:
  - Conveys the ciphered and integrity protected RRC Handover Confirm generated by the RRC layer and transmitted via DCCH;
  - Conveys the C-RNTI of the UE (which was allocated via the Handover Command);
  - Includes an uplink Buffer Status Report when possible.
- For other events:
  - Conveys at least the C-RNTI of the UE.

4) Contention Resolution on DL-SCH:

- Early contention resolution shall be used i.e. eNB does not wait for NAS reply before resolving contention
- Not synchronised with message 3;
- HARQ is supported;
- Addressed to:
  - The Temporary C-RNTI on L1/L2 control channel for initial access and after radio link failure;
  - The C-RNTI for UE in RRC_CONNECTED;
- HARQ feedback is transmitted only by the UE which detects its own UE identity, as provided in message 3, echoed in the RRC Contention Resolution message;
- For initial access and after radio link failure, no segmentation is used (RLC-TM).

The Temporary C-RNTI is promoted to C-RNTI for a UE which detects RA success and does not already have a C-RNTI; it is dropped by others. A UE which detects RA success and already has a C-RNTI, resumes using its C-RNTI.

### 10.1.5.2 Non-contention based random access procedure

The non-contention based random access procedure is outlined on Figure 10.1.5.2-1 below:

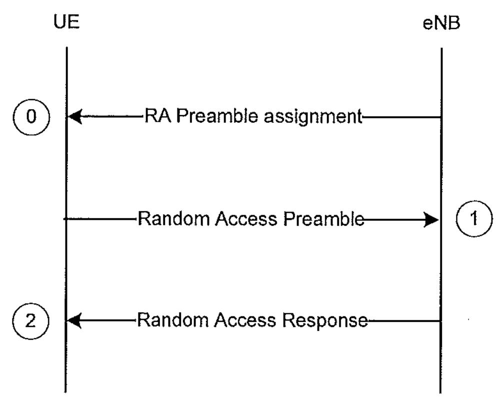


**Figure 10.1.5.2-1: Non-contention based Random Access Procedure**

The three steps of the non-contention based random access procedures are:

0) Random Access Preamble assignment via dedicated signalling in DL:
   - eNB assigns to UE a non-contention Random Access Preamble (a Random Access Preamble not within the set broadcasted on BCH).
   - Signalled via:
     - HO command generated by target eNB and sent via source eNB for handover;
     - MAC signalling (L1/L2 control channel or MAC control PDU is FFS) in case of DL data arrival.

1) Random Access Preamble on RACH in uplink:
   - UE transmits the assigned non-contention Random Access Preamble.

2) Random Access Response on DL-SCH:
   - Semi-synchronous (within a flexible window of which the size is one or more TTI) with message 1;
   - No HARQ;
   - Addressed to RA-RNTI on L1/L2 control channel;
   - Conveys at least:
     - Timing Alignment information and initial UL grant for handover;
     - Timing Alignment information for DL data arrival;
     - RA-preamble identifier.
   - Intended for one or multiple UEs in one DL-SCH message.

### 10.1.5.3 Interaction model between L1 and L2/3 for Random Access Procedure

Random access procedure described above is modelled in Figure 10.1.5.3-1 below from L1 and L2/3 interaction point of view. L2/L3 receives indication from L1 whether ACK is received or DTX is detected after indication of Random

Access Preamble transmission to L1. L2/3 indicates L1 to transmit first scheduled UL transmission (RRC Connection Request in case of initial access) if necessary or Random Access Preamble based on the indication from L1.

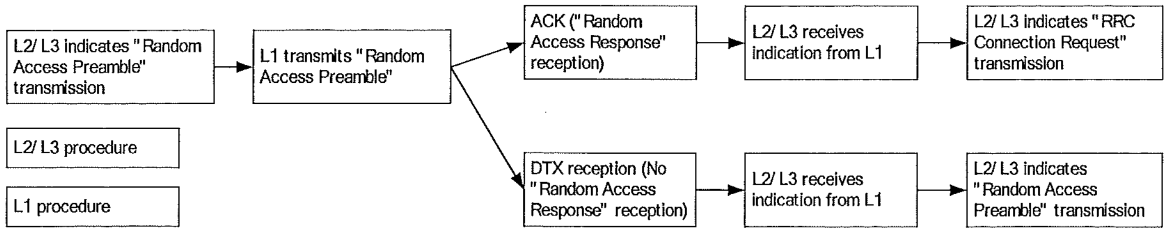


**Figure 10.1.5.3-1: Interaction model between L1 and L2/3 for Random Access Procedure**

## 10.1.6 Radio Link Failure

Two phases governs the behaviour associated to radio link failure as shown on Figure 10.1.6-1:

- First phase:
  - started upon radio problem detection;
  - leads to radio link failure detection;
  - no UE-based mobility;
  - based on timer or other (e.g. counting) criteria ($T_1$).
- Second Phase:
  - started upon radio link failure detection or handover failure;
  - leads to RRC_IDLE;
  - UE-based mobility;
  - Timer based ($T_2$).

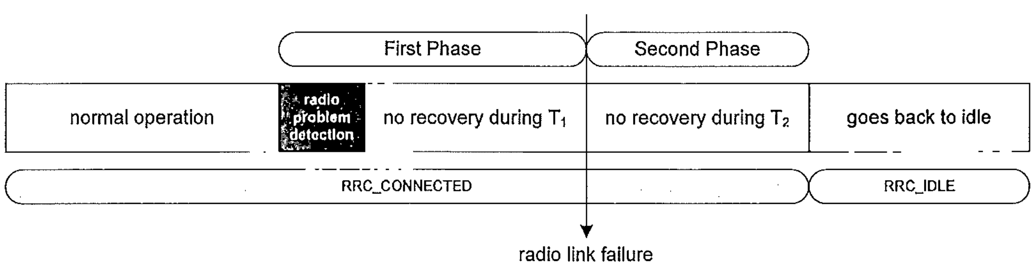


**Figure 10.1.6-1: Radio Link Failure**

Table 10.1.6-1 below describes how mobility is handled with respect to radio link failure:

**Table 10.1.6-1: Mobility and Radio Link Failure**

| Cases | First Phase | Second Phase | T2 expired |
|---|---|---|---|
| UE returns to the same cell | Continue as if no radio problems occurred | Activity is resumed by means of explicit signalling between UE and eNB | Go via RRC_IDLE |
| UE selects a different cell from the same eNB | N/A | Activity is resumed by means of explicit signalling between UE and eNB | Go via RRC_IDLE |
| UE selects a cell of a prepared eNB (NOTE) | N/A | Activity is resumed by means of explicit signalling between UE and eNB | Go via RRC_IDLE |
| UE selects a cell of a different eNB that is not prepared (NOTE) | N/A | Go via RRC_IDLE (FFS) | Go via RRC_IDLE |
| NOTE: a prepared eNB is an eNB which has admitted the UE during an earlier executed HO preparation phase. | | | |

In the Second Phase, in order to resume activity and avoid going via RRC_IDLE when the UE returns to the same cell or when the UE selects a different cell from the same eNB, or when the UE selects a cell from a different eNB, the following procedure applies:

- The UE stays in RRC_CONNECTED;
- The UE accesses the cell through the random access procedure;
- The UE identifier used in the random access procedure for contention resolution (i.e. C-RNTI of the UE in the cell where the RLF occurred + physical layer identity of that cell + MAC based on the keys of that cell) is used by the selected eNB to authenticate the UE and check whether it has a context stored for that UE:
  - If the eNB finds a context that matches the identity of the UE, it indicates to the UE that its connection can be resumed;
  - If the context is not found, RRC connection is released and UE initiates procedure to establish new RRC connection. In this case UE may be required to go via RRC_IDLE (FFS).

## 10.1.7 Radio Access Network Sharing

E-UTRAN shall support radio access network sharing based on support for multi-to-multi relationship between E-UTRAN nodes and EPC nodes (S1-flex).

If the E-UTRAN is shared by multiple operators, the system information broadcasted in each shared cell contains the PLMN-id of each operator (up to 6) and a single tracking area code (TAC) valid within all the PLMNs sharing the radio access network resources.

The UE shall be able to read up to 6 PLMN-ids, to select one of the PLMN-ids at initial attachment and to indicate this PLMN-id to the E-UTRAN in subsequent instances of the Random Access procedures (e.g. as defined in subclause 10.1.5). The E-UTRAN shall select an appropriate MME for the PLMN indicated by the UE. Once attached to an MME, the UE shall be able to indicate the allocated MME in subsequent instances of the Random Access procedures. Whether the indication of the selected PLMN or the allocated MME is contained in the temporary UE identity or signalled separately is FFS.

Handling of area restrictions for UE in ECM-CONNECTED shall follow the principles specified in sub-clause 10.4.

## 10.1.8 Handling of Roaming and Area Restrictions for UEs in ECM-CONNECTED

Handling of roaming/area restrictions and handling of subscription specific preferences in ECM-CONNECTED is performed in the eNB based on information provided by the EPC over the S1 interface.

## 10.2 Inter RAT

Service-based redirection between GERAN / UTRAN and E-UTRAN is supported in both directions. This should not require inter-RAT reporting in RRC CONNECTION REQUEST.

### 10.2.1 Cell reselection

A UE in RRC_IDLE performs cell reselection. The principles of this procedure are as follows:

- The UE makes **measurements** of attributes of the serving and neighbour cells to enable the reselection process:
    - For a UE to search and measure neighbouring GERAN cells, the ARFCNs of the BCCH carriers need to be indicated in the serving cell system information (i.e., an NCL). The NCL does not contain BSICs or cell specific offsets and Qrxlevmin is given per frequency band.
    - For a UE to search and measure neighbouring UTRAN cells, the serving cell can indicate an NCL containing a list of carrier frequencies and scrambling codes.
    - Measurements may be omitted if the serving cell attribute fulfils particular search or measurement criteria.
- **Cell reselection** identifies the cell that the UE should camp on. It is based on cell reselection criteria which involves measurements of the serving and neighbour cells:
    - Inter-RAT reselection is based on absolute priorities where UE tries to camp on highest priority RAT available. Absolute priorities for inter-RAT reselection are provided only by the RPLMN and valid only within the RPLMN; priorities are given by the system information and valid for all UEs in a cell, specific priorities per UE can be signalled in the RRC Connection Release message. A validity time can be associated with UE specific priorities.
    - It should be possible to prevent the UE from reselecting to specific detected neighbouring cells;
    - The UE is allowed to "leave" the source E-UTRAN cell to read the target GERAN cell broadcast, in order to determine its "suitability", prior to completing the cell reselection;
    - Cell reselection can be speed dependent (speed detection based on UTRAN solution);

Cell access restrictions apply as for UTRAN, which consist of access class (AC) barring and cell reservation (e.g. for cells "reserved for operator use") applicable for mobiles in RRC_IDLE mode.

When performing cell reselection while the UE is camped on another RAT, the principles of this procedure are as follows:

- The UE measures attributes of the E-UTRA neighbouring cells:
    - Only the carrier frequencies need to be indicated to enable the UE to search and measure E-UTRA neighbouring cells;
- Cell reselection identifies the cell that the UE should camp on. It is based on cell reselection criteria which involves measurements of the serving and neighbour cells:
    - For E-UTRA neighbouring cells, there is no need to indicate cell-specific cell reselection parameters i.e. these parameters are common to all neighbouring cells on an E-UTRA frequency;
- Cell reselection parameters are applicable to all UEs in a cell, but it is possible to configure specific reselection parameters per UE group or per UE.
- It should be possible to prevent the UE from reselecting to specific detected neighbouring cells.

### 10.2.2 Handover

Inter RAT HO is designed so that changes to GERAN and UTRAN are minimised. This can be done by following the principles specified for GERAN to/from UTRAN intersystem HO. In particular the following principles are applied to E-UTRAN Inter RAT HO design:

1. Inter RAT HO is network controlled through source access system. The source access system decides about starting the preparation and provides the necessary information to the target system in the format required by the target system. That is, the source system adapts to the target system. The actual handover execution is decided in the source system.

2. Inter RAT HO is backwards handover, i.e. radio resources are prepared in the target 3GPP access system before the UE is commanded by the source 3GPP access system to change to the target 3GPP access system.

3. To enable backwards handover, and while RAN level interfaces are not available, a control interface exists in CN level. In Inter RAT HO involving E-UTRAN access, this interface is between 2G/3G SGSN and corresponding MME/Serving Gateway.

4. The target access system will be responsible for giving exact guidance for the UE on how to make the radio access there (this includes radio resource configuration, target cell system information etc.). This information is given during the handover preparation and should be transported completely transparently through the source access system to the UE.

5. Mechanisms for avoiding or mitigating the loss of user data (i.e. forwarding) can be used until the 3GPP Anchor determines that it can send DL U-plane data directly to the target system.

6. The handover procedure should not require any UE to CN signalling in order for data to start to flow in the target system. This requires that the security context, UE capability context and QoS context is transferred (or translated) within the network between source and target system.

7. Similar handover procedure should apply for handovers of both real time and non-real time services.

8. Similar handover procedure should apply for both Inter RAT Handover and intra-LTE Handover with EPC node change.

9. Network controlled mobility is supported even if no prior UE measurements have been performed on the target cell and/or frequency i.e. 'blind HO' is supported.

## 10.2.2a Inter-RAT cell change order to GERAN with NACC

For interworking towards GERAN, inter-RAT cell change order with NACC is supported even if no prior UE measurements have been performed on the system i.e. 'blind NACC' is supported.

## 10.2.3 Measurements

### 10.2.3.1 Inter-RAT handovers from E-UTRAN

Measurements to be performed by a UE for inter-RAT mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC_CONNECTED state, a UE shall follow the measurement parameters specified by RRC or MAC commands (FFS) directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

UE performs inter-RAT neighbour cell measurements during DL/UL idle periods that are provided by the network through suitable DRX/DTX period or packet scheduling if necessary.

### 10.2.3.2 Inter-RAT handovers to E-UTRAN

From UTRAN, UE performs E-UTRAN measurements by using idle periods created by compressed mode (CELL_DCH), FACH measurement occasions (CELL_FACH - FFS), or DRX (other states).

From GERAN, E-UTRAN measurements are performed in the same way as WCDMA measurements for handover to UTRAN: E-UTRAN measurements are performed in GSM idle frames in a time multiplexed manner. However, it should be discussed with GERAN how to ensure that inter-RAT measurements do not take too much measurement time, while the requested 3GPP inter-RAT measurements can be performed well enough.

Design constraints of 3GPP inter-RAT measurements should be considered when L1 details of E-UTRAN concept are defined.

# 3GPP TS 36.321 V8.0.0 (2007-12)

*Technical Specification*

## 3rd Generation Partnership Project;
## Technical Specification Group Radio Access Network;
## Evolved Universal Terrestrial Radio Access (E-UTRA)
## Medium Access Control (MAC) protocol specification
## (Release 8)



The present document has been developed within the 3rd Generation Partnership Project (3GPP ™) and may be further elaborated for the purposes of 3GPP.

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# Contents

# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document specifies the E-UTRA MAC protocol.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

# 3 Definitions and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Active Time:** time that the UE is awake. When DRX is configured by higher layer, this includes the On Duration, the time UE is continuously monitoring the PDCCH while the DRX Inactivity Timer has not expired and the time UE is continuously monitoring the PDCCH while the DRX Retransmission Timer has not expired.

**DRX Cycle:** Specifies the periodic repetition of the On Duration followed by a possible period of inactivity (see figure 3.1-1 below).

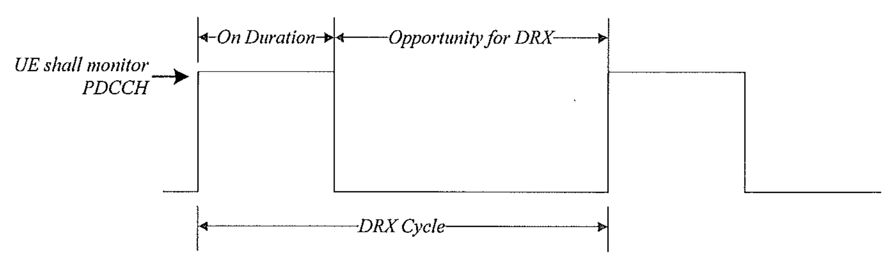



**Figure 3.1-1: DRX Cycle**

**DRX Inactivity Timer**: Specifies the number of consecutive TTIs during which the UE shall monitor the PDCCH after successfully decoding a PDCCH indicating an initial UL or DL user data transmission for this UE.

**DRX Retransmission Timer**: Specifies the number of consecutive TTIs the UE shall monitor the PDCCH for as soon as a DL retransmission is expected by the UE.

**DRX Short Cycle Timer**: This parameter specifies the number of consecutive TTIs the UE shall follow the short DRX cycle after the DRX Inactivity Timer has expired.

**HARQ RTT Timer**: This parameter specifies the minimum amount of TTIs before a DL HARQ retransmission is expected by the UE.

**On Duration Timer:** Specifies the number of consecutive TTIs during which the UE shall monitor the PDCCH for possible allocations. The On Duration Timer is a part of a DRX Cycle.

**RA-RNTI:** The Random Access RNTI is used on the [PDCCH] when Random Access Response messages are transmitted. It unambiguously identifies which time-frequency resource was utilized by the UE to transmit the Random Access preamble.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

| | |
|---|---|
| C-RNTI | Cell RNTI |
| E-UTRA | Evolved UMTS Terrestrial Radio Access |
| E-UTRAN | Evolved UMTS Terrestrial Radio Access Network |
| MAC | Medium Access Control |
| RA-RNTI | Random Access RNTI |
| RNTI | Radio Network Temporary Identifier |
| SR | Scheduling Request |

# 4 General

## 4.1 Introduction

The objective is to describe the MAC architecture and the MAC entity from a functional point of view.

## 4.2 MAC architecture

The description in this sub clause is a model and does not specify or restrict implementations.

RRC is in control of configuration of MAC.

### 4.2.1 MAC Entities

E-UTRA defines two MAC entities; one in the UE and one in the E-UTRAN. These MAC entities handle the following transport channels:

- Broadcast Channel (BCH)
- Downlink Shared Channel (DL-SCH)
- Paging Channel (PCH)
- Multicast Channel (MCH)
- Uplink Shared Channel (UL-SCH)
- Random Access Channel(s) (RACH)

The exact functions performed by the MAC entities are different in the UE from those performed in the E-UTRAN.

## 4.3 Services

### 4.3.1 Services provided to upper layers

This clause describes the different services provided by MAC sub layer to upper layers.

- Data transfer
- Radio resource allocation

### 4.3.2 Services expected from physical layer

The physical layer provides the following services to MAC:

- data transfer services;
- signalling of HARQ feedback;
- signalling of Scheduling Request;
- measurements (e.g. Channel Quality Indication (CQI)).

The access to the data transfer services is through the use of transport channels. The characteristics of a transport channel are defined by its transport format (or format set), specifying the physical layer processing to be applied to the transport channel in question, such as channel coding and interleaving, and any service-specific rate matching as needed.

## 4.4 Functions

The following functions are supported by MAC sub layer:

- Mapping between logical channels and transport channels;
- Multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;
- Demultiplexing of MAC SDUs from one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;
- Scheduling information reporting;
- Error correction through HARQ;
- Priority handling between UEs by means of dynamic scheduling;
- Priority handling between logical channels of one UE;
- Logical Channel prioritisation;
- Transport format selection;

NOTE: How the multiplexing relates to the QoS of the multiplexed logical channels is FFS.

The location of the different functions and their relevance for uplink and downlink respectively is illustrated in Table 4.4-1.

**Table 4.4-1: MAC function location and link direction association.**

| MAC function | UE | eNB | Downlink | Uplink |
|---|---|---|---|---|
| Mapping between logical channels and transport channels | X | | X | X |
| | | X | X | X |
| Multiplexing | X | | | X |
| | | X | X | |
| Demultiplexing | X | | X | |
| | | X | | X |
| Error correction through HARQ | X | | X | X |
| | | X | X | X |
| Transport Format Selection | | X | X | X |
| Priority handling between UEs | | X | X | X |
| Priority handling between logical channels of one UE | | X | X | X |
| Logical Channel prioritisation | X | | | X |
| Scheduling information reporting | X | | | X |

# 4.5 Channel structure

The MAC sub layer operates on the channels defined below; transport channels are SAPs between MAC and Layer 1, logical channels are SAPs between MAC and RLC.

## 4.5.1 Transport Channels

The transport channels used by MAC are described in Table 4.5.1-1 below.

**Table 4.5.1-1: Transport channels used by MAC**

| Transport channel name | Acronym | Downlink | Uplink |
|---|---|---|---|
| Broadcast Channel | BCH | X | |
| Downlink Shared Channel | DL-SCH | X | |
| Paging Channel | PCH | X | |
| Multicast Channel | MCH | X | |
| Uplink Shared Channel | UL-SCH | | X |
| Random Access Channel | RACH | | X |

## 4.5.2 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC.

Each logical channel type is defined by what type of information is transferred.

MAC provides the control and traffic channels listed in Table 4.5.2-1 below. When MAC uses the [L1/L2 control channel (name FFS)] to indicate radio resource allocation, the RNTI that is mapped on the [L1/L2 control channel (name FFS)] depends on the logical channel type.

**Table 4.5.2-1: Logical channels provided by MAC.**

| Logical channel name | Acronym | Control channel | Traffic channel |
|---|---|---|---|
| Broadcast Control Channel | BCCH | X | |
| Paging Control Channel | PCCH | X | |
| Common Control Channel | CCCH | X | |
| Multicast Control Channel | MCCH | X | |
| Dedicated Control Channel | DCCH | X | |
| Dedicated Traffic Channel | DTCH | | X |
| Multicast Traffic Channel | MTCH | | X |

### 4.5.3 Mapping of Transport Channels to Logical Channels

The mapping of logical channels on transport channels depends on the multiplexing that is configured by RRC.

#### 4.5.3.1 Uplink mapping

The MAC entity is responsible for mapping logical channels for the uplink onto uplink transport channels. The uplink logical channels can be mapped as described in Figure 4.5.3.1-1 and Table 4.5.3.1-1.

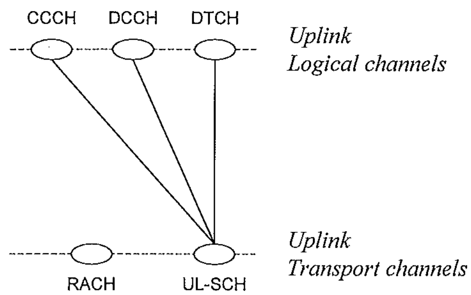



**Figure 4.5.3.1-1**

**Table 4.5.3.1-1: Uplink channel mapping.**

| Transport channel / Logical channel | UL-SCH | RACH |
|---|---|---|
| CCCH | X | |
| DCCH | X | |
| DTCH | X | |

#### 4.5.3.2 Downlink mapping

The MAC entity is responsible for mapping the downlink logical channels to downlink transport channels. The downlink logical channels can be mapped as described in Figure 4.5.3.2-1 and Table 4.5.3.2-1.

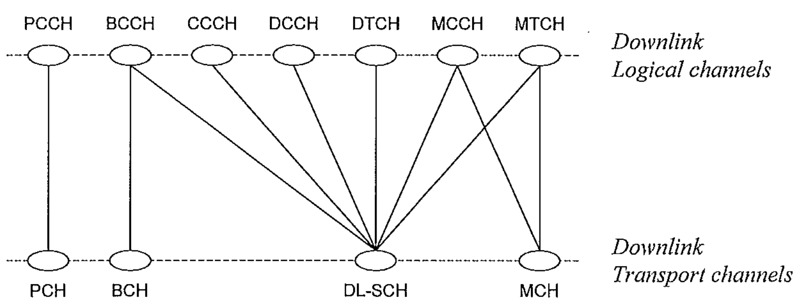



**Figure 4.5.3.2-1**

**Table 4.5.3.2-1: Downlink channel mapping.**

| Transport channel / Logical channel | BCH | PCH | MCH | DL-SCH |
|---|---|---|---|---|
| BCCH | X | | | X |
| PCCH | | X | | |
| CCCH | | | | X |
| MCCH | | | X | X |
| DCCH | | | | X |
| DTCH | | | | X |
| MTCH | | | X | X |

# 5 MAC procedures

## 5.1 Random Access procedure

### 5.1.1 Random Access Procedure initialization

The Random Access procedure described in this subclause is initiated upon request from higher layer or by the MAC sublayer itself.

Before the procedure can be initiated, the following information is assumed to be available:

- The available set of PRACH resources for the transmission of the Random Access Preamble and their corresponding RA-RNTIs.
- The groups of Random Access Preambles and the set of available Random Access Preambles in each group.
- The thresholds required for selecting one of the two groups of Random Access Preambles.
- The parameters required to derive the TTI window described in subclause 5.1.4.
- The power-ramping factor POWER_RAMP_STEP [integer ≥ 0].
- The parameter PREAMBLE_TRANS_MAX [integer > 0].
- The initial preamble power PREAMBLE_INITIAL_POWER.

[Note that the above parameters may be updated from higher layers before each Random Access procedure is initiated.]

The Random Access procedure shall be performed as follows:

- Set the PREAMBLE_TRANSMISSION_COUNTER to 1;
- proceed to the selection of the Random Access Resource (see subclause 5.1.2).

### 5.1.2 Random Access Resource selection

The Random Access Preamble can either be provided to MAC through explicit signalling (from RRC or from L1/L2 control channel (name FFS) [FFS] or a MAC control PDU [FFS]) or must be selected by MAC itself.

If the Random Access Preamble and PRACH resource are explicitly signalled it can directly proceed to its transmission (see subclause 5.1.3).

If the Random Access Preamble must be selected by MAC, the UE shall:

- depending on the size of the message to be transmitted on the UL or the requested resource blocks [FFS] [the selection also depends on radio conditions], select one of the two groups of Random Access Preambles configured by RRC;

- randomly select a Random Access Preamble within the selected group. The random function shall be such that each of the allowed selections can be chosen with equal probability;

- if more than one PRACH resources are available in the same subframe (TDD), randomly select one. The random function shall be such that each of the allowed selections can be chosen with equal probability;

- proceed to the transmission of the Random Access Preamble (see subclause 5.1.3).

### 5.1.3 Random Access Preamble transmission

The random-access procedure shall be performed as follows:

[- Set the parameter PREAMBLE_TRANSMISSION_POWER to PREAMBLE_INITIAL_POWER + (PREAMBLE_TRANSMISSION_COUNTER-1) * POWER_RAMP_STEP.]

[- If the PREAMBLE_TRANSMISSION_POWER is below the minimum power level, set the PREAMBLE_TRANSMISSION_POWER to the minimum power level.]

[- If the PREAMBLE_TRANSMISSION_POWER is above the maximum power level, set the PREAMBLE_TRANSMISSION_POWER to the maximum power level.]

- If PREAMBLE TRANMISSION COUNTER = 1, determine the next available Random Access occasion. If PREAMBLE TRANSMISSION COUNTER > 1, the Random Access occasion is determined by the back-off procedure.

- Instruct the physical layer to transmit a preamble using the selected PRACH resource, corresponding RA-RNTI, preamble index and PREAMBLE_TRANSMISSION_POWER.

### 5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted, the UE shall monitor the [PDCCH] in the TTI window [RA_WINDOW_BEGIN—RA_WINDOW_END] for Random Access Response(s). The UE may stop monitoring for Random Access Response(s) after successful reception of a Random Access Response corresponding to the Random Access Preamble transmission.

- If notification of a reception of the Random Access Response is received from lower layers, the UE shall:
    - if the Random Access Response contains a Random Access Preamble identifier corresponding to the transmitted Random Access Preamble (see subclause 5.1.3)
        - the UE shall:
            - consider this Random Access Response reception successful and provide an indication to the higher layers;
            - process the received Timing Alignment value (see subclause 5.2);
            - if an UL grant was received, process the UL grant value;
            - if the UE does not have a C-RNTI, Temporary C-RNTI shall be set to the value received in the Random Access Response message.

If no Random Access Response is received within the TTI window [RA_WINDOW_BEGIN—RA_WINDOW_END], or if all received Random Access Responses contain Random Access Preamble identifiers that do not match the transmitted Random Access Preamble, the Random Access Response reception is considered not successful and the UE shall:

- If the PREAMBLE_TRANSMISSION_COUNTER is less than PREAMBLE_TRANS_MAX
    - increment PREAMBLE_TRANSMISSION_COUNTER by 1;
    - [compute a backoff value indicating when a new Random Access transmission shall be attempted];
    - proceed to the selection of a Random Access Resource (see subclause 5.1.2).

- Else if PREAMBLE_TRANSMISSION_COUNTER is equal to PREAMBLE_TRANS_MAX
    - indicate to the higher layer that the random access procedure failed.

## 5.2 Maintenance of Uplink Time Alignment

The UE has a configurable Time Alignment Timer. The Time Alignment Timer is valid only in the cell for which it was configured and started.

If the Time Alignment Timer has been configured, the UE shall:

- when a Time Alignment Command is received:
    - apply the Time Alignment Command;
    - start the Time Alignment Timer (if it is not running) or restart the Time Alignment Timer (if it was already running)
- when the Time Alignment Timer has expired or is not running:
    - prior to any uplink transmission, use the Random Access procedure in order to obtain uplink Time Alignment
- when the Time Alignment Timer expires:
    - release all PUCCH resources.

## 5.3 DL-SCH data transfer

### 5.3.1 DL Assignment reception

When the UE has a C-RNTI, Temporary C-RNTI or RA-RNTI, the UE shall for each TTI during Active Time, for each TTI when a Random Access Response or Contention Resolution is expected and for each TTI for which a DL assignment has been configured:

- If a downlink assignment for this TTI has been received on the [PDCCH] for the UE's C-RNTI, Temporary C-RNTI or RA-RNTI:
    - Indicate a downlink assignment and the associated HARQ information to the HARQ entity for this TTI;
- else, if a downlink assignment for this TTI has been configured and a downlink assignment for this TTI has not been received on the [PDCCH] for the UE's C-RNTI, Temporary C-RNTI or RA-RNTI:
    - Indicate a downlink assignment, for a new transmission, and the associated HARQ information to the HARQ entity for this TTI;

When the UE needs to read BCCH, the UE shall:

- If a downlink assignment for this TTI has been received on the [PDCCH] for the [broadcast identity];
    - Indicate a downlink assignment for the dedicated broadcast HARQ process to the HARQ entity for this TTI;

NOTE: Downlink assignments for both C-RNTI and [broadcast identity] can be received in the same TTI

### 5.3.2 HARQ operation

NOTE: Additional optimisations (e.g. less adaptive/synchronous) are FFS

#### 5.3.2.1 HARQ Entity

There is one HARQ entity at the UE which processes the HARQ process identifiers indicated by the HARQ information associated with TBs received on the DL-SCH.

A number of parallel HARQ processes are used in the UE to support the HARQ entity. [The number of HARQ processes is FFS].

For a received TB the UE shall:

- If a downlink assignment has been indicated or configured for this TTI:
  - allocate the received TB to the HARQ process indicated by the associated HARQ information.

NOTE: In case of BCCH a dedicated broadcast HARQ process will be used

#### 5.3.2.2 HARQ process

The HARQ process processes the New Data Indicator (name FFS) indicated from the HARQ entity for each received MAC PDU.

The UE shall:

- if a new transmission is indicated for this HARQ process:
  - replace the data currently in the soft buffer for this HARQ process with the received data.
- if a retransmission is indicated for this HARQ process:
  - if the data has not yet been successfully decoded:
    - combine the received data with the data currently in the soft buffer for this HARQ process.
  - if the transport block size is different from the last valid transport block size signalled for this HARQ process:
    - the UE may replace the data currently in the soft buffer for this HARQ process with the received data.
- if the data in the soft buffer has been successfully decoded:
  - deliver the decoded MAC PDU to the disassembly and demultiplexing entity;
  - generate a positive acknowledgement (ACK) of the data in this HARQ process.
- else:
  - generate a negative acknowledgement (NACK) of the data in this HARQ process;
- if the HARQ process is associated with a transmission indicated with an RA-RNTI; or
- if the HARQ process is associated with a transmission indicated with a Temorary C-RNTI and a Random Access Identity match is not indicated; or
- if the HARQ process is equal to the broadcast process:
  - do not indicate the generated positive or negative acknowledgement to the physical layer
- otherwise
  - indicate the generated positive or negative acknowledgement to the physical layer.

### 5.3.3 Disassembly and demultiplexing

## 5.4 UL-SCH data transfer

### 5.4.1 UL Grant reception

The UE shall for each TTI:

- If an uplink grant for this TTI has been received on the [PDCCH]; or
- if an uplink grant for this TTI has been received in a Random Access Response:
    - Indicate a valid uplink grant and the associated HARQ information to the HARQ entity for this TTI;
- else, if an uplink grant for this TTI has been configured and an uplink grant for this TTI has not been received on the [PDCCH], nor in a Random Access Response:
    - Indicate an uplink grant, valid for new transmission, and the associated HARQ information to the HARQ entity for this TTI.

NOTE: The period of configured uplink grants is expressed in TTIs.

### 5.4.2 HARQ operation

NOTE: Whether resource allocation and modulation and coding scheme can be adapted for retransmissions is FFS.

#### 5.4.2.1 HARQ entity

There is one HARQ entity at the UE. A number of parallel HARQ processes are used in the UE to support the HARQ entity, allowing transmissions to take place continuously while waiting for the feedback on the successful or unsuccessful reception of previous transmissions.

At a given TTI, if an uplink grant is indicated for the TTI, the HARQ entity identifies the HARQ process for which a transmission should take place. It also routes the receiver feedback (ACK/NACK information), relayed by the physical layer, to the appropriate HARQ process.

The number of HARQ processes is equal to [X] [FFS]. Each process is associated with a number from 0 to [X-1].

At the given TTI, the HARQ entity shall:

- if an uplink grant, indicating a new transmission, is indicated for this TTI:
    - notify the "uplink prioritisation" entity that the TTI is available for a new transmission;
    - if the "uplink prioritisation" entity indicates the need for a new transmission:
        - obtain the MAC PDU to transmit from the "Multiplexing and assembly" entity;
        - instruct the HARQ process corresponding to this TTI to trigger the transmission of this new payload using the identified parameters.
    - else:
        - flush the HARQ buffer.
- else:
    - if an uplink grant, indicating a re-transmission, is indicated for this TTI; or
    - if the HARQ buffer of the HARQ process corresponding to this TTI is not empty:
        - instruct the HARQ process to generate a re-transmission.

NOTE: Adaptive retransmissions are 'sticky'; i.e., when parameters are modified for a retransmission, previous parameters no longer apply for subsequent retransmissions.

#### 5.4.2.2 HARQ process

Each HARQ process is associated with a HARQ buffer.

Each HARQ process shall maintain a state variable CURRENT_TX_NB, which indicates the number of transmissions that have taken place for the MAC PDU currently in the buffer. When the HARQ process is established, CURRENT_TX_NB shall be initialized to 0.

In case of dynamically scheduled transmissions, the UE is configured with a maximum number of transmissions that is identical across all HARQ Processes and all Logical Channels.

If the HARQ entity provides a new PDU, the HARQ process shall:

- set CURRENT_TX_NB to 0;
- set CURRENT_IRV to 0;
- store the MAC PDU in the associated HARQ buffer;
- generate a transmission as described below.

If the HARQ entity requests a re-transmission, the HARQ process shall:

- if an uplink grant for this was received on [PDCCH]:
    - set CURRENT_IRV to the value indicated in the uplink grant;
- generate a transmission as described below.

To generate a transmission, the HARQ process shall:

- instruct the physical layer to generate a transmission with the redundancy version corresponding to the CURRENT_IRV value and the transmission timing;
- if CURRENT_IRV < [Y] [FFS]:
    - increment CURRENT_IRV by 1;
- increment CURRENT_TX_NB by 1;

The HARQ process shall:

- if a HARQ ACK is received; or
- if CURRENT_TX_NB ≥ maximum number of transmissions configured:
    - flush the HARQ buffer.

The HARQ process shall also:

- if CURRENT_TX_NB = maximum number of transmissions configured; and
- no HARQ ACK is received for this process:
    - notify the relevant ARQ entities in the upper layer that the transmission of the corresponding RLC PDUs failed.

## 5.4.3 Multiplexing and assembly

### 5.4.3.1 Logical channel prioritization

The Logical Channel Prioritization procedure shall be applied when a new transmission is performed.

RRC can control the scheduling of uplink data by giving each logical channel a priority where increasing priority values indicate lower priority levels. In addition, each logical channel is given a Prioritized Bit Rate (PBR) and optionally, a Maximum Bit Rate (MBR) is also provided. The Logical Channel Prioritization procedure ensures that the UE serves the logical channels in the following sequence:

- All the logical channels are served in a decreasing priority order up to their configured PBR;
- if any resources remain, all the logical channels are served in a strict decreasing priority order up to their configured MBR. In case no MBR is configured the logical channel is served until either the data for that logical channel or the UL grant is exhausted, whichever comes first.

Logical channels configured with the same priority shall be served equally the by UE.

#### 5.4.3.2 Multiplexing of MAC SDUs

### 5.4.4 Scheduling Request

The Scheduling Request is for requesting UL resources.

If a Scheduling Request is triggered, the UE shall, for each TTI:

- If no UL resources were allocated in this TTI, and Scheduling Request has been mapped on PUCCH, instruct the physical layer to signal the Scheduling Request on PUCCH;

- If no UL resources were allocated in this TTI and Scheduling Request has not been mapped on PUCCH, instruct the Random Access procedure (see subclause 5.1) to initiate a Random Access procedure.

A triggered Scheduling Request shall be considered pending until UL resources are granted.

### 5.4.5 Buffer Status reporting

The Buffer Status reporting procedure is used to provide the serving eNB with information about the amount of data in the UL buffers of the UE.

A Buffer Status report shall be triggered if any of the following events occur:

- UL data arrives in the UE transmission buffer and the data belongs to a logical channel group with higher priority than those for which data already existed in the UE transmission buffer;

- UL resources are allocated and number of padding bits is larger than the size of the [Short/Long] Buffer Status Report MAC control element;

- a serving cell change occurs.

If the Buffer Status reporting procedure determines that a Buffer Status report is pending:

- if the UE has UL resources allocated for this TTI, instruct the Multiplexing and Assembly procedure to generate a [Short/Long] Buffer Status Report MAC control element;

- else:

    - a Scheduling Request shall be triggered

NOTE: Even if multiple events occur by the time a Buffer Status Report can be transmitted, only one Buffer Status Report will be included in the MAC PDU.

A pending Buffer Status report is cancelled in case the UL grant can accommodate all pending data but is not sufficient to accommodate the [Short/Long] Buffer Status Report MAC control element in addition.

## 5.5 PCH reception

When in RRC_IDLE, the UE shall at its paging occasions:

- If a PCH assignment has been received on the [PDCCH] with the Paging RNTI:

    - attempt to decode the TB on the PCH as indicated by the [PDCCH] information;

- If a TB on the PCH has been successfully decoded:

    - deliver the decoded MAC PDU to higher layers.

## 5.6 BCH reception

When the UE needs to receive BCH, the UE shall:

- receive and attempt to decode the BCH;
- if a TB on the BCH has been successfully decoded:
    - deliver the decoded MAC PDU to higher layers;

## 5.7 Discontinuous Reception (DRX)

The UE may be configured [by RRC/MAC] with a DRX functionality that allows it to stop monitoring PDCCH during some period of time.

The DRX functionality consists of a Long DRX cycle, a DRX Inactivity Timer, a DRX Retransmission Timer and optionally a Short DRX Cycle and a DRX Short Cycle Timer all defined in subclause 3.1.

When a DRX cycle has been configured, the UE shall for each TTI:

- Whenever a new DRX Cycle begins, the On Duration Timer is started.
- If a DL assignment has been configured for this TTI start the HARQ RTT Timer.
- If the On Duration Timer or DRX Inactivity Timer or DRX Retransmission Timer is running; or
- if an UL grant for a retransmission can occur:
    - UE shall monitor the PDCCH;
    - if the PDCCH is successfully decoded:
        - if the PDCCH indicates a DL transmission:
            - start the HARQ RTT Timer.
        - If On Duration Timer or DRX Inactivity Timer is running and the PDCCH indicates a new transmission:
            - start or restart the DRX Inactivity Timer.
- If the DRX Inactivity Timer expires in this TTI:
    - start DRX Short Cycle Timer if configured;
    - use the short DRX cycle if configured else use the long DRX cycle.
- If DRX Short Cycle Timer or the On Duration Timer expires in this TTI:
    - use the long DRX cycle.
- If HARQ RTT Timer expires in this TTI:
    - UE shall start or restart the DRX Retransmission Timer.

Regardless of whether the UE is monitoring PDCCH or not the UE receives and transmits HARQ feedback when such is expected.

## 5.8 MAC reconfiguration

## 5.9 MAC Reset

## 5.X Handling of unknown, unforeseen and erroneous protocol data

# 6 Protocol Data Units, formats and parameters

## 6.1 Protocol Data Units

### 6.1.1 General

### 6.1.2 MAC PDU (DL-SCH and UL-SCH)

A MAC PDU consists of a MAC header, zero or more MAC Service Data Units (MAC SDU), zero, or more MAC Control elements, and optionally padding; as described in figure 6.1.2-3.

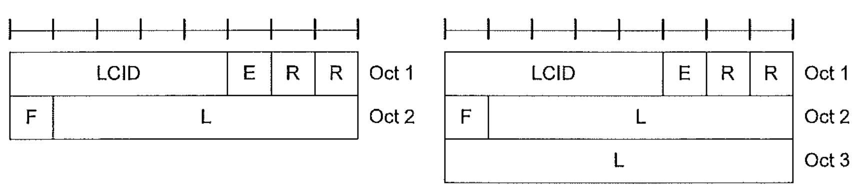
Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one or more MAC PDU sub-headers; each sub-header corresponding to either a MAC SDU, a MAC Control element or padding.

A MAC PDU sub-header corresponding to a MAC SDU consists of the six header fields LCID/E/R/R/F/L (as described in figure 6.1.2-1) but for the last sub-header in the MAC PDU which consists solely of the four header fields LCID/E/R/R (as described in figure 6.1.2-2).

A MAC PDU sub-header corresponding to a MAC Control element consists of the six header fields LCID/E/R/R/F/L but for the last sub-header in the MAC PDU and for fixed sized MAC Control elements which consist solely of the four header fields LCID/E/R/R.

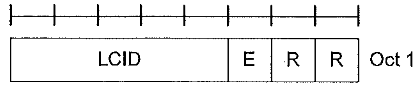
A MAC PDU sub-header corresponding to padding consists of the four header fields LCID/E/R/R.




LCID/E/R/R/F/L sub-header with 7-bits L field

LCID/E/R/R/F/L sub-header with 15-bits L field

Figure 6.1.2-1: LCID/E/R/R/F/L MAC sub-header




LCID/E/R/R sub-header

**Figure 6.1.2-2: LCID/E/R/R MAC sub-header**

MAC PDU sub-headers have the same order as the corresponding MAC SDUs, MAC Control elements and padding.

MAC Control elements are always placed before any MAC SDU and padding occurs at the end of the MAC PDU.

A maximum of one MAC PDU can be transmitted per TB per UE. [Depending on the physical layer category], one or two TBs can be transmitted per TTI per UE.

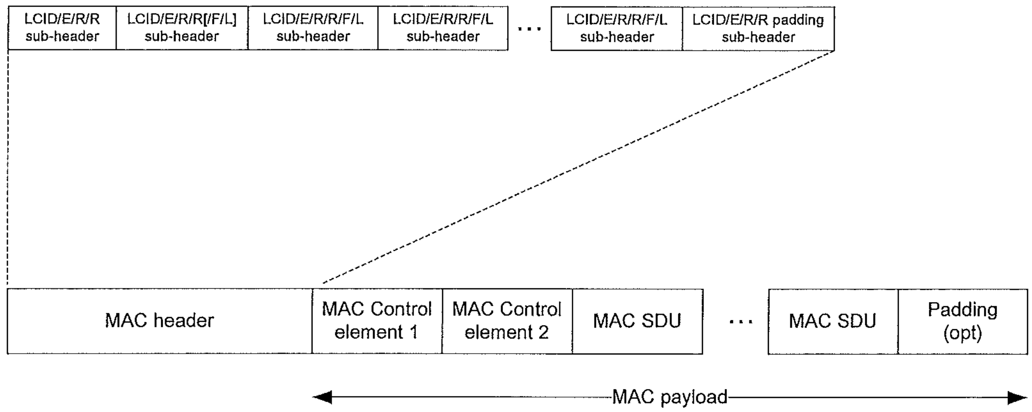



**Figure 6.1.2-3: MAC PDU consisting of MAC header, MAC Control elements, MAC SDUs and padding**

## 6.1.3 MAC Control Elements

### 6.1.3.1 Buffer Status Report Control Elements

Buffer Status Report (BSR) Control Elements consist of either:

- Short BSR format: one LCG ID field and one corresponding BS field (figure 6.1.3.1-1); or
- Long BSR format: four Buffer Size fields, corresponding to LCG IDs #1 through #4 (figure 6.1.3.1-2).

The BSR formats are identified by MAC PDU subheaders with LCIDs as specified in table 6.2.1.-1.

The fields LCG ID and BS are defined as follow:

- LCG ID: The Logical Channel Group ID field identifies the group of logical channel(s) which buffer status is being reported. The length of the field is 2 bits.

- Buffer Size: The Buffer Size field identifies the total amount of data available across all logical channels of a logical channel group after the MAC PDU has been built. The amount of data is indicated in number of bytes. The length of this field is 6 bits. The values taken by the Buffer Size field are shown in [Table 6.1.2.1-1].

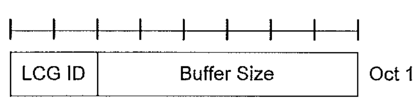



**Figure 6.1.3.1-1: Short Buffer Status MAC control element**

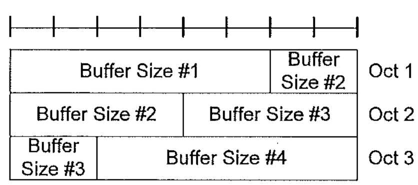



**Figure 6.1.3.1-2: Long Buffer Status MAC control element**

## 6.2 Formats and parameters

### 6.2.1 MAC header for DL-SCH and UL-SCH

The MAC header is of variable size and consists of the following fields:

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC Control element or padding as described in tables 6.2.1-1 and 6.2.1-2 for the DL and UL-SCH respectively. There is one LCID field for each MAC SDU, MAC Control element or padding included in the MAC PDU. The LCID field size is 5 bits.
- L: The Length field indicates the length of the corresponding MAC SDU or MAC Control element in bytes. There is one L field per MAC SDU included in the MAC PDU except for the last MAC SDU. For MAC Control elements, the presence of an L field depends on the type of MAC Control element. The size of the L field is indicated by the F field.
- F: The Format field indicates the size of the Length field as indicated in table 6.2.1-3. There is one F field per MAC SDU included in the MAC PDU except for the last MAC SDU. The size of the F field is 1 bit.
- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate another set of at least LCID/E/R/R fields. The E field is set to "0" to indicate that either a MAC SDU, a MAC control element or padding starts at the next byte
- R: Reserved bits.

The MAC header and sub-headers are octet aligned.

**Table 6.2.1-1 Values of LCID for DL-SCH;**

| Index | LCID values |
|---|---|
| 00000-xxxxx | Identity of the logical channel |
| xxxxx-11011 | reserved |
| 11100 | [RACH Message 2] |
| 11101 | [Timing Advance] |
| 11110 | [DRX] |
| 11111 | Padding |

**Table 6.2.1-2 Values of LCID for UL-SCH;**

| Index | LCID values |
|---|---|
| 00000-yyyyy | Identity of the logical channel |
| yyyyy-11100 | reserved |
| 11101 | Short Buffer Status Report |
| 11110 | Long Buffer Status Report |
| 11111 | Padding |

**Table 6.2.1-3 Values of F field:**

| Index | Size of Length field (in bits) |
|---|---|
| 0 | 7 |

1 15

# 7 Variables and constants

# Annex A (informative): Change history

| Change history | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 2007-06 | RAN2#58 bis | R2-072710 | | | MAC Protocol Specification Baseline | - | |
| 2007-06 | RAN2#58 bis | R2-072912 | | | Text Proposal for UL HARQ (Tdoc R2-072708)<br>Text Proposal for DL HARQ (Tdoc R2-072707)<br>Text Proposal for RACH procedure (Tdoc R2-072640)<br>Text Proposal for Logical Channel prioritization (Tdoc R2-072643) | | 0.1.0 |
| 2007-06 | RAN2#58 bis | R2-072994 | | | Basic MAC PDU structure (Tdoc R2-072983) with updates<br>Agreements on time-frequency resource configuration (Tdoc R2-072993)<br>Agreement on RA-RNTI association (Tdoc R2-072993)<br>Clarification on RA Response reception (Tdoc R2-072993) | 0.1.0 | 0.1.1 |
| 2007-08 | RAN2#59 | R2-073715 | | | Removed reference to non-existing table (Tdoc R2-073473)<br>Incorrect mapping of logical to transport channel (Tdoc R2-073473)<br>Un-necessary error checking in HARQ process procedure (Tdoc R2-073473)<br>Removal of reference to timing relation for HARQ feedback (Tdoc R2-073473)<br>Correction of Internal variable name (Tdoc R2-073473)<br>Correction of procedure in case of successful HARQ reception (Tdoc R2-073473) | 0.1.1 | 0.2.0 |
| 2007-09 | RAN2#59 | R2-073885 | | | Text proposal for Random Access procedure<br>Text proposal on HARQ clarification for TDD<br>Text proposal on HARQ for grants | 0.2.0 | 0.2.1 |
| 2007-09 | RAN#37 | RP-070688 | | | Clean version for information | 0.2.1 | 1.0.0 |
| 2007-10 | RAN2#59 bis | R2-074530 | | | Editorial update with Editor's notes (Tdoc R2-074211). | 1.0.0 | 1.1.0 |
| 2007-11 | RAN2#60 | R2-075093 | | | Agreements on MAC PDU format (R2-074536)<br>Corrections on Random Access Procedure (R2-074536) | 1.1.0 | 1.1.1 |
| 2007-11 | RAN2#60 | R2-075243 | | | Endorsement of v1.1.1<br>Removal of FFS on DL CCCH existence | 1.1.1 | 1.2.0 |
| 2007-11 | RAN2#60 | R2-075488 | | | Agreement on identity used Random Access Response (R2-075038)<br>Agreement on Local Nack1 (R2-074949)<br>PUCCH Resource handling (R2-075432)<br>UL HARQ agreements (R2-075432)<br>Agreements on semi-persistent scheduling (R2-075432, 36.300)<br>Agreements on BSR/SR triggers (R2-075432)<br>Agreements on BSR contents (R2-075432)<br>Agreements on Timing Advance principles (36.300)<br>Agreements on DRX control (36.300)<br>Handling of P-BCH, D-BCH, PCH (R2-075246) | 1.2.0 | 1.3.0 |
| 2007-11 | RAN#38 | RP-070917 | | | Clean version, presented at TSG RAN-38 for approval | 1.3.0 | 2.0.0 |
| 2007-12 | RAN#38 | - | | | Approved at TSG RAN-38 and placed under change control | 2.0.0 | 8.0.0 |

Trials@uspto.gov
571-272-7822

Paper 12
Entered: May 1, 2015

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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SECURUS TECHNOLOGIES, INC.,
Petitioner,

v.

GLOBAL TEL*LINK CORPORATION,
Patent Owner.

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Case IPR2015-00153
Patent 7,783,021 B2

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Before KEVIN F. TURNER, BEVERLY M. BUNTING, and PATRICK M. BOUCHER, *Administrative Patent Judges*.

BOUCHER, *Administrative Patent Judge*.

# DECISION
Denying Institution of *Inter Partes* Review
*37 C.F.R. § 42.108*

On October 24, 2014, Securus Technologies, Inc. ("Petitioner") filed a Petition (Paper 1, "Pet.") pursuant to 35 U.S.C. §§ 311–319 to institute an *inter partes* review of claims 1–23[1] of U.S. Patent No. 7,783,021 B2 ("the '021 patent"). Global Tel*Link Corporation ("Patent Owner") filed a Preliminary Response (Paper 10, "Prelim. Resp.") on February 5, 2015. Applying the standard set forth in 35 U.S.C. § 314(a), which requires demonstration of a reasonable likelihood that Petitioner would prevail with respect to at least one challenged claim, we deny the Petition and decline to institute an *inter partes* review.

## I. BACKGROUND

### *A. The '021 Patent*

The application for the '021 patent was filed on January 28, 2005, and relates to telephone communication systems in penal institutions or similar facilities. Ex. 1001, col. 1, ll. 6–8. Figure 1 of the '021 patent is reproduced below.

[1] The Petition's statement at page 1 that Petitioner "requests *inter partes* review of claims 1-*27*" (emphasis added) appears to be a typographical error. The '021 patent only has 23 claims.

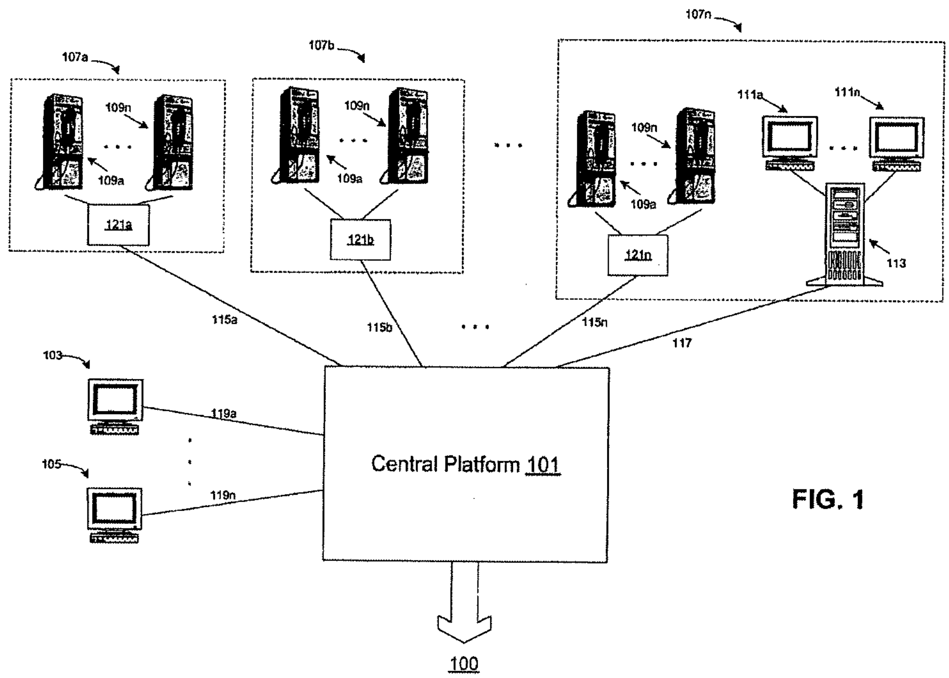


FIG. 1

Figure 1 is a block diagram illustrating a centralized setup of a call-management system over a public switched telephone network ("PSTN"). *Id.* at col. 15, ll. 59–62. Central call platform 101 connects to routers 121*a*–*n* at sites 107*a*–*n* via connections 115*a*–*n*. *Id.* at col. 15, ll. 62–64. Sites 107*a*–*n* contain telephonic instruments 109*a*–*n* and may contain workstations 111*a*–*n* connected to server 113 as illustrated for site 107*n*. *Id.* at col. 15, l. 65 – col. 16, l. 2. In addition to other functions, administrative workstation 105 can use a live operator or software to monitor calls without detection. *Id.* at col. 17, ll. 8–22. Investigative workstation 103 controls monitoring and security features. *Id.* at col. 17, ll. 38–40.

### *B. Illustrative Claim*

Claim 1 of the '021 patent is illustrative of the claims at issue:

1. An inmate telecommunication call processing system comprising:

a plurality of trunk lines of a Public Switched Telephone Network (PSTN);

at least one telephone terminal for making a telephone call, wherein said telephone terminal is located onsite at an institution;

a central platform coupled to said plurality of trunk lines and coupled to said at least one telephone terminal for said telephone call,

wherein said central platform is located offsite from said institution, and

further wherein said central platform comprises one or more apparatuses for processing said telephone call;

an administrative workstation for connecting to a said telephone terminal to monitor conversations between said institution without detection by said user; and

at least one routing means coupled to said telephone terminal and said central platform;

wherein said one or more apparatuses controls telephonic communication between said at least one telephone terminal and said plurality of trunk lines,

wherein said one or more apparatuses records said conversations in said telephone call between a user associated with said at least one telephone terminal and an external party, and

further wherein said one or more apparatuses digitizes audio and stores said audio for caller identification at said institution, and

further wherein said one or more apparatuses communicates with an administrative workstation for billing regarding said telephone call originating from said institution.

### *C. Asserted Ground of Unpatentability*

Petitioner challenges claims 1–23 as anticipated by U.S. Patent No. 7,881,446 B1 (Ex. 1002, "Apple").

### *D. Related Proceedings*

Petitioner states that the '021 patent is the subject of the following civil action: *Global Tel*Link Corp. v. Securus Technologies, Inc.*, Civil Action 3:14-cv-0829-K (N.D. Tex.). Pet. 1. In addition, Petitioner identified additional petitions challenging the patentability of a certain subset of claims in the following patents owned by Patent Owner: U.S. Patent No. 7,551,732 (Case IPR2015-00156) and U.S. Patent No. 7,853,243 (Case IPR2015-00155). *Id.*

## II. ANALYSIS

The first, and dispositive, question we must resolve is whether Petitioner establishes that the disclosure of Apple relied upon to prove anticipation is prior art. Apple was filed on September 2, 2005, and claims the benefit of the filing date of several provisional applications under 35 U.S.C. § 119(e): (1) Appl. No. 60/607,447, filed September 3, 2004; (2) Appl. No. 60/676,155, filed April 29, 2005; (3) Appl. No. 60/676,153, filed April 29, 2005; (4) Appl. No. 60/676,151, filed April 29, 2005; (5) Appl. No. 60/676,154, filed April 29, 2005; and (6) Appl. No. 60/676,152, filed April 29, 2005. *Id.* at col. 1, ll. 6–20. Of these six provisional applications, only one—Appl. No. 60/607,447 (Ex. 1005, "the '447 application")—was filed before the January 28, 2005, filing date of the ’021 patent. Accordingly, Apple is prior art only to the extent that its content is supported by disclosure of the ’447 application in a manner that complies with 35 U.S.C. § 112, first paragraph. *See* 35 U.S.C. §§ 102(e), 119(e)(1); *see Ex parte Yamaguchi*, 88 USPQ2d 1606, 1609 (BPAI 2008) (precedential); *see Square, Inc. v. REM Holdings 3, LLC*, Case IPR2014-00312, slip op. at 20–21 (PTAB July 10, 2014) (Paper 12).

Petitioner asserts that "[a]ll subject matter of [Apple] is supported by [the ’447 application]." Pet. 9 (citing Ex. 1003 ¶ 56). Petitioner provides no analysis to support this assertion, but cites the declaration testimony of Dr. Robert Akl, who attests that "[b]ased on my review, all subject matter of [Apple] is supported by [the ’447 application]." Ex. 1003 ¶ 56. Dr. Akl neither explains the criteria he applied in making that determination nor provides any analysis to support his conclusion.

Petitioner's analysis of its challenge against claims 1–23 relies solely on the disclosure of Apple, without explaining how the specific disclosures it relies upon are supported by the ’447 application. Indeed, as Patent Owner correctly observes, "the Petition does not provide a single citation to the ’447 [application]." Prelim. Resp. 7. We agree with Patent Owner that Petitioner has the burden of demonstrating that Apple qualifies as prior art under 35 U.S.C. § 102(e). *See id.* 8–9 (citing 37 C.F.R. § 42.20(c); *Cisco Sys., Inc. v. Constellation Techs. LLC*, Case IPR2014-00914, slip op. at 23 (PTAB Jan. 2, 2015) (Paper 11); *Marvell Semiconductor, Inc. v. Intellectual Ventures I LLC*, Case IPR2014-00547, slip op. at 10 (PTAB Dec. 3, 2014)

(Paper 17); *Butamax Advanced Biofuels LLC v. Gevo, Inc.*, Case IPR2013-00539, slip op. at 18 (PTAB Mar. 4, 2014) (Paper 9)). We do not credit Dr. Akl's testimony that all subject matter of Apple is supported by the '447 application. That testimony is conclusory in nature and entitled to little, if any, weight.

Patent Owner observes that the '447 application includes 34 pages of text, 10 sheets of drawings, and over 600 pages of exhibits, while Apple includes 19 sheets of drawings and more than 42 columns of text. Prelim. Resp. 13. "Of the drawings, FIGS. 10-18 of Apple were not disclosed in the '447 [application]." *Id.* Although it is not a requirement that the drawings be reproduced in identical form, neither the Petition nor the testimony of Dr. Akl explains how the content of those drawings is otherwise supported by the '447 application.

In addition, our review of Petitioner's analysis raises specific concerns regarding the accuracy of Dr. Akl's conclusion when applied to particular claim limitations. For example, independent claim 1 recites "an administrative workstation for connecting to a said telephone terminal to monitor conversations between said institution without detection by said user." Independent claims 7, 16, and 20 include similar limitations. Dr. Akl identifies Figure 5 of Apple, as "explained further in the specification," as disclosing the limitations. Ex. 1003 ¶ 83. The paragraph at column 8, lines 35–44 of Apple is among those relied on by Dr. Akl as providing such further explanation. *Id.* at ¶ 84. The Petition repeats the same analysis. Pet. 26–27. The cited paragraph does not appear to be reproduced verbatim in the '447 application, and Petitioner does not explain what portions of the '447 application provide specific support.

It is incumbent upon Petitioner to "specify where each element of the claim is found in the prior art patents or printed publications relied upon." 37 C.F.R. § 42.104(b)(4). When the qualification of a reference as prior art depends on the existence of adequate support in another reference, this mandate requires that Petitioner explain where such support for its challenge can be found. "A brief must make all arguments accessible to the judges, rather than ask them to play archaeologist with the record." *DeSilva v. DiLeonardi*, 181 F.3d 865, 867 (7th Cir. 1999).

Because Petitioner fails to demonstrate that all parts of Apple relied on for its challenge to claims 1–23 are prior art to the '021 patent, we conclude that Petitioner has not demonstrated a reasonable likelihood of prevailing on that challenge.

## III. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that the Petition is *denied* and no *inter partes* review is instituted.

IPR2015-00153
Patent 7,783,021 B2

for PETITIONER

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