would be an IRA encoder, right? 02:52:25
A. I have formed no opinion with respect to how IRA codes are defined in the actual patents. But, let's say, as a casual observer taking some very vaguely specified form of what IRA codes might be, that could be perhaps an interpretation. 02:52:29 02:52:32 02:52:35 02:52:41 02:52:44
Q. Okay. That would be an IRA code as you've used it in your report, right? 02:52:47 02:52:49
A. This would require a lot of assumptions in mappings between the two pictures. So I'm not claiming that this cannot be done. But this would require a very specific set of assumptions on how these numbers or how these pictures relate to. 02:52:51 02:52:55 02:52:58 02:53:02 02:53:06
Q. Now, back in '99 and 2000, what group were you in of the classic code theorists versus the computer science physicists? 02:53:12 02:53:44 02:53:51
A. In my Ph.D., most of my work related to questions of information theory. Information theory is kind of the abstract level of coding. So information theory sets limits of what can be done or not. 02:53:53 02:54:01 02:54:05 02:54:08 02:54:11
And coding can be viewed as the kind of more applied practical way of how to actually accomplish these limits. My background is in EE. I was hired into Bell Labs into what was called the 02:54:12 02:54:15 02:54:19 02:54:24

mathematics of communications group. 02:54:28
So this was a mix, people of somewhat a mix of backgrounds, most of them would have an EE background. But, for example, some people might have had a math -- math background as, for example, in the case of Dr. Shokrollahi, who got hired at some point and -- 02:54:31 02:54:34 02:54:39 02:54:41 02:54:44 02:54:44
THE REPORTER: Wait. State that last part over. 02:54:44 02:54:50
THE WITNESS: Some people might have had a math background, as was the case, I believe, for Dr. Shokrollahi, who, I think, I believe, got his degree in mathematics or perhaps computer science, but I think it was mathematics. 02:54:50 02:54:52 02:54:57 02:54:59 02:55:03
BY MR. DOWD: 02:55:07
Q. So the Luby group was -- was in the computer science and physicists group? 02:55:09 02:55:13
A. No. The Luby group was squarely in the theoretical computer science and math group. There were various physics groups. David MacKay might be considered, to some degree, part of the physics group. But there were also other people working in physics being interested in these topics. 02:55:16 02:55:21 02:55:28 02:55:31 02:55:34 02:55:37
Q. And what was -- what group would you place Divsalar in? 02:55:39 02:55:42

A. I would say he was working at JPL, if I'm not mistaken, so he would be probably considered towards the standard classical coding group with EE backgrounds. 02:55:48 02:55:51 02:55:55 02:56:03

THE REPORTER: If we -- I'm sorry. 02:56:03

THE WITNESS: With EE backgrounds. Electric engineering. 02:56:03 02:56:03

BY MR. DOWD: 02:56:05

Q. Okay. So you were in the classical coding EE background group, right? 02:56:05 02:56:09

A. My group was mixed. I myself, have that background. But in -- within Bell Labs, that group was mixed. 02:56:12 02:56:16 02:56:24

Q. And Divsalar would have been in the same group as you the way that you've divided the world? 02:56:25 02:56:28

A. He has this -- sorry. I would assume without knowing exactly his training that he is trained more classically with EE background. 02:56:32 02:56:35 02:56:38

Q. But Dr. MacKay would have been in a different group, according to the way you're looking at the world, right? 02:56:42 02:56:47 02:56:49

A. Dr. MacKay played a special role because I believe he was either a student or -- or postdoc of Bob McEliece. He has a background in physics but had strong connections to this group in -- at 02:56:50 02:56:54 02:57:00 02:57:03

Caltech and at JPL. 02:57:06
Q. But all of the groups, yourself, Dr. MacKay, Dr. Luby, were looking at irregular LDPC codes, right? 02:57:08 02:57:14 02:57:20
A. I became aware of irregular LDPC codes via Dr. Shokrollahi when he got hired, I believe it was in '99 or perhaps late '98, whenever it was that he got hired. That's when I learned about the work of Luby and that group. 02:57:21 02:57:27 02:57:30 02:57:34 02:57:40
Q. My question was, all of you were looking at irregular LDPC codes, correct? 02:57:42 02:57:45
A. In a very specified sequence of timed events which had to do with how people got connected. 02:57:50 02:57:53 02:57:56
Q. And your Richardson '99 paper, that was before Dr. Shokrollahi got hired at Bell Labs? 02:57:56 02:57:59
A. No. 02:58:02
Q. So he was already there by that point? 02:58:02
A. He's there or must have had visited. I don't know if he was already permanently hired or not. But we had met him. That's how we learned about these works from Luby. 02:58:05 02:58:08 02:58:10 02:58:13
Q. Okay. And that paper was in March of 1999, right? 02:58:14 02:58:18
A. Which paper? 02:58:18

Q. Your Richardson '99 paper. 02:58:19
A. I -- I don't know the exact date. I have seen a preprint which dates April '99. 02:58:23 02:58:25
Q. Okay. So April-ish 1999? 02:58:30
A. Yes. I don't know if that was, you know, the exact inception date. It's a preprint that differs from the final 2001 version in some fairly substantial ways. 02:58:32 02:58:35 02:58:38 02:58:43
Q. So at least as of April 1999, you knew about Luby, right? 02:58:44 02:58:49
A. Yes. 02:58:50
Q. You knew about Divsalar, right? 02:58:50
A. I would believe so, yes. 02:58:53
Q. And you also knew, obviously, about your own paper, the Richardson '99 paper? 02:58:55 02:58:58
A. Yes. 02:59:03
Q. Okay. And at that point, if we go back to the MacKay Ambleside '99 paper, you would have been aware of his work as well, right? 02:59:04 02:59:10 02:59:15
A. I'm pretty sure that I was not at the Ambleside conference. And I'm not sure to what degree I was aware of that paper that you showed me in exhibit -- the Ambleside paper, whatever -- whatever exhibit that was. 02:59:17 02:59:22 02:59:25 02:59:29 02:59:38
Q. I believe it was Exhibit 15. 02:59:40

A. 15, perhaps. 02:59:42
Q. Let's go back to Luby '97, which I think is Exhibit 9. 02:59:44 02:59:52
Are you familiar with something called a low-density generator matrix? 02:59:57 03:00:00
A. Yes. 03:00:02
Q. If I refer to that as an "LDGM," will that make sense? 03:00:02 03:00:07
A. Yes. 03:00:08
Q. Low-density means that the matrix is sparse, right? 03:00:08 03:00:12
A. Yes, that's correct. 03:00:13
Q. And that means that it has relatively few 1s, mostly 0s, right? 03:00:14 03:00:21
A. That is correct. 03:00:22
Q. It's called a generator matrix because it's used to generate check bits, right? 03:00:22 03:00:25
A. It's -- yes, that is correct. 03:00:28
Q. And the way it works is that you multiply the information bits by the matrix to get parity check bits, right? 03:00:32 03:00:35 03:00:41
A. That is correct. So you multiply your information bit and -- with the matrix and whatever you get out would actually represent the code word that you're then transmitting. 03:00:42 03:00:44 03:00:47 03:00:50

Q. And we said earlier that that code word would be comprised of parity check bits, right? 03:00:55 03:00:58
A. You could consider that. Typically you would simply call it the code word. 03:01:03 03:01:06
Q. Let's turn to page, using the Bates pages along the bottom, Khandekar -- 03:01:14 03:01:17
A. Okay. Which exhibit are we talking about? 03:01:22
Q. Oh, Exhibit 9. Do you have that? 03:01:24
A. Yes. 03:01:28
Q. So Bates page is 937 of the Luby '97 reference. 03:01:31 03:01:38
A. Yes. 03:01:38
Q. So on the left column there, there's a statement in the second full paragraph, the paragraph that begins: 03:01:39 03:01:51 03:01:53
"It's a challenge." 03:01:54
Do you have that paragraph? 03:01:55
A. Yes. 03:01:56
Q. In there the second sentence says: 03:01:56
"In this paper we present codes that can be encoded and decoded in linear time while providing near optimal loss protection." 03:01:59 03:02:00 03:02:04 03:02:07
Do you see that there? 03:02:08
A. Yes. 03:02:08

Q. What does it mean to encode in linear time? 03:02:08 03:02:12
A. What they meant in that paper was that if you take the block length of the code, which sometimes is referred to as N, and if you look at a family of such codes where N is varied and might take on different values, that the effort that is needed to do either the encoding or do the decoding would be a linear function of that parameter N. 03:02:12 03:02:15 03:02:18 03:02:25 03:02:30 03:02:34 03:02:40
So perhaps if you had an input that was only 100 long, it would take you, let's say, just 100 operations, to keep it simple. But if you had an input that was a thousand long, then it would take you thousands. So it would be proportional to the length of the input. 03:02:45 03:02:47 03:02:50 03:02:54 03:02:57 03:03:00
Q. And that's the same explanation of an encoding and decoding in linear time that you give in your report, right? 03:03:01 03:03:06 03:03:10
A. Yes. 03:03:11
Q. Now, if we go over to the right column -- 03:03:16
A. Yes. 03:03:22
Q. -- the last full paragraph in the right column that begins: 03:03:22 03:03:24
"Our encoding." 03:03:27
Do you have that? 03:03:29

A. The last -- sorry. The last on the right column... 03:03:29 03:03:32
"Our analytical tools"? Sorry. 03:03:32
Q. The one above that, that is our encoding -- 03:03:36 03:03:36
THE REPORTER: Wait. Wait. Wait. One at a time. Start again. 03:03:36 03:03:41
THE WITNESS: The paragraph: 03:03:41
"Our encoding and decoding algorithm." 03:03:42
Yes, I see that paragraph. 03:03:45
BY MR. DOWD: 03:03:47
Q. Okay. It says: 03:03:47
"Our encoding and decoding algorithms are almost symmetrical." 03:03:48 03:03:50
Do you see that? 03:03:52
A. Yes. 03:03:53
Q. What does it mean for the encoding and decoding to be symmetrical? 03:03:53 03:03:56
A. What they mean in this paper is that they use a similar type of operations to perform both, and that's what is meant with "almost symmetrical." 03:03:58 03:04:03 03:04:10
Q. Okay. In Luby the encoding is irregular, right? 03:04:13 03:04:27
A. In -- you're talking about this particular paper, Luby '97? 03:04:27 03:04:30

Q. Correct. 03:04:32
A. What do you mean with encoding is irregular? You mean whether the code is an irregular code? 03:04:34 03:04:36 03:04:38
Q. Well, let me start there. 03:04:42
In Luby '97 the code is an irregular code, correct? 03:04:44 03:04:46
A. It is a very particularly hierarchically structured code in which some of the nodes have irregular degrees, yes. 03:04:46 03:04:51 03:04:55
Q. Okay. And that means that when you're performing an encoding it's an irregular encoding, right? 03:04:57 03:05:01 03:05:07
A. It's not quite clear to me what do you mean by that. 03:05:07 03:05:09
Q. That doesn't make sense to you? 03:05:10
A. No. 03:05:12
Q. Okay. Now, if we continue in the right column, same paragraph, Page 937, it states: 03:05:13 03:05:25
"As in many similar applications, the graph is chosen to be sparse, which immediately implies that the encoding and decoding algorithms are fast." 03:05:29 03:05:31 03:05:34 03:05:37
Do you see that? 03:05:41
A. Sorry, are we still on the same page? 03:05:41

Q. Yes. 03:05:44
A. On the right -- oh, the next sentence. 03:05:45
Q. "As in many similar applications." 03:05:48
A. Sorry, I just -- just hold on a second. 03:05:51
Oh, I see: Both are extremely simple computing exactly -- okay. 03:05:56 03:05:59
"As in many similar applications -- " 03:06:00
Q. Uh-huh. 03:06:02
A. " -- the graph is chosen to be sparse, which immediately implies that the encoding and decoding algorithms are -- " 03:06:03 03:05:34 03:05:37
THE REPORTER: Wait. Wait. If you're going to read into the record, you have to read it clearly and slowly. 03:05:37 03:05:37 03:05:37
THE WITNESS: 03:05:37
"As in many similar applications, the graph is chosen to be sparse, which immediately implies that the encoding and decoding algorithms are fast." 03:06:12 03:06:15 03:06:18 03:06:21
BY MR. DOWD: 03:06:23
Q. And that reference to "sparse," that refers to what we were talking about earlier about there are few 1s, many 0s? 03:06:23 03:06:28 03:06:31
A. That is correct. 03:06:35
Q. And so in Luby '97 you use a low-density 03:06:36

generator matrix as a part of this code, right? 03:06:44
A. Part of these codes can be interpreted as a low-density generated. 03:06:46 03:06:48
Q. Okay. 03:06:50
A. And part would be an LDPC. 03:06:50
Q. And on encoding side, it's the LDGM, correct? 03:06:52 03:06:58
A. Both are, in fact, used. Both the LDGM and the LDPC. The reason they still construct codes that have low or linear time encoding complexity is that they have so many layers in the hierarchical structure. So imagine that like a pyramid, that the LDPC, which sits kind of at the very end of the pyramid at the top, has a size that is, at most, square root of the total block length. 03:06:58 03:07:02 03:07:05 03:07:12 03:07:16 03:07:20 03:07:23 03:07:27
And so even though that part has a decoding complexity to which is quite erratic, the overall effect it has, since it only have size which is linear of the overall part, gives you still something that's linear in the overall block length. 03:07:30 03:07:33 03:07:35 03:07:40 03:07:43
Q. Okay. 03:07:47
A. But let me -- but also remark that even though this is linear time encoding, it's not actually a practical way of proceeding. 03:07:47 03:07:51 03:07:53
Q. Well, irrespective of that, let -- let's 03:07:57

return to the patents for a second.
You've no opinion that the claims of the patents require linear or quadratic, right?
A. No.
Q. You have no opinion that the claims of the patents actually require that it is a commercially practicable code, right?
A. No.
Q. Okay. So if we go back to Luby '97, we can agree that Luby '97 does disclose an irregular LDGM; is that correct?
A. It enclose -- it -- it discloses a very particular irregular and hierarchical LDGM/LDPC combination.
Q. Now, if we turn to Page 930 -- withdrawn.
If we go to Page 943, the portion that begins with the heading: "8."
A. 943. Section 8?
Q. Yes. That first paragraph, if you could just read that to yourself for a moment and then let me know when you've read it.
A. Yes, I read it.
Q. Okay. The matrix MB that they're describing there, that is the generator matrix in Luby, right?

A. Right. I believe that that's one -- it's a matrix that corresponds to one of the stages that they have in their hierarchical description. 03:10:28 03:10:32 03:10:35
Q. Okay. So let's just focus on this one stage. 03:10:38 03:10:43
The way this works is that you have a -- a vector of N message bits, right? 03:10:43 03:10:49
A. Yes. 03:10:54
Q. That's another way of saying N information bits, right? 03:10:54 03:11:00
A. I -- I believe that all the -- I believe that these are actually all the bits that you have in the -- these are actually all the bits. So this is actually the code word itself in this case. 03:11:01 03:11:10 03:11:13 03:11:18
Q. So you've got N message bits, right, and that's multiplied by the beta N times N matrix MB? 03:11:21 03:11:27
A. Right. 03:11:34
Q. And then that will produce check bits, right? 03:11:34 03:11:41
A. Right. 03:11:41
Q. And those are parity check bits, right? 03:11:42
A. Yes. 03:11:46
Q. And because it says: 03:11:46
"We choose our graphs B to be sparse, the resulting matrix MB is sparse." 03:11:48 03:11:51

That's how we know that it's a low-density generator matrix, right? 03:11:54 03:11:58
A. Yes. 03:11:59
Q. And we also know that it is an irregular low-density generator matrix because the paper's already told us that it's irregular, right? 03:11:59 03:12:03 03:12:06
A. Each component of that can be interpreted that the overall graph, of course, has some additional structure. 03:12:08 03:12:11 03:12:14
Q. Okay. But I'm just focusing on the LDGM piece, that would be an irregular LDGM? 03:12:14 03:12:18
A. Right. Each stage of the LDGM is, itself, an element. Each stage of the first part is an LDGM or it can be interpreted as an LDGM code. 03:12:19 03:12:23 03:12:25
Q. Okay. Now, I was going to refer you to Paragraph 139 of your report where you talk about the cascade issue, but I think whether you need that or not. 03:12:36 03:12:39 03:12:41 03:12:44
If we turn to Page 939, there was the Figure 2 there. 03:12:46 03:12:52
THE WITNESS: I would just request a small bathroom break. It doesn't have to be this second, but I just need one minute. Unfortunately, I drank too much Coke. So could be any time whenever is convenient for you. 03:12:53 03:12:55 03:12:58 03:13:02 03:13:05

MR. DOWD: Why don't we just finish this one issue --
THE WITNESS: Okay.
MR. DOWD: -- then we can break.
THE WITNESS: Sure.
BY MR. DOWD:
Q. If we go to Page 939 in Figure 2 where it 03:13:07
says: "The code levels"? 03:13:11
A. 939, Figure 2, yes. 03:13:13
Q. And that's what you're pointing to when 03:13:15
you're saying that there's a cascade of graphs, 03:13:17
right? 03:13:22
A. Exactly. 03:13:22
Q. And what that means is that you've got a 03:13:22
graph of one code whose output is the input to the 03:13:25
next code, right? 03:13:29
A. Yes. 03:13:31
Q. Now, in a serial concatenated code, the 03:13:36
output of the first code is the input to the second 03:13:42
code, right? 03:13:46
A. Yes, that is correct. 03:13:47
Q. So that's also how serial concatenated 03:13:49
codes work, right? 03:13:52
A. A standard definition of how serial 03:13:54
concatenated works, that at least part of the output 03:13:59

of some code might be the input of something else. 03:14:00
Q. And the RA code in Divsalar that we've been focused on is a type of serial concatenated code, right? 03:14:04 03:14:05 03:14:09
A. You can interpret them as a serial code. 03:14:11
MR. DOWD: Okay. Why don't we take the break. 03:14:15 03:14:17
THE VIDEOGRAPHER: Going off the record. The time is 3:14 p.m. 03:14:18 03:14:20
(Recess taken at 3:14 p.m.) 03:14:22
THE VIDEOGRAPHER: We are back on the record. The time is 3:20 p.m. 03:20:32 03:20:33
BY MR. DOWD: 03:20:36
Q. So let's stick with Luby '97 and go to Page 3 -- I'm sorry, 938. And I'm looking at the Section 2, the codes. 03:20:36 03:20:41 03:20:48
Do you see that there's a statement there, second sentence: 03:20:49 03:20:52
"We begin by defining a code C(B) within message bits and beta end check bits by associating these bits with a bipartite graph B"? 03:20:53 03:20:58 03:21:02 03:21:06
A. Yes. 03:21:07
Q. What they're talking about there are -- is a Tanner graph representation, right? 03:21:07 03:21:09

A. In hindsight, or in 2015, you might call this a Tanner graph representation, yes. 03:21:12 03:21:15

Q. And the graph that they're talking about is shown in Figure 1, right? 03:21:17 03:21:19

A. Yes, it's shown in Figure 1A, I believe. 03:21:23

Q. Right. Now, Tanner graphs existed before 1997, right? 03:21:28 03:21:31

A. So Tanner's paper was published, I believe, sometimes in the '80s. 03:21:34 03:21:38

But, you know, just from my own experience, in the -- in our own '99 paper in April, when we submitted it to be -- to the journal, we actually do not cite it. And I believe I was at that point actually not aware of the paper. It is in the final 2001 published version. 03:21:41 03:21:45 03:21:49 03:21:52 03:21:55 03:21:59

And I don't remember now who alerted me to that paper. But at least in the '99 somehow April time frame, I must have not been aware of that paper. 03:22:01 03:22:08 03:22:13 03:22:16

Q. Okay. Well, setting aside what -- what you were or were not aware of, in Luby '97 they're describing a bipartite graph that has message nodes on the left and check bit nodes on the right? Right? 03:22:17 03:22:19 03:22:27 03:22:36 03:22:39

A. They're describing exactly the picture 03:22:40

that was given in terms in -- gathered during his 60s thesis. 03:22:42 03:22:46

Q. And what they say is that the graph B has N left nodes and beta N right nodes corresponding to the message bits and the check bits respectively, right? 03:22:48 03:22:51 03:22:56 03:22:59

A. That is correct. 03:22:59

Q. Now, to make the code irregular, you can have two different degrees for the message nodes on the left? Right? 03:23:00 03:23:06 03:23:13

A. To make it irregular what you have to do is to choose, let's say, either variable or check nodes and -- or both and decide that some of these nodes within the same group would have different degrees. 03:23:14 03:23:16 03:23:22 03:23:26 03:23:29

Q. And that's what Luby '97 does, right? 03:23:30

A. Yes. Within the structure of these cascaded or hierarchical LDGM/LDPC codes, they introduce a notion of irregularity. 03:23:36 03:23:38 03:23:44

Q. Now, in Luby '97, the information bit variable nodes have different degree profiles, right? 03:23:58 03:24:07 03:24:13

A. In the -- yes, in this picture they have different degrees. So there's a certain fraction of nodes that has a certain degree. And there's 03:24:13 03:24:35 03:24:38

something which is called a "degree profile" that describes what fraction of the nodes has what degree. 03:24:42 03:24:46 03:24:48

Q. Okay. So there's some fraction of information bit nodes that has one degree and another fraction of information bit nodes that has a different degree, right? 03:24:48 03:24:53 03:24:56 03:25:00

A. That is correct. There is a degree profile that describes what fraction of the various nodes has what degree. 03:25:03 03:25:05 03:25:08

Q. And what that means is that the first fraction -- withdrawn. 03:25:10 03:25:24

What that means is that the information bits of the first fraction will be repeated a different number of times than the information bits of the second fraction? 03:25:25 03:25:28 03:25:31 03:25:33

A. What it means is that the degrees, the edges -- the number of edges that one such variable node would have is that that, call it degree, would vary -- 03:25:34 03:25:36 03:25:40 03:25:40

THE REPORTER: Sorry. 03:25:40

"That that..." 03:25:49

THE WITNESS: Let me restart it. 03:25:49

THE REPORTER: Thank you. 03:25:49

THE WITNESS: That what it means is that 03:25:50

for different variables the number of edges that such a variable would have would depend on to which group this bit belongs to. So there might be some fraction of bits that perhaps has two edges outgoing, there's some edges that perhaps has four bit -- four edges going out, and there's some bits that perhaps has five edges going out. 03:25:52 03:25:56 03:26:01 03:26:05 03:26:10 03:26:13 03:26:15

BY MR. DOWD: 03:26:17

Q. Okay. And the number of edges that are going out from an information node, that determines how many times the bit of that node is repeated, right? 03:26:17 03:26:21 03:26:28 03:26:31

A. "Repeat," unless you give me an exact definition, which I don't think is in this paper here, it simply means that in a graph the number of edges that go out from such a bit is different. That's what it means. 03:26:31 03:26:34 03:26:37 03:26:40 03:26:43

Q. So you don't know what "repeat" means? 03:26:44

MR. GLASS: Objection. Mischaracterizes the testimony. 03:26:47 03:26:48

THE WITNESS: "Repeat" can have many, many different meanings. I don't see, you know, in this paper that the word "repeat" is being used, being used as an edge degree profile or as a variable node degree profile. 03:26:49 03:26:52 03:26:54 03:26:56 03:27:01

So I would like to characterize it in exactly the same way as they do it. 03:27:02 03:27:04
BY MR. DOWD: 03:27:07
Q. Well, yes, no, or I don't know; the degree profile of an information node in an irregular LDPC code corresponds to the number of repeats of the information bit that will occur? 03:27:07 03:27:13 03:27:21 03:27:24
A. Unless you give me an exact definition of what "repeat" means, I cannot answer that question. 03:27:25 03:27:28
Q. You're aware that the word "repeat" has been construed in this case? 03:27:30 03:27:33
A. I have no legal opinion to what's in respect to patents, I don't know. 03:27:34 03:27:37
Q. Okay. Let's for the sake of this question assume that "repeat" means "duplicate," okay? Do you have that in mind? 03:27:39 03:27:42 03:27:47
A. What does "duplicate" mean? 03:27:47
Q. It means create a copy of. 03:27:49
Does an irregular LDPC code repeat bits? 03:27:58
A. "Copy of," meaning in exactly what way? What do you mean with making a copy? 03:28:02 03:28:05
Q. I mean create duplicate bits. 03:28:08
A. No, it simply means that there's a node and the value of this node is stored somewhere, and there's some certain edges going out. And these 03:28:10 03:28:12 03:28:17

edges, you know, go to the check nodes. And this number of edges that go from a particular variable node differs from variable node to variable node. That's what it means to me. 03:28:21 03:28:25 03:28:29 03:28:32
Q. Okay. So I can implement an irregular code in the sense that there is a different number of edges from the information node to the check node? Are you with me so far? 03:28:34 03:28:37 03:28:41 03:28:44
A. I don't think that this paper talks about the implementation of how this is done. It simply talks about a mathematical concept of a bipartite graph in which nodes have different degrees. That's what the paper talks about. 03:28:45 03:28:48 03:28:50 03:28:55 03:28:58
Q. Okay. Let's set this paper aside for one second and just talk about -- 03:28:59 03:29:06
(Overlapping speakers.) 03:29:06
THE REPORTER: Wait. Wait. One at a -- hold on. I didn't -- you guys overlapped, so can I get a clean question, please. 03:29:06 03:29:06 03:29:07
BY MR. DOWD: 03:29:07
Q. Let's set the paper aside for one second, okay? 03:29:07 03:29:10
A. My expertise and my particular question was regarding this paper and was not about any hypothetical implementation. 03:29:10 03:29:12 03:29:16

Q. I'm asking you, just set the paper aside for one second; are you capable of doing that? 03:29:17 03:29:21
A. Sure. 03:29:26
Q. And I'd like you to have in mind an irregular graph where the number of edges from one fraction of information nodes is different than the number of edges from another fraction of information nodes. 03:29:28 03:29:35 03:29:39 03:29:44 03:29:49
Do you have that? 03:29:49
A. Sure. 03:29:51
Q. Okay. Now, that could be implemented without repeating any of the information bits, right? 03:29:54 03:29:56 03:30:03
A. I -- you know, this paper doesn't talk about implementation. I have not thought about in this context, about how exactly such a code would be implemented. That was not the question posed to me. 03:30:03 03:30:05 03:30:08 03:30:10
Q. Irrespective of the question posed to you, can you tell me the answer? 03:30:13 03:30:16
A. I don't know. 03:30:17
Q. Okay. So let's get back to -- let's get back to our irregular graph. In the case where you have some fraction of information nodes with one number of edges, another fraction with a different number of edges, am I correct that the information 03:30:18 03:30:29 03:30:32 03:30:35 03:30:38

nodes of the first fraction will contribute to a different number of parity checks than the second fraction? 03:30:42 03:30:45 03:30:49
A. Not clear. It could be or could not be. 03:30:53
Q. All right. So at least what we know is, when you read Luby '97, one way to make the bipartite graph irregular is that you can have one fraction with one degree profile, a different fraction with a different degree profile, right? 03:30:56 03:31:00 03:31:06 03:31:09 03:31:13
A. The profile actually refers to the whole -- to -- to the set of all these fractions. So the profile already specifies for each set. So what is meant typically as a profile is simply there's a certain probability or certain fraction that applies to some set, a certain fraction to another set. 03:31:15 03:31:19 03:31:22 03:31:25 03:31:28 03:31:30 03:31:34
Q. Let me ask you a better question, then. 03:31:34
What we can know from Luby '97 is that one way to make an irregular graph is to have one fraction of information nodes with one number of edges and a different fraction of information nodes with a different number of edges, correct? 03:31:37 03:31:41 03:31:44 03:31:49 03:31:54
A. Yes, that's what the degree profile says. 03:31:56
Q. All right. 03:32:00
MR. DOWD: Now, let's mark as Exhibit 17, 03:32:05

a copy of Luby '98. 03:32:07
(Urbanke Exhibit 17 was marked for identification and attached to the transcript.) 03:32:11 03:32:11 03:32:25
BY MR. DOWD: 03:32:25
Q. Do you recognize Exhibit 17? 03:32:25
A. Yes. 03:32:27
Q. What is it? 03:32:28
A. Appears to be the -- what we called Luby '98 paper. Its title is: "Analysis of Low-Density Codes and Improved the Science Using Irregular Graphs." 03:32:29 03:32:34 03:32:36 03:32:39
Q. And if you could turn to Page 925. In the right-hand column, there's a paragraph that begins: 03:32:40 03:32:50
"The main contribution." 03:32:52
Do you see that there? 03:32:54
A. Yes. 03:32:54
Q. It says: 03:32:54
"The main contribution of this paper is the design and analysis of low-density parity check codes based on irregular graphs. This work follows the general approach introduced in 7 for the design and analysis of erasure codes." 03:32:56 03:32:58 03:33:01 03:33:04 03:33:07 03:33:10
Do you see that? 03:33:14

A. Yes. 03:33:15
Q. 7 is a reference to Luby '97, right? 03:33:15
So -- 03:33:15
THE REPORTER: Did you answer? 03:33:15
THE WITNESS: Yes. 03:33:15
THE REPORTER: Thank you. 03:33:27
BY MR. DOWD: 03:33:27
Q. So Luby '98 says that Luby '97 was a general approach to irregular codes, right? 03:33:29 03:33:34
A. I believe the way I read it that "general" here doesn't mean in general is applicable to a general set of channels or a general set of graphs, but it means, you know, the -- the approach, essentially you can skip the "general" here. It doesn't mean general in the sense of applicable to a general class or a general channel. 03:33:36 03:33:38 03:33:42 03:33:46 03:33:51 03:33:54 03:33:58
Q. So the way you read it is you strike the word "general" from the sentence? 03:34:01 03:34:04
MR. GLASS: Objection. Mischaracterizes the testimony. 03:34:06 03:34:07
THE WITNESS: The way I read it is -- is, you know, without being, you know, anything specific. So not a specific thing, but, you know, an idea that was put forth in that paper. And so they're saying that it shares some characteristics 03:34:07 03:34:12 03:34:14 03:34:23 03:34:24

with that idea. 03:34:28
BY MR. DOWD: 03:34:29
Q. The next sentence of Luby '98 says: "There," referring to Luby '97, right? 03:34:29 03:34:33
A. Uh-huh. 03:34:34
Q. "There it is shown that using irregular graphs yields codes with much better performance than regular graphs." 03:34:36 03:34:39 03:34:42
Right? 03:34:45
A. Yes. 03:34:45
Q. And there's no mention there of any specific type of code, right? 03:34:46 03:34:51
A. That is correct. But the paper '97 only deals with a very specific channel limited BC, a very specific decoding algorithm; namely, what is message passing for the BC, which is also called a peeling decoder, and with a very specific code structure. 03:34:54 03:34:58 03:35:03 03:35:07 03:35:13 03:35:15
Q. Well, in Luby '98, the statement that: 03:35:16
"...irregular graphs yield codes with much better performance than regular graphs," 03:35:19 03:35:21 03:35:24
that isn't talking about any specific code, right? There's no code named there, right? 03:35:24 03:35:28
A. The only thing that is in the '97 paper is 03:35:31

a very specific code, a very specific channel, and a very specific decoding algorithm. So the only thing that can be claimed is what exactly is in that paper. 03:35:36 03:35:39 03:35:42 03:35:45
Q. Well, I'm asking a different question. 03:35:46
My question is, if you look at Luby '98, the statement: 03:35:49 03:35:53
"...that using irregular graphs yields codes with much better performance than regular graphs." 03:35:55 03:35:58 03:36:00
That statement is made out without naming any specific code, correct? 03:36:01 03:36:03
A. In that particular statement, they don't name any codes. But they don't give any evidence that that would be true. 03:36:05 03:36:07 03:36:11
Q. Okay. Whether or not there's evidence that it's true, they're making the statement without naming any specific code, right? 03:36:12 03:36:14 03:36:18
A. They reference particularly their paper, and that paper only deals with a specific code. It deals with a specific type of channel, and it deals with a specific type of decoder. That's the only thing that can possibly be claimed. 03:36:20 03:36:22 03:36:25 03:36:28 03:36:32
Q. Now, in the -- in the left column, the second paragraph also talks about the Luby '97 paper 03:36:41 03:36:46

introducing a general approach, close quote, right? 03:36:53
A. In the sentence there's a "general" in 03:36:57
there, indeed, yes. 03:37:00
Q. And it says: 03:37:02
"We consider error correcting codes 03:37:03
based on random irregular bipartite 03:37:06
graphs, which we call irregular codes." 03:37:10
Right? 03:37:12
A. Yes. 03:37:13
Q. So, again, in Luby '98, what they say 03:37:14
about Luby '97 is that it is error correcting codes 03:37:19
based on random irregular bipartite graphs, not a 03:37:25
particular type of code, right? 03:37:30
MR. GLASS: Objection. Vague. 03:37:33
THE WITNESS: They're talking about their 03:37:34
own paper and have some particular characterization 03:37:41
which, you know, I don't know how to -- how they 03:37:43
wanted to interpret it. But the only thing that can 03:37:45
possibly be claimed is what actually is in the 03:37:48
paper. 03:37:51
And in the actual paper, if you look at 03:37:51
Luby '97, they're talking about a very specific code 03:37:55
construction. There's no such claim in the '97 03:37:58
paper. They're talking about a very particular 03:37:58
decoding algorithm. They're talking about -- 03:37:58

THE REPORTER: Wait. Slow down. Slow down. 03:37:58 03:37:58
"They are talking about..." 03:38:05
THE WITNESS: -- a very particular code structure, a very particular decoding algorithm, and a very particular channel. 03:38:05 03:38:08 03:38:11
BY MR. DOWD: 03:38:13
Q. Well, let's turn to Page 926. At the top of the left column Luby '98 says: 03:38:14 03:38:23
"Gallager decoding" -- "Gallager's decoding algorithm is a simplification of belief propagation." 03:38:28 03:38:29 03:38:32
Do you see that? 03:38:34
A. Yes. 03:38:34
Q. Is that true? 03:38:35
A. What they do in the '98 paper is to look at a very specific decoding algorithm, which is a combination of what's called "Gallager's algorithm," sometimes also called "Gallager algorithm A," and a what's called "flipping algorithm." 03:38:35 03:38:38 03:38:41 03:38:44 03:38:47
So that's a very particular decoding algorithm. And Gallager's algorithm A can be interpreted as a fairly suboptimum case of the general belief propagation algorithm. 03:38:49 03:38:53 03:38:56 03:39:04
Q. So my question is, the Gallager decoding 03:39:08

algorithm A is a simplification of belief propagation, correct? 03:39:12 03:39:15
A. It is a suboptimal version which can be considered a simplification. 03:39:16 03:39:20
Q. And then if we go down to the bottom of that column -- actually, withdrawn. 03:39:27 03:39:36
If we go over to the right-hand column on Page 926. 03:39:41 03:39:46
A. Just if you allow me to do so. 03:39:46
The decoding algorithm in total that they're looking at is a combination of Gallager's algorithm and what is called the flipping algorithm. The flipping algorithm is not in any way a simplification or generalization of the message-passing algorithm. 03:39:50 03:39:53 03:39:57 03:40:00 03:40:03 03:40:08
So the overall algorithm that they're using is not connected in any simple way to the message-passing decoder. 03:40:09 03:40:11 03:40:15
MR. DOWD: Okay. Well, that's not what I asked. So move to strike. 03:40:17 03:40:19
MR. GLASS: Objection to motion. 03:40:20
BY MR. DOWD: 03:40:22
Q. If you go to the right column, there's a paragraph that begins: 03:40:23 03:40:25
"In the sequel." 03:40:26

Do you see that? 03:40:27
A. Yes. 03:40:28
Q. So it says: 03:40:28
In the sequel, we focus on one 03:40:29
bipartite graph only." 03:40:34
And then it continues, right? 03:40:36
A. Yes. 03:40:37
Q. So in this paper there is analysis of a single bipartite graph, right? 03:40:37 03:40:41
A. Yes. 03:40:43
Q. Now, if we go to Page 929, there's a discussion of the reasons why irregular graphs improve performance, right? 03:40:44 03:40:52 03:40:55
A. Page 929? 03:41:02
Q. Yes. 03:41:05
A. In Page 929 -- oh, 929, sorry, I'm on 928. You're referring to Section 3.1? 03:41:19 03:41:28
Q. Correct. 03:41:31
So in Page 929, Section 3 on irregular codes, the first section is a discussion of the reasons why irregular graphs improve performance, right? 03:41:32 03:41:36 03:41:39 03:41:45
A. Yes, there's some discussion of an intuition. There is at that point in this paper no actual rigorous analysis of why they work. They 03:41:45 03:41:48 03:41:51

have bounds. So this is an intuition. 03:41:56
Q. Okay. And they say there are two competing requirements, right? 03:41:58 03:42:00
A. So they're talking about that there are competing requirements, yes. 03:42:06 03:42:10
Q. For message nodes, it's best to have a high degree, right? 03:42:12 03:42:16
A. Yes. 03:42:19
Q. For check nodes, it's best to have a low degree, right? 03:42:20 03:42:23
A. Yes. 03:42:24
Q. And irregular graphs allow you to balance those competing requirements, right? 03:42:24 03:42:30
A. You might try to balance these requirements. 03:42:33 03:42:36
Q. And the way you do that is by having different message nodes of different degrees, right? 03:42:36 03:42:46
A. You have a degree profile which specifies for various nodes what kind -- you know, what fraction of these nodes has what kind of degree, yes. 03:42:48 03:42:51 03:42:55 03:43:00
Q. And the reason that that improves performance, according to Luby '98, is message nodes with a high degree will correct their value quickly, right? 03:43:00 03:43:04 03:43:10 03:43:16

A. It is correct that if you have only messages of high degree, then they would have an easy way of decoding and would quickly decode. 03:43:16 03:43:19 03:43:21
Q. And then those nodes will provide good information to the check nodes, right? 03:43:25 03:43:28
A. That is an intuition that they describe here. Whether that is actually possible to balance or, you know, is a different question. 03:43:34 03:43:37 03:43:40
Q. And then the check nodes will, in turn, provide better information to the lower degree message nodes, right? 03:43:43 03:43:47 03:43:52
A. That is what they describe in this paper. 03:43:58
Q. Uh-huh. Now, if some message nodes have a high degree and other message nodes have a low degree, that means that there's an irregular repeat, right? 03:44:01 03:44:04 03:44:07 03:44:10
A. It means there's an irregular degree. 03:44:10
Q. In the case of an RA code, if you gave some message nodes a high degree and other message nodes a low degree, that would mean that you'd have an irregular repetition, right? 03:44:17 03:44:22 03:44:28 03:44:31
A. How do you define a degree in an IRA code? 03:44:33
Q. I define the degree by the number of edges from the message nodes. 03:44:37 03:44:41
A. For which representation? 03:44:42

Q. In a Tanner graph representation of an RA code. 03:44:44 03:44:49
A. So if you have once managed to represent IRA codes, in that particular representation then there is a notion of degree. And then you can vary amongst many other things that notion of the degree. 03:44:49 03:44:54 03:44:57 03:45:01
Q. Okay. So let's return to the idea of a -- an RA code like we saw from Divsalar, okay? 03:45:06 03:45:11
Do you have that in mind? 03:45:16
A. I guess you're referring to Picture 3 in Exhibit 6? 03:45:18 03:45:24
Q. Yes. And if we have a Tanner graph of an RA code like the RA code of Divsalar, I'd like you to have that in mind. 03:45:26 03:45:37 03:45:40
A. That is not compatible or it's not what Figure 3 shows. 03:45:41 03:45:44
Q. Is it possible for you to have in mind a Tanner graph of an RA code? 03:45:44 03:45:47
A. I believe that we had several exhibits that might show that. So perhaps if you want to refer to which one you want to actually talk about, that might be easiest. 03:45:50 03:45:52 03:45:55 03:45:58
Q. Okay. So without referring to a specific exhibit, can you have in mind a Tanner graph of an RA code? 03:46:01 03:46:04 03:46:07

A. There are many ways of how I can have that in mind, so it will be very difficult unless you give me a specific realization to answer any specific questions. 03:46:07 03:46:09 03:46:13 03:46:16
Q. Okay. Let's take Exhibit 10. 03:46:17
A. I have it in front of me. 03:46:40
Q. And you testified previously that Exhibit 10 represents the Tanner graph of an RA code; do you recall that? 03:46:42 03:46:45 03:46:48
A. One particular interpretation, given that you tell me what the roles of these various nodes are, is one of an -- of an RA code, yes. 03:46:49 03:46:52 03:46:56
Q. All right. So in Exhibit 10 we've got information nodes at the top, a random permutation box, check nodes filled in, and then at the bottom parity nodes. Okay? 03:47:00 03:47:04 03:47:08 03:47:15
A. That requires the interpretation that you just say is not written in Exhibit 10. 03:47:16 03:47:18
Q. I'm giving you those parameters. Do you have those in mind? 03:47:20 03:47:23
A. If you write next in Exhibit 10 that this is the interpretation, then I agree. 03:47:23 03:47:27
Q. Okay. Now, referring back to Luby '98 and the discussion about having some message nodes with a high degree and some message nodes with a low 03:47:32 03:47:37 03:47:41

degree; do you recall that? 03:47:44
A. Yes. 03:47:46
Q. If I was going to apply that teaching to Exhibit 10, that would mean that I would have some information nodes at the top that have a larger number of edges than others, right? 03:47:46 03:47:50 03:47:55 03:47:58
MR. GLASS: Objection. Vague. Incomplete hypothetical. 03:48:02 03:48:03
THE WITNESS: Which -- which Luby are we talking about here? 03:48:04 03:48:10
BY MR. DOWD: 03:48:11
Q. I'm saying -- we were just looking at Luby '98; do you remember that? 03:48:12 03:48:15
A. Yes. 03:48:17
Q. We just looked at the teaching in Luby '98 about how you could have some message nodes with a high degree and other message nodes with a low degree; do you remember that? 03:48:17 03:48:21 03:48:24 03:48:25
A. Yes. 03:48:26
Q. If I apply that teaching to Exhibit 10, that means I'd have some information nodes that have a greater number of edges than others, right? 03:48:26 03:48:29 03:48:32
MR. GLASS: Same objection. 03:48:35
THE WITNESS: If you apply -- if you -- if you -- if you apply what teaching, what exactly do 03:48:36 03:48:40

you mean, you apply that teaching? Can you specify? 03:48:43
BY MR. DOWD: 03:48:46
Q. Sure. If I apply the teaching to have some message nodes with a high degree profile and others with a low -- I'm sorry, I said: Profile. Let me start again. 03:48:47 03:48:50 03:48:55 03:48:59
If I apply the teaching to have some message nodes with -- with a high degree and other message nodes with a low degree, that means that in Exhibit 10 you'd have some of the information nodes at the top with a greater number of edges than others, right? 03:49:00 03:49:02 03:49:06 03:49:11 03:49:15 03:49:18
MR. GLASS: Same objection. 03:49:20
THE WITNESS: As far as I read Luby '98, they're talking about a decoder which is not a message-passing decoder. So this is not the same realm that we're talking about. Whether or not certain motivations might have a positive or negative benefit depends largely on what decoder we're looking at. 03:49:20 03:49:23 03:49:26 03:49:28 03:49:31 03:49:34 03:49:38
BY MR. DOWD: 03:49:39
Q. I -- I'm not asking about whether it would be beneficial, I'm not asking about whether it could produce a better code, so set those issues aside. 03:49:39 03:49:42 03:49:45
All I'm saying is, if I take the teaching 03:49:48

in Luby '98 to have some message nodes with a high degree and some message nodes with a low degree and I apply that to the RA graph of Exhibit 10, what you would get is some information nodes at the top have a greater number of edges than others, right? 03:49:52 03:49:57 03:49:58 03:50:04 03:50:08

MR. GLASS: Same objection. 03:50:12

THE WITNESS: So if you start with the assumption that you represent an RA code in terms of that diagram which was not what was in the state-of-the-art, if in addition you tell me that these nodes have very specific roles which is not in Exhibit 10 nor anywhere else written, if in addition then you tell me which nodes exactly you would like to make irregular and you have a very specific notion of how you do that, then you can arrive at IRA codes. 03:50:13 03:50:16 03:50:19 03:50:23 03:50:26 03:50:30 03:50:34 03:50:36 03:50:39 03:50:44

BY MR. DOWD: 03:50:44

Q. At an IRA code? 03:50:44

A. If you tell me that, make the RA code an IRA code in -- 03:50:46 03:50:49

THE REPORTER: Wait. Wait. Wait. I didn't get that. Say it again. 03:50:49 03:50:52

THE WITNESS: If you tell me take the RA code and make it an IRA code, then you get an IRA code. But that's, again, tautology. You're simply 03:50:52 03:50:54 03:50:57

asking me if I make it an IRA code, do I get an IRA code, yes. 03:51:01 03:51:05
BY MR. DOWD: 03:51:05
Q. I'm actually asking you a different question. 03:51:05 03:51:07
A. Okay. 03:51:08
Q. If I -- if you take Exhibit 10 -- 03:51:09
A. Right. 03:51:11
Q. -- the top nodes are the information nodes, the filled-in nodes are the check nodes, the bottom nodes are the parity nodes. 03:51:13 03:51:16 03:51:18
A. That's your interpretation. It's not in Exhibit 10. 03:51:21 03:51:24
Q. Okay. If you want, let's just write that in there so that we can -- do you want to hand that back, I'll just write it on there so that there's no confusion about what I'm talking about. 03:51:24 03:51:27 03:51:31 03:51:34
A. (Witness complied.) 03:51:51
Q. Okay. I'm going to hand this back now. 03:51:52
A. Thank you. 03:51:56
Q. I think you've got it upside down. 03:51:56
So I've written in at the top information nodes, the filled in circles, check nodes; the bottom, parity nodes. 03:51:59 03:52:02 03:52:06
A. Correct. 03:52:08

Q. Okay. So with Exhibit 10, if I tell you I'd like you to make half of the -- half of the message nodes have a high degree and the other half have a low degree, what that would mean is that there would be half of the information nodes that have a greater number of edges than other half, right? 03:52:10 03:52:13 03:52:18 03:52:22 03:52:28 03:52:32 03:52:35
A. Yes. 03:52:35
Q. And that would mean that you've got a greater number of these lines between the information nodes and the random permutation nodes for half of the information nodes, right? 03:52:35 03:52:37 03:52:40 03:52:42
A. Yes. 03:52:46
Q. What that means is that you would repeat half of the information nodes a greater number of times than the other half, right? 03:52:46 03:52:49 03:52:52
A. No, you would change the degree. That's what it means. 03:52:53 03:52:55
Q. Okay. And if we go to Exhibit 12, the same assumptions about which ones are the information node, which ones are the check nodes, which ones are the parity nodes; do you have that in mind? 03:52:57 03:53:21 03:53:25 03:53:27 03:53:30
A. Yes. 03:53:31
Q. Exhibit 12 shows the Tanner graph of a 03:53:31

repeat-accumulate code where half of the information nodes have a high degree -- higher degree than the other half, right? 03:53:34 03:53:38 03:53:40
MR. GLASS: Objection. Incomplete hypothetical. 03:53:42 03:53:43
THE WITNESS: I don't know if that's half. I don't know exactly what it shows. 03:53:43 03:53:44
BY MR. DOWD: 03:53:47
Q. Well, if it's intended to show -- it's intended to show the break points in the middle. 03:53:47 03:53:52
A. Perhaps. This is not written. I mean, you essentially tell me exactly what it says and maybe ask me, but -- 03:53:54 03:53:56 03:53:56
THE REPORTER: Wait. Wait. No, no, no. Slow down and repeat your answer. 03:53:56 03:54:01
THE WITNESS: You -- you're asking me first a specific question: Does it say that? And that's your definition what you tell me it says. 03:54:01 03:54:03 03:54:05
BY MR. DOWD: 03:54:05
Q. Fair enough. 03:54:08
A. There's no -- you're simply -- 03:54:08
Q. I'll withdraw the question. 03:54:09
A. You're simply asking me; is what I say what I say? 03:54:10 03:54:14
Q. Okay. I'll withdraw the question. 03:54:14

You see there are -- there are six information nodes actually drawn on the page? 03:54:16 03:54:18
A. There are six nodes on top, yes. 03:54:20
Q. Y3. And so Figure 12 -- withdrawn. 03:54:23
Exhibit 12 shows the Tanner graph of a RA code where three of the information bits have a higher degree than the other three information bits, right? 03:54:28 03:54:32 03:54:37 03:54:41
MR. GLASS: Incomplete hypothetical. 03:54:41
THE WITNESS: In hindsight, and with 2015-vision, that can be interpreted in the particular way that you're saying, yes. 03:54:42 03:54:44 03:54:48
BY MR. DOWD: 03:54:51
Q. Okay. 03:54:51
MR. GLASS: Actually, would you mind if we go off the record for a minute? 03:55:09 03:55:10
MR. DOWD: Let me just wrap this up and then we can do that. 03:55:12 03:55:14
MR. GLASS: Sure. 03:55:15
BY MR. DOWD: 03:55:16
Q. Now, if we go to page -- just to finish up Luby, and then we can take that break, if we go to Page 931. 03:55:25 03:55:28 03:55:33
A. Exhibit 17? 03:55:38
Q. Yes. 03:55:41

A. 931, yes. 03:55:42
Q. Yes, Luby '98. 03:55:44
Down near the bottom on the left he says: 03:55:49
"Using the linear programming technique we've considered graphs where the nodes on the left side may have varying degrees and the nodes on the right side all have the same degree." 03:55:54 03:55:56 03:55:59 03:56:02 03:56:05
Do you see that there? 03:56:06
A. Yes. 03:56:07
Q. And that's talking about, you have a degree profile where some of the message nodes have a different number of edges than other message nodes, right? 03:56:08 03:56:12 03:56:16 03:56:19
A. Yes. 03:56:20
Q. And Luby says at, again, Page 931 of Luby '98: 03:56:22 03:56:31
"This suffices to find codes with significantly better performance than that given by codes determined by regular graphs." 03:56:32 03:56:35 03:56:37 03:56:39
Right? 03:56:40
A. It says that, but it says that for the particular decoding algorithm. This is not the standard message-passing algorithm. 03:56:41 03:56:44 03:56:47

Q. But it's also true that an RA code with an irregular graph performs better than an RA code with a regular graph, right? 03:56:53 03:56:58 03:57:03
MR. GLASS: Objection. Vague. Incomplete hypothetical. 03:57:05 03:57:06
THE WITNESS: That can be true. 03:57:09
BY MR. DOWD: 03:57:11
Q. Okay. Now, in an -- if we go over to Page 932, there's a Table 1 that shows parameters of our codes. 03:57:13 03:57:37 03:57:42
A. Yes. 03:57:43
Q. And it shows for each of four codes: 14, 22, 10 prime, 14 prime? 03:57:44 03:57:52
A. Yes. 03:57:55
Q. The degree profile for the nodes, right? 03:57:56
A. Yes, I believe that this is degree profile for the edges actually, and not for the nodes. 03:58:00 03:58:03
Q. For the edges of the right nodes and the edges of the left nodes, right? 03:58:05 03:58:08
A. This would be the edges of the left nodes, I believe. The right nodes are irregular. 03:58:10 03:58:13
Q. Right. Okay. So focusing on the degree profile of the left nodes, the edges of the left nodes, Code 14, you've got four different groups of information nodes, each of which have a different 03:58:15 03:58:18 03:58:22 03:58:32

degree, right? 03:58:37
A. That is correct. 03:58:37
Q. And then for Code 22, it's six different subsets of information nodes, each having a different degree? 03:58:38 03:58:42 03:58:45
A. That is correct. 03:58:46
Q. And then Code 10 prime, it's three subsets of information nodes, each with a different degree? 03:58:46 03:58:50
A. That is correct. 03:58:53
Q. Finally, for Code 14 prime, it's four subsets of information nodes, each with a different degree? 03:58:53 03:58:57 03:59:01
A. That is also correct. 03:59:01
Q. Okay. And the different degrees, if -- if we focus on -- just take Code 22, for example? 03:59:04 03:59:10
A. Yes. 03:59:15
Q. We've got six subsets, each with a different degree? 03:59:15 03:59:18
A. Yes. 03:59:19
Q. The different degrees means that the bits within each subset will contribute to a different number of parity checks, right? 03:59:20 03:59:24 03:59:28
A. No, it means that their degree, how many outgoing is -- is different to how many they actually contribute depends on the -- how actually 03:59:32 03:59:36 03:59:38

the edges are mapped onto the check nodes. So it simply means, a priori, that there's more number of edges that are going out, and then that can mean that it contributes to a different number, but it doesn't necessarily have to mean that. 03:59:42 03:59:45 03:59:49 03:59:53 03:59:57

Q. Each outgoing edge from an information node is going to connect to a check node, right? 03:59:59 04:00:03

A. Yes. But several of them might connect to the same, that's entirely possible. 04:00:09 04:00:12

Q. So it could be that you have multiple information node edges connecting to the same check node? 04:00:14 04:00:19 04:00:22

A. Yes. 04:00:22

Q. But my question is that if you take one information node that has, say, four edges and another information node that has only two edges, the number of check nodes to which those two contribute is different? 04:00:23 04:00:29 04:00:34 04:00:37 04:00:40

A. It could be or it could not be. 04:00:41

Q. Even though there's only two edges -- 04:00:44

A. Could be. 04:00:46

Q. -- it could contribute to four check nodes? 04:00:46 04:00:51

A. No. But it could connect to two and the -- 04:00:51

THE REPORTER: Wait. Say your answer again.
THE WITNESS: It could be or it could not be.
BY MR. DOWD: 04:00:54
Q. Okay. I think I understand the answer. 04:00:54
Now, just finishing this up, if we go to Page 933 -- 04:01:01 04:01:06
A. 933, yes. 04:01:14
Q. -- on the left side, there in the middle of the first paragraph it says: 04:01:15 04:01:17
"These codes perform better than the codes based on regular graphs presented in 15, albeit at the expense of greater but still linear running time." 04:01:19 04:01:20 04:01:24 04:01:28
Right? 04:01:32
A. Right. 04:01:32
Q. So all four of Luby '98 irregular graphs perform better than the regular graphs, right? 04:01:33 04:01:38
MR. GLASS: Objection. 04:01:40
THE WITNESS: Okay. So let me explain why I don't agree with your conclusion. The codes in 15 are extremely bad codes. They're interesting for a computer science application but would be of absolutely no interest for any actual application. 04:01:41 04:01:44 04:01:47 04:01:51 04:01:53

They're using the -- what's called the flipping algorithm, which has very, very bad performance. 04:01:56 04:02:00

Now, as we talked about in the '98 paper, the algorithm is a mixture of the flipping and the Gallager A, so it is neither flipping nor is it message passing. Not even the first part is really message passing. The first part is some simplified version of message passing, but the overall decoder is some mixture of that. 04:02:05 04:02:10 04:02:13 04:02:16 04:02:21 04:02:26 04:02:29

And so the only conclusion that he can draw is that by using irregular codes, as they have done with this particular type of decoder, and using an irregularity as they have described, they can do better using a different type of decoder than with just the flipping algorithm and regular codes. 04:02:30 04:02:33 04:02:37 04:02:39 04:02:43 04:02:48

BY MR. DOWD: 04:02:53

Q. Okay. Well, let's set that aside, then, and go down to the last paragraph before the conclusion. 04:02:53 04:02:55 04:02:57

Luby '98 says in the summary: 04:02:57

"Irregular Codes 14 and 22 appear superior to any regular code in practice and irregular Codes 10 prime and 14 prime are far superior to any regular code." 04:03:00 04:03:02 04:03:05 04:03:08

Have I read that correctly? 04:03:12

A. That's what it says. 04:03:13
Q. Okay. 04:03:15
A. I simply don't see evidence that supports that claim. 04:03:15 04:03:20
Q. Okay. Well, at least what Luby '98 is saying, whether or not it's true, is that irregular codes perform superior to regular codes? 04:03:22 04:03:26 04:03:31
A. It says that irregular codes with a very particular type of decoding algorithm, which is not the same type of decoding algorithm that we're talking about -- 04:03:33 04:03:35 04:03:38 04:03:38
THE REPORTER: Slow down. Wait. Slow down. 04:03:38 04:03:43
THE WITNESS: It says that irregular codes with a very particular type of decoding algorithm. And irregular codes here, I mean, according to the standard notion of Gallager, are better than some regular codes with an even different type of decoding algorithm, for example, as described in 15 where the flipping algorithm is used. That's when it draws its conclusion. 04:03:43 04:03:45 04:03:48 04:03:52 04:03:58 04:04:02 04:04:05 04:04:08
BY MR. DOWD: 04:04:19
Q. Well, it doesn't say -- in Luby '98 it doesn't say: Are superior to a flipping algorithm regular code, it says: Are far superior to, quote, 04:04:20 04:04:32 04:04:34

any regular code, close quote, correct? 04:04:38
A. It refers specifically to codes in 15, which are exactly what I described. 04:04:42 04:04:45
Q. Well, I'm -- I'm looking at this passage at the bottom here. And is it your position that where Luby '98 says that irregular Codes 10 prime and 14 prime are far superior to any regular code that that doesn't actually mean any regular code? 04:04:48 04:04:51 04:04:54 04:05:00 04:05:05
A. That would be something that one would have to look at exactly the point in time. 04:05:08 04:05:10
But I don't see any conclusion -- I don't see any supporting material in there that would allow us to make that conclusion. 04:05:13 04:05:15 04:05:18
Q. All right. Finally, is it your position that Luby and Divsalar were working in different fields and wouldn't been -- wouldn't have been aware of each other's work? 04:05:19 04:05:22 04:05:26 04:05:29
A. They were definitely working in very different fields and having different conferences. To what degree Divsalar was aware of Luby or the other way, it's best to, you know, talk to them. 04:05:31 04:05:37 04:05:39 04:05:42
Certainly, Luby had some reference here to Divsalar. He has in this paper '98 a reference, for example, of three. Now, you know, it's some progress report that he -- that he -- that he 04:05:45 04:05:51 04:05:54 04:05:58

mentions here. I don't know exactly what is in this progress report. 04:06:02 04:06:05
But he at least, you know, had some idea about Divsalar. 04:06:06 04:06:10
Q. Okay. And Luby also in '98 was aware of Frey, if you look at Reference 5, right? 04:06:13 04:06:17
A. He has Reference 5, yes, that he recollects. 04:06:20 04:06:25
Q. And, of course, if you turn the page to 934, References 10 through 12 are papers by MacKay, right? 04:06:25 04:06:28 04:06:33
A. Yes, there's some references to MacKay in there. 04:06:33 04:06:47
Q. So Luby's aware of MacKay's work in '98, right? 04:06:48 04:06:53
A. Yes, he has some citation to MacKay's work in '98. I -- I must say that on this paper here I actually don't see the publication date. We're referring to this as Luby '98. Whether or not that actually is the version that came out in '98, I'm not sure. 04:06:53 04:06:57 04:07:00 04:07:02 04:07:06 04:07:10
Q. And -- well, you've rendered no opinion that Luby '98 was published on any date other than '98 in your report, correct? 04:07:12 04:07:17 04:07:20
A. I don't know if this particular version 04:07:22

here is actually from '98, yes. 04:07:24
Q. My question is, there's no opinion in your report about the date on which Luby '98 was published, is there? 04:07:29 04:07:30 04:07:34
A. There was definitely a version of Luby '98 which was from '98. Whether or not it's exactly that version that I have now in front of me, I don't know for sure. 04:07:34 04:07:43 04:07:44 04:07:48
Q. And if we go back to Khandekar 933, the first listed reference is the Berrou reference on turbo codes, right? 04:07:49 04:07:53 04:07:58
A. That is correct. 04:07:59
Q. And so Luby was aware of turbo codes too, right? 04:07:59 04:08:03
A. He references them. 04:08:03
MR. DOWD: Okay. Your counsel asked for a break, why don't we take the break. 04:08:04 04:08:07
THE VIDEOGRAPHER: Going off the record. The time is 4:08 p.m. 04:08:10 04:08:11
(Recess taken at 4:08 p.m.) 04:08:14
THE VIDEOGRAPHER: We are back on the record. The time is 4:16 p.m. 04:16:18 04:16:19
MR. DOWD: So, Dr. Urbanke, during the break I handed over what has been marked as Exhibits 18 and 19. 04:16:21 04:16:24 04:16:27

(Urbanke Exhibit 18 was marked for identification and attached to the transcript.) 04:16:29
(Urbanke Exhibit 19 was marked for identification and attached to the transcript.) 04:16:29
BY MR. DOWD: 04:16:29
Q. 18 bears Production No. Caltech 23593, Exhibit 19 bears Caltech Production No. 93390. 04:16:30
Do you have those? 04:16:41
A. Yes. 04:16:44
Q. Okay. Let's start with Exhibit 18. Do you recognize this? 04:16:45
A. Yes, that is probably the e-mail that we sent to a small subset of people when we worked on the paper. And it seems to refer to the Richardson '99 paper. 04:16:49
Q. Okay. And if we turn to Exhibit 19, do you recognize that? 04:17:10
A. Y3, it seems to be essentially the same e-mail -- I don't. 04:17:24
Q. Y3, I'll represent to you that it appears to be the same e-mail, and the only difference is that Exhibit 19, Caltech has represented to us, was produced from Dr. McEliece's files? 04:17:41

A. Okay. 04:17:59
Q. If we look at Exhibits 18 and 19, both discuss the preprint of your Richardson '99 paper? 04:17:59 04:18:06
A. Yes. 04:18:11
Q. And so just -- I'll ask the questions using Exhibit 18; but if you want, the same question would apply to Exhibit 19. 04:18:13 04:18:15 04:18:19
Am I correct that on April 5th, 1999, you and your co-authors e-mailed the Richardson 1999 paper to a group of colleagues? 04:18:21 04:18:27 04:18:31
A. So I -- I don't remember exactly what the date is, but here it's written April 5th, then it probably was April 5th. 04:18:34 04:18:37 04:18:41
Q. Okay. 04:18:42
A. I don't have a specific recollection about the date. 04:18:43 04:18:45
Q. Okay. And it says the paper can be obtained at, and then there's a URL for a Bell Labs website. Do you see that? 04:18:45 04:18:47 04:18:52
A. Right. 04:18:53
Q. Was the paper available for download from the website in April of 1999? 04:18:53 04:18:56
A. I think it would be best to ask these people. Really, to the best of my knowledge, I don't have a recollection exactly how, you know, if 04:18:59 04:19:02 04:19:05

it was available there or not. But, you know, if it was written there, you know, there's a -- there's a chance that it was. But I don't have a particular recollection. 04:19:07 04:19:10 04:19:13 04:19:15

Q. Would you have -- you see Exhibit 18 is sent to Dr. Divsalar at JPL? 04:19:18 04:19:21

A. I see his e-mail address, yes. 04:19:24

Q. Would you have told Dr. Divsalar that a preprint of your Richardson '99 paper was available for download at a website if it was not available for download at the website? 04:19:26 04:19:28 04:19:31 04:19:34

A. No, I'm sure we had the intention to make it available there. Whether or not it was then actually available, I don't know. 04:19:35 04:19:38 04:19:41

Q. So to the best of your recollection, starting in April of 1999, the Richardson 1999 paper was distributed to colleagues? 04:19:43 04:19:45 04:19:53

A. We sent -- 04:19:56

MR. GLASS: Objection. Calls for a legal conclusion. 04:19:59 04:20:00

Go ahead. 04:20:01

THE WITNESS: As far as I recall, there was a set of people, perhaps 20, perhaps something on this order, that this e-mail was sent to. 04:20:03 04:20:04 04:20:07

///

BY MR. DOWD: 04:20:10
Q. And who were those 20 people? 04:20:11
A. Unfortunately, I don't have the list of these people because the way it was sent out, to the best of my recollection, was via what's called a "batch execution." So this is not like an e-mail as you would see today in which you define groups, but it's simply some text file in which you put some e-mail addresses and it was sent via a UNIX command. 04:20:16 04:20:19 04:20:23 04:20:26 04:20:29 04:20:33 04:20:36
Unfortunately, neither do I still have the e-mail itself, nor do I still have the list of people that it was distributed to. 04:20:42 04:20:44 04:20:48
Q. Can you tell me whether it was sent to Dr. Divsalar? 04:20:51 04:20:53
A. Well, since here it says: Dr. Divsalar, I must've sent it to him, but I don't have any specific recollection. 04:20:54 04:20:58 04:21:00
Q. Was the Richardson '99 paper sent to Dr. McEliece? 04:21:01 04:21:07
A. If -- you know, if you have here something where it says it was sent to McEliece, then I believe that must be the case. 04:21:07 04:21:09 04:21:11
Q. Okay. 04:21:14
A. But again, I don't have a specific recollection that it was sent to a specific set of 04:21:14 04:21:16

people. 04:21:18
Q. Was it sent to Dr. MacKay? 04:21:18
A. Unfortunately, again, I really don't 04:21:20
remember exactly who the people were. 04:21:23
Q. Do you remember any people, other than 04:21:25
Dr. McEliece and Dr. Divsalar, to whom it was sent? 04:21:27
A. You know, I've tried to think about who 04:21:31
these people were and tried to, you know, see 04:21:35
whether or not still had this distribution list. 04:21:37
Unfortunately, I don't. So it's -- you know, right 04:21:40
now it's -- it would have to be to pure guessing to 04:21:43
whom exactly I sent that. 04:21:47
Q. Without resorting to guessing, what's your 04:21:49
best understanding of the group? 04:21:53
A. It would have been some set of people 04:21:54
that, you know, we thought might be interested in 04:21:57
there -- in that paper. 04:22:00
Q. Okay. And that group included 04:22:02
Dr. Divsalar? 04:22:04
A. Well, since you have here an e-mail that 04:22:04
says he was on that list, then he must have been on 04:22:07
that list. 04:22:11
Q. Okay. And that group included 04:22:11
Dr. McEliece? 04:22:13
A. If that e-mail says that it was sent to 04:22:14

him, then it must have been sent to him. 04:22:16
Q. Okay. Was Dr. Frey on the list? 04:22:20
A. Unfortunately, I really don't have a specific recollection of the set of people. Honestly, I don't. 04:22:25 04:22:27 04:22:30
Q. Was Dr. Luby on the list? 04:22:30
A. I don't know. But it's possible since Amin was good friends with him, so it's possible that he was on the list. 04:22:34 04:22:38 04:22:41
MR. DOWD: Let's mark as Exhibit 20, a copy of the April 6, 1999 paper: "Design of Provably Good Low-Density Parity Check Codes." 04:23:01 04:23:03 04:23:08
(Urbanke Exhibit 20 was marked for identification and attached to the transcript.) 04:23:13 04:23:13 04:23:21
BY MR. DOWD: 04:23:21
Q. Do you have Exhibit 20? 04:23:21
A. Yes. 04:23:22
Q. Do you recognize it? 04:23:23
A. Yes. It appears to be the April 6th version of 1999 of a paper entitled: "Design of Provably Good Low-Density Parity Check Codes," of which I am a co-author. 04:23:24 04:23:27 04:23:31 04:23:34
Q. And is this document, Exhibit 20, is this the same design of provably good low-density parity 04:23:36 04:23:39

check codes that's referenced in Exhibits 18 and 19? 04:23:43
A. Whether or not this is exactly that version, I don't know. It has a slightly different date, but it would, you know, share certain portions, for sure. 04:23:47 04:23:49 04:23:52 04:23:55
Q. Okay. And so you see that the e-mails, Exhibits 18 and 19, those were sent April 5th, 1999, whereas Exhibit 20 has the date April 6th, 1999, right? 04:23:57 04:24:01 04:24:05 04:24:11
A. Right. 04:24:11
Q. Was the Exhibit 20 document posted to the Bell Labs website on April 6th? 04:24:12 04:24:16
A. I have absolutely no recollection whether or not -- you know, I don't know how this exhibit was gathered. I don't know who provided that to you. So I have no idea if that was a version that was available or if there was any other way that it got into your hands. It would be impossible for me to say. 04:24:18 04:24:22 04:24:24 04:24:26 04:24:29 04:24:31 04:24:34
Q. Okay. Am I correct that you offered no opinion in your report that the Richardson 1999 document does not qualify as prior art to the patents in this case? 04:24:36 04:24:42 04:24:47 04:24:55
A. Yes, I have not rendered any particular opinion. The only thing I have said is that the 04:24:56 04:24:59

version that was published differs in some significant portions from that particular version here from April 6th. 04:25:03 04:25:07 04:25:09
Q. All right. Let's go back to Exhibit 15, which is MacKay's Ambleside '99 paper. Let me know when you have that. It's the one that looks like that (indicating). It could be the one that's folded over in front of you there. 04:25:13 04:25:39 04:25:49 04:27:33 04:27:35
A. This one? No, this is my report. I see. Yes, that's it. 04:27:39 04:27:41
Q. All right. So you now have Exhibit 15? 04:27:42
A. Yes, I have Exhibit 15. 04:27:44
Q. And don't lose Exhibit 20, your Richardson '99 paper. 04:27:46 04:27:48
So in -- in MacKay's Ambleside '99 paper, Exhibit 15, if you turn to the last page, the last reference cited is: Urbanke/Richardson/Shokrollahi 1999 design of provably good low-density parity check codes submitted. 04:27:50 04:28:02 04:28:05 04:28:09 04:28:13
Do you see that? 04:28:14
A. Yes. 04:28:15
Q. And that's the same title as Exhibit 20, right? 04:28:15 04:28:20
A. Yes. 04:28:20
Q. Does that refresh your recollection that 04:28:20

you sent a copy of Exhibit 20 to MacKay? 04:28:23
A. No, I don't know how he got it, but, you know, I'm not shocked that he got it. But I don't have any specific recollection. 04:28:25 04:28:28 04:28:30
Q. So we can agree that Exhibit 20 was publically available in 1999? 04:28:32 04:28:40
MR. GLASS: Objection. Calls for a legal conclusion. 04:28:41 04:28:43
THE WITNESS: What I know and now see also through the e-mails, that it was sent to a set of people. My recollection, it might be on the order of 20. And we have established that it was sent, obviously, to Divsalar and McEliece. Unfortunately, I don't have a recollection about the other set of people that might have been on that list. 04:28:43 04:28:48 04:28:51 04:28:53 04:28:58 04:29:04 04:29:06
BY MR. DOWD: 04:29:08
Q. Okay. But that distribution to the 20 people, that was just a distribution to people in the field for them to read and learn what they could from the paper? 04:29:08 04:29:10 04:29:14 04:29:19
A. Yes. 04:29:20
Q. And there was no restriction on their reading it or using it in any way, right? 04:29:20 04:29:22
A. It's understood that if a paper is not published that, you know, for example, you could not 04:29:25 04:29:29

go and simply, you know, for example, read through parts of it. 04:29:32 04:29:36
So there are some implicit restrictions which are not mentioned in the e-mail which are the standard ones of proper conduct in the field. 04:29:37 04:29:40 04:29:43
Q. Fair enough. I -- I don't mean to suggest that they could plagiarize your work or anything like that. I -- I just mean to say that the -- the people to whom you distributed this, you didn't require them to sign some kind of confidentiality agreement before you sent the e-mail? 04:29:45 04:29:47 04:29:50 04:29:53 04:29:56 04:29:58
A. I don't see anything in the e-mail that would suggest that, no. 04:29:59 04:30:02
Q. Okay. Now, if we go to Paragraph 75 of your report, there's some discussion there and at other places in the report about how in the 1999/2000 time frame it would have been counterintuitive that making codes simpler can result in better performance. 04:30:04 04:30:23 04:30:29 04:30:34 04:30:37 04:30:41
Do you see that? 04:30:42
A. Yes. Sorry, which paragraph are we talking about, 75? 04:30:43 04:30:47
Q. I'm pointing specifically to Paragraph 75 of your report. 04:30:48 04:30:50
A. Yes, okay. 04:30:51

Q. And that was your opinion throughout the report, right? 04:30:52 04:30:54
A. Yes. 04:30:55
Q. Now, let's go back to Exhibit 20, your Richardson '99 paper. 04:30:56 04:31:00
On Page 1, you're describing irregular low-density parity check codes, right? 04:31:03 04:31:12
A. Yes. The first line says: 04:31:17
"In this paper we present irregular density parity check codes." 04:31:19 04:31:22
Yes. 04:31:25
Q. And then in the second paragraph you describe distinct advantages of irregular LDPC codes over turbo codes, right? 04:31:26 04:31:28 04:31:32
A. Yes. 04:31:34
Q. And the first listed advantage was that the complexity of decoding is somewhat less than that of turbo codes, right? 04:31:34 04:31:38 04:31:43
A. Yes. 04:31:45
Q. And the second distinct advantage was: 04:31:45
"That as indicated in our previous paper, very low complexity decoders that closely approximate belief propagation performance may be and have been designed for these codes." 04:31:51 04:31:53 04:31:57 04:32:00 04:32:04

Right? 04:32:05
A. Yes, that refers in general to belief propagation as opposed to maximum likelihood which has exponential complexity. 04:32:08 04:32:13 04:32:16
Q. Now, we can agree that people in the field knew that lower complexity was an advantage in 1999, right? 04:32:20 04:32:24 04:32:29
MR. GLASS: Objection. Vague. 04:32:29
THE WITNESS: Low complexity is typically something that one would strive for, yes. 04:32:30 04:32:35
BY MR. DOWD: 04:32:37
Q. And if we turn to Page 4, you say that: 04:32:38
"In this paper we present results indicating the remarkable performance that can be achieved by properly chosen irregular codes." 04:32:47 04:32:50 04:32:52 04:32:56
Right? 04:32:56
A. I'm looking for the exact line. You're talking about Page 4? 04:32:58 04:33:05
Q. Page 4. And it's the last line of the paragraph that begins: "Further." 04:33:06 04:33:10
A. Yes. 04:33:13
Q. And when you say that irregular codes can result in remarkable performance, you don't limit the type of code in that statement, do you? 04:33:21 04:33:27 04:33:33

A. The only context in which we are talking about here is irregular Gallager codes. There's no other code that we discuss in this paper. 04:33:37 04:33:41 04:33:44
Q. Fair enough. 04:33:48
But the point that you make is that your results indicate "the remarkable performance that can be achieved by properly chosen irregular codes." 04:33:49 04:33:53 04:33:56
Have I read that correctly? 04:34:01
A. This is not a legal document. That's a document written by scholars or read by scholars, and it's very clear that the context is one of irregular Gallager codes, nothing else, nothing more. 04:34:02 04:34:04 04:34:08 04:34:14 04:34:16
Q. I understand that you're saying today that you want to read some context in, but the words that you chose to wrote -- to write in 1999 was that remarkable performance can be achieved by properly chosen irregular codes, correct? 04:34:16 04:34:18 04:34:21 04:34:25 04:34:28
A. It's irregular Gallager codes -- 04:34:33
THE REPORTER: Wait. Wait. Hold on. 04:34:33
THE WITNESS: Sorry. 04:34:33
THE REPORTER: What was your objection? Go ahead. 04:34:33 04:34:33
MR. GLASS: Asked and answered. 04:34:33
Go ahead. Sorry. 04:34:34

THE WITNESS: This is irregular Gallager codes. This is the only thing we discuss here. It is not customary to repeat every single limitation or every single context in every single line. It's understood from the context of what we are talking about here. 04:34:35 04:34:37 04:34:40 04:34:45 04:34:47 04:34:49
BY MR. DOWD: 04:34:50
Q. Now, Page 5 shows a graph showing performance characteristics of different types of codes against the Shannon limit, right? 04:34:51 04:34:55 04:34:57
A. Yes. 04:34:59
Q. And you've got, reading from right to left, regular LDPC codes at the right. Right? 04:34:59 04:35:03
A. Yes. 04:35:08
Q. Turbo codes in the middle? 04:35:08
A. Yes. 04:35:10
Q. Irregular LDPC codes at the left closest to the Shannon limit, right? 04:35:10 04:35:17
A. That is correct. 04:35:19
Q. And so we said a moment ago that an advantage of irregular LDPC codes over turbo codes is their lower complexity; do you recall that? 04:35:21 04:35:32 04:35:38
A. Yes. Now this must also be quantified. It depends a lot on the specific implementation that is used. And, you know, depending if this is 04:35:41 04:35:44 04:35:48

hardware, software, et cetera, these conclusions might vary. 04:35:53 04:35:56
Q. Uh-huh. Well, in the graph on Figure 5, irregular codes -- irregular LDPC codes produce better performance than turbo codes, correct? 04:35:58 04:36:01 04:36:07
A. Than one specific turbo code that we compared it with. This is not necessarily all turbo codes there are. 04:36:10 04:36:12 04:36:16
Q. The answer to my question is, yes, right? 04:36:17
A. It is one specific turbo code. That's what my answer is. 04:36:20 04:36:22
Q. Well, my question was, the graph on Page 5 shows that an irregular LDPC code is outperforming a turbo code, correct? 04:36:24 04:36:29 04:36:36
A. A particular -- 04:36:37
MR. GLASS: Objection. Asked and answered. 04:36:37 04:36:38
Go ahead. 04:36:38
THE WITNESS: A particular irregular code is outperforming a particular turbo code, that is correct. 04:36:39 04:36:41 04:36:48
BY MR. DOWD: 04:36:48
Q. Okay. Now, let's go back to pages -- starting on 2, and the discussion that begins at the bottom of -- actually, I guess it begins near the 04:36:48 04:36:52 04:36:56

top of Page 2 and carries over on Page 3: 04:37:01
"Let us recall some basic notation." 04:37:05
Do you see that there? 04:37:08
A. On the bottom of Page 2? 04:37:09
Q. Sorry. I didn't mean to misdirect you. Near -- near the top of Page 2 -- 04:37:14 04:37:18
A. Yes. 04:37:18
Q. -- there's a paragraph: "Let us recall some basic notation"? 04:37:20 04:37:22
A. Uh-huh, yes. 04:37:24
Q. And what you're saying there is you're describing bipartite graphs, right? 04:37:25 04:37:27
A. I'm describing bipartite graphs, but please note that I don't call them Tanner graphs. 04:37:29 04:37:32
Q. What you say is that these bipartite graphs for LDPC codes are well known, right? 04:37:36 04:37:42
A. A bipartite graph, in particular, for a representation of Gallager type codes was in Gallager's thesis. So, yes. 04:37:47 04:37:52 04:37:55
Q. And so it was well known, correct? 04:37:58
A. Not a Tanner graph, but a bipartite graph. 04:38:00
Q. Now, in the bipartite graphs that you're describing, you say there are variable nodes on the left, right? 04:38:03 04:38:06 04:38:10
A. Yes. 04:38:11

Q. You say there are check nodes on the right? 04:38:11 04:38:14
A. That is correct. 04:38:15
Q. The variable nodes represent the information bits to be encoded, right? 04:38:15 04:38:19
A. No, they present the whole code word. 04:38:22
Q. Well, they represent bits that will be encoded by the LDPC code, right? 04:38:25 04:38:27
A. No, this is incorrect. 04:38:30
Q. So the variable nodes on the left do not represent information bits? 04:38:31 04:38:34
A. No. 04:38:36
Q. Do the check nodes represent parity check constraints? 04:38:36 04:38:39
A. That is correct. 04:38:41
Q. And so the variable nodes on the left are the -- is the code word produced by the code? 04:38:42 04:38:45
A. That is correct. 04:38:47
Q. All right. Now, for an irregular LDPC code, the variable nodes will have different degrees, right? 04:38:48 04:38:59 04:39:02
A. That is correct. 04:39:02
Q. And you give an example where one subset of variable nodes has degree five, right? 04:39:02 04:39:06
A. I believe we have a table with particular 04:39:14

degree profiles. 04:39:18
Q. I'm -- I'm actually just reading from the sentence that starts on the bottom of Page 2 and carries over on to the top of Page 3. 04:39:18 04:39:21 04:39:23
A. It simply is an explanation of what irregularity might mean. The actual examples of profiles should be somewhere in the examples that define later on around Page 24. Whether or not any of those indeed have degree five or only degree five, one would have to check. 04:39:37 04:39:39 04:39:44 04:39:47 04:39:50 04:39:54
Q. Okay. 04:39:56
A. This is simply an example of what irregularity means. 04:39:56 04:39:58
Q. Okay. Let's -- let's stick with the example in Page 2 to 3. As an example of what irregularity means, you give an example where some variable nodes have a degree five and -- withdrawn. 04:39:59 04:40:01 04:40:05 04:40:08
In the example on Pages 2 to 3 of what irregularity means, you give the example where half the variable nodes have degree five and the other half have degree three? 04:40:14 04:40:17 04:40:19 04:40:22
A. That is correct. 04:40:24
Q. And we discussed earlier that if you -- if you look at the bipartite graph of an IRA code -- withdrawn. 04:40:38 04:41:04 04:41:04

If you looked at the bipartite graph of an RA code and half of the variable nodes had degree five and half of the variable nodes had degree three, would that be an irregular RA code? 04:41:12 04:41:15 04:41:18 04:41:22
MR. GLASS: Objection. Vague. Incomplete hypothetical. 04:41:26 04:41:28
THE WITNESS: According to some definition, I believe in the paper, that would be some -- potentially some version of an irregular RA code. 04:41:28 04:41:33 04:41:36 04:41:40
BY MR. DOWD: 04:41:43
Q. Okay. Now, let's go back to Page 5 and the performance chart. As of April '99, you were aware of irregular LDPC codes, right? 04:41:43 04:42:03 04:42:10
A. Yes. 04:42:12
Q. You were also aware of turbo codes, right? 04:42:13
A. Yes. 04:42:16
Q. At this point you were also aware of RA codes, right? 04:42:20 04:42:23
A. Yes. 04:42:24
Q. And you were aware of Luby '97 and Luby '98, right? 04:42:25 04:42:33
A. Yes. 04:42:33
Q. And we see that if we go to Page 34 of the paper, Luby '97 is Reference 5, right? 04:42:33 04:42:36

A. That is correct. 04:42:44
Q. And Luby '98 is Reference 3, right? 04:42:46
A. Yes, that is correct. 04:42:49
Q. Why did you choose to compare the performance of irregular LDPC codes against turbo codes? 04:43:07 04:43:09 04:43:17
A. Because at that point in time there was essentially a race to capacity. People were not necessarily interested in coming up with codes that were the most practical or would be the ones that would be implemented. But people tried to understand why some type of these iterative codes worked and what made them work. 04:43:17 04:43:20 04:43:24 04:43:27 04:43:30 04:43:33 04:43:38
And one way to somehow advance in this theme was to show that one could design better and better codes and to say something or predict somehow how a code would behave. These particular codes are of very, very large length. I believe they're about a million. So this is not something that certainly at that point in time people would have implemented. 04:43:40 04:43:45 04:43:48 04:43:52 04:43:56 04:44:01 04:44:03
But the two main competitors at that point were versions of turbo code codes and, you know, versions of LDPC codes. These were the kind of two big groups where people worked on. 04:44:05 04:44:11 04:44:14 04:44:20
Q. Now, was -- were turbo codes used as a 04:44:26

benchmark for comparison to determine whether you 04:44:30
were a good performing code? 04:44:32

MR. GLASS: Objection. Vague. 04:44:33

THE WITNESS: Turbo codes were invented in 04:44:34
'93, and so they were certainly something that 04:44:37
people worked quite actively. And so it would not 04:44:40
be uncommon to -- to look at a turbo code, for 04:44:46
example, if you wanted to have a comparison. Not 04:44:49
necessarily. But it would not be uncommon to do 04:44:51
that. 04:44:53

BY MR. DOWD: 04:44:53

Q. Okay. So a common way to demonstrate that 04:44:54
what you'd come up with was a good performing code 04:44:57
was to show that it outperformed turbo codes; is 04:45:01
that fair? 04:45:04

A. Typically, a common way of showing that 04:45:04
whatever you do is better is trying to find some 04:45:07
prior art that relates to what you're doing and then 04:45:11
demonstrating that in some aspect you can be doing 04:45:13
better. 04:45:17

Q. And -- and the reason that you chose turbo 04:45:17
codes was that was regarded as a good performing 04:45:21
code, right? 04:45:25

A. Turbo codes were good codes, yes. 04:45:26

Q. Okay. So if you outperform turbo codes, 04:45:29

then you must be even better, right? 04:45:32
A. So definitely -- you know, and again, this was one particular turbo code that we compared with. We didn't necessarily compare to every possible turbo code. But clearly outperforming turbo code was considered something to be desirable. 04:45:36 04:45:39 04:45:41 04:45:45 04:45:47
Q. Okay. Now, if we go in your report to the Paragraph 177. Let me know when you have that. 04:45:50 04:46:13
A. Yes. 04:46:34
Q. There's discussion there of the Frey '99 paper; do you recall that? 04:46:34 04:46:40
A. Yes. 04:46:43
Q. And you're disagreeing with Dr. Frey about what's disclosed in the '99 paper that he wrote, right? 04:46:57 04:47:00 04:47:04
A. That is correct. 04:47:04
MR. DOWD: So let's mark as Exhibit 21, a copy of the Frey '99 paper. 04:47:06 04:47:08
(Urbanke Exhibit 21 was marked for identification and attached to the transcript.) 04:47:12 04:47:12 04:47:29
MR. DOWD: I just got a signal that we need to change tape, so before we launch into this new subject why don't we go off and change tape. 04:47:29 04:47:31 04:47:34
THE VIDEOGRAPHER: This marks the end of 04:47:37

Video No. 3 in the deposition of Dr. Rüdiger Urbanke. We are off the record at 4:47 p.m. 04:47:39 04:47:42 04:47:45

(Recess taken at 4:47 p.m.) 04:56:03

THE VIDEOGRAPHER: Here begins Video No. 4 in the deposition of Dr. Rüdiger Urbanke. We are back on the record at 4:56 p.m. 04:56:03 04:56:05 04:56:10

BY MR. DOWD: 04:56:13

Q. So, Dr. Urbanke, this morning we were talking about the Divsalar paper and RA codes; do you recall that? 04:56:14 04:56:18 04:56:22

A. Yes. 04:56:22

Q. And you testified that RA codes are a particular version of a turbo code; do you recall that? 04:56:23 04:56:27 04:56:29

A. Yes, it's a very slimmed down version, one that strips away every possible thing to get to the simplest possible version that still somewhat has a flavor of a turbo code in there. 04:56:29 04:56:33 04:56:38 04:56:41

Q. Okay. So RA codes, as we've said, are serially -- serial concatenated codes, right? 04:56:44 04:56:51

A. One can interpret them as serial concatenated codes. 04:56:54 04:56:58

Q. There's an outer coder and an inner coder, correct? 04:56:58 04:57:04

A. In the standard version RA codes -- 04:57:04
THE REPORTER: I'm sorry. Can you restate that part, please. 04:57:09 04:57:10
THE WITNESS: In the standard version of an RA code, there's simply a repetition in there. 04:57:10 04:57:12
BY MR. DOWD: 04:57:17
Q. There's a -- 04:57:18
A. A repetition, right. 04:57:18
Q. Well, there's a repetition followed by an interleaver, followed by -- 04:57:20 04:57:23
A. It's a repetition by an interleaver, yes. 04:57:23
Q. Followed by an accumulate? 04:57:26
A. Exactly. 04:57:28
Q. Okay. Now, if you could have the Divsalar paper out and let's then turn to Exhibit 21, which was marked right before the break. 04:57:29 04:57:36 04:57:42
So do you have Exhibit 21 as well? 04:57:45
A. Yes. 04:57:48
Q. Do you recognize this paper? 04:57:48
A. It's called: "Irregular Turbo Codes." 04:57:52
Q. And this is the Frey '99 paper that you analyzed in your report, right? 04:57:54 04:57:59
A. Yes. 04:58:00
Q. And what Frey '99 is talking about is making turbo codes irregular, right? 04:58:04 04:58:08

A. That is correct. 04:58:10
Q. Now, if you turn to -- I'm using the Bates page Hughes 1827, near the back. 04:58:13 04:58:23
A. Yes. 04:58:30
Q. The third cited reference is your Richardson '99 paper, right? 04:58:30 04:58:35
A. I can see that, yes. 04:58:37
Q. Does that refresh your recollection that you provided a copy of that paper to Dr. Frey? 04:58:37 04:58:39
A. No. 04:58:43
Q. Is it correct that the Richardson '99 paper was actually submitted to the IEEE transactions on information theory in July '99? 04:58:43 04:58:51 04:58:53
A. I don't know the exact date, but I believe it was in '99. 04:58:56 04:58:58
Q. All right. Let's go back to the front page there. The cover says that this was presented at the proceedings of the 37th Allerton conference in 1999. 04:59:01 04:59:03 04:59:10 04:59:14
Do you see that at the top? 04:59:15
A. Yes. 04:59:16
Q. Was that one of the Allerton conferences that you attended? 04:59:16 04:59:20
A. I don't have an exact recollection. It's possible, but I don't know for sure whether I was 04:59:21 04:59:24

there or not. 04:59:26
Q. Did you attend the presentation of this paper? 04:59:27 04:59:31
A. If I was there, it would have been likely that I would have, you know, attended the thing. I must say I -- you know, I don't know for sure if I was there. It's about 16 years ago. I go to quite a few conference a year. So I'm not 100 percent sure. 04:59:31 04:59:34 04:59:38 04:59:40 04:59:43 04:59:49
Q. Okay. Were you aware of Exhibit 21 back in 1999? 04:59:49 04:59:53
A. I definitely heard about irregular turbo codes. At what point in time exactly, I don't know. 04:59:53 04:59:57
Q. Now, if we go down under the introduction, the first discussion there is about irregular Gallager codes, another way of saying irregular LDPC codes, right? 05:00:02 05:00:05 05:00:10 05:00:14
A. You're referring to the first line in the introduction, I presume? 05:00:15 05:00:18
Q. Yes. 05:00:19
A. Yes, it refers to irregular Gallager codes there. 05:00:25 05:00:27
Q. And the first listed reference that Dr. Frey cites is the Luby '98 paper, right? 05:00:27 05:00:31
A. That is correct. 05:00:36

Q. And the third paper that he cites there is your Richardson '99 paper, right? 05:00:36 05:00:39
A. That is also correct. 05:00:41
Q. And so what he's saying is: 05:00:42
"Recent work on irregular Gallager codes (low-density parity check codes) has shown that by making the code word bits participate in varying numbers of parity check equations significant coding gains can be achieved." 05:00:45 05:00:48 05:00:52 05:00:55 05:01:00 05:01:02
Right? 05:01:04
A. That's what -- that's how it reads. 05:01:04
Q. So in other words, irregular -- making the LDPC code irregular achieves significant coding gains for LDPC codes, right? 05:01:07 05:01:13 05:01:20
A. Here it refers to "code word bits," which is slightly different what is written in the Luby paper, '98 paper. They don't refer to code word bits. 05:01:23 05:01:27 05:01:30 05:01:34
And so, strictly speaking, perhaps this might not be exactly accurate. 05:01:35 05:01:40
Q. Okay. But what's going on in -- what's going on in the Frey '99 paper is Frey and MacKay have looked at the performance improvement of irregular LDPC codes over regular LDPC codes, right? 05:01:41 05:01:47 05:01:53 05:01:58

A. They have obviously read or -- References 1 point -- 1 and 3, which have some flavors of irregular LDPC codes in the style of Gallager, yes. 05:02:06 05:02:11 05:02:16
Q. Uh-huh. And now they're applying this concept of an irregular code to turbo codes, right? 05:02:22 05:02:25
A. They're applying some irregularity to turbo codes. They're making turbo codes in some way irregular. 05:02:28 05:02:31 05:02:35
Q. Okay. And he says in the abstract: 05:02:36
"Just like regular turbo codes, irregular turbo codes are linear time encodable." 05:02:45 05:02:48 05:02:52
Do you see that? 05:02:54
A. You're still referring to the first page? 05:02:54
Q. I am. It's the last line of the abstract. 05:03:00
A. Oh, the abstract. Yes, that's what it says. 05:03:03 05:03:07
Q. So Frey '99's irregular turbo codes were linear time encodable, right? 05:03:07 05:03:11
A. That is correct. 05:03:13
Q. Now, if we go to the second page, Bates page Hughes 1822, he says at the top: 05:03:22 05:03:26
"In this paper we show that by tweaking a turbo code so that it is irregular we obtain a coding gain of 05:03:34 05:03:37 05:03:38

0.15-DB for a block length of N equals 131072." 05:03:40 05:03:48
Right? 05:03:49
A. Yes, that's what's stated. 05:03:51
Q. Now, tweaking something is not making a big change, right? 05:03:53 05:03:58
A. That I think is in the eye of the beholder. MacKay is British. That might simply be his British understatement. I would not read too much into that. 05:04:01 05:04:05 05:04:09 05:04:14
Q. Okay. But at least we know they didn't -- withdrawn. 05:04:15 05:04:15
They're not saying they have to create a brand new class of codes, right, they're just saying they're tweaking turbo codes? 05:04:17 05:04:19 05:04:23
A. Some people would be boastful about what they're doing; some people would be less boastful. I would not read anything in how they, themselves, describe whatever it took as indicative whether or not this was difficult to do or not. 05:04:24 05:04:28 05:04:30 05:04:33 05:04:35
Q. Okay. Now, in a regular turbo code, each bit is repeated exactly the same time -- number of times, right? 05:04:38 05:04:45 05:04:49
A. In a regular turbo code you would have a fixed number of branches. And so in each of these 05:04:54 05:04:57

branches there would be one of the bits that follows along these branches, yes. 05:05:02 05:05:05

Q. In an irregular turbo code, some of the bits are repeated a different number of times, right? 05:05:07 05:05:09 05:05:14

A. So I assume you're referring to Figure 1 here? 05:05:14 05:05:18

Q. I'm actually not referring to any figure yet. 05:05:19 05:05:26

So my question is just, it's a fact that in an irregular turbo code some bits are repeated a different number of times than other bits, right? 05:05:26 05:05:29 05:05:34

A. I think, you know, this is difficult to make as a statement without referring to a particular way of viewing such a code. Depending on how you view such a code, there's many different interpretations of what you can think of how this code is constructed. 05:05:37 05:05:40 05:05:43 05:05:46 05:05:50 05:05:53

So I think it would be better to refer to a specific way of how you would like to view these codes and then within the specific picture one could talk about the particular concept that you're interested in. 05:05:55 05:05:58 05:06:01 05:06:04 05:06:06

Q. Well, let's turn to page Hughes 1824 in Figure 2. Figure 2 is a -- an irregular turbo code, 05:06:06 05:06:11

right? 05:06:23
A. That's what the heading says in Figure 2. 05:06:23
Q. And you've got information bits in groups along the bottom, right? 05:06:26 05:06:31
A. Yes. 05:06:35
Q. There's F1, F2, F3, through FD, right? 05:06:35
A. Yes, that's correct. 05:06:40
Q. And what it says is that for each fraction of those bits they're going to be repeated a different number of times, right? 05:06:40 05:06:50 05:06:52
A. So he refers to here to code word bits, okay? So one question I would have exactly what he means here, right, does he mean information bits, does he mean related bits of a code word, does he mean the parity bits? It's not 100 percent clear to me what he refers to here. 05:06:59 05:07:07 05:07:12 05:07:16 05:07:20 05:07:23
Q. Well, if you look at Figure 1, there's a fraction F2, right? Do you see that? 05:07:24 05:07:27
A. In Figure 1? 05:07:35
Q. I'm sorry, I misspoke. If you look at Figure 2, there's a fraction F2? 05:07:36 05:07:40
A. Yes, I see that they're fractions. I just wonder exactly, you know, what bits he had in mind here. He refers to them as code word bits. 05:07:42 05:07:46 05:07:48
Q. Okay. The F2 bits will be repeated two 05:07:52

times, right? 05:07:55
A. So there's some bits which refers to them as code word bits, but which would mean all the bits of the code word. He claims that they're repeated a certain numbers of times. 05:07:55 05:07:58 05:08:01 05:08:05
That seems to be that he's misspeaking here. 05:08:06 05:08:09
Q. Well, let's just look at Figure 2. You see that there is -- for the F2 bits, out of the repetition block, there are two edges, right? 05:08:09 05:08:13 05:08:19
A. Yes. 05:08:21
Q. For the F3 bits of the repetition blocks, there are three edges, right? 05:08:22 05:08:25
A. That is correct. 05:08:28
Q. And out of the -- for the FD bits out of the repetition blocks, there are essentially D edges, right? 05:08:28 05:08:29 05:08:32
A. That is correct. My objection was not to the fraction. My objection is to what bits he's actually referring to. If you think of the rules as we established in LDPC world, in the RA world, in the IRA world -- 05:08:33 05:08:37 05:08:41 05:08:44 05:08:50
THE REPORTER: Wait. Slow -- slow down and repeat the acronyms, please. 05:08:51 05:08:52
THE WITNESS: In the LDPC world, the RA 05:08:52

world, or the IRA world, what is meant by irregularity and how irregularity's applied can take on very different forms and shapes. 05:08:56 05:09:01 05:09:06

He's here referring to code word bits, which would imply that he takes every single bit that later on appears in the code word and repeats them a different number of times. 05:09:08 05:09:10 05:09:14 05:09:17

BY MR. DOWD: 05:09:18

Q. Okay. And so let's -- let's just walk through what happens when the bits are inputted -- input to the repeaters, okay? Do you have that in mind? 05:09:19 05:09:24 05:09:29 05:09:35

A. Yes. 05:09:35

Q. So the bits in the fraction F2, those bits will be repeated twice, right? 05:09:36 05:09:42

A. That's what he says. 05:09:43

Q. The bits in the fraction F3 will be repeated three times, right? 05:09:45 05:09:51

A. That's what he claims. 05:09:52

Q. And then the bits in the fraction FD will be repeated D times, right? 05:09:54 05:09:58

A. Yes. 05:10:01

Q. Then the repeated bits are input to a permuter, right? 05:10:05 05:10:10

A. Yes. 05:10:12

Q. And that changes the order of the bits, right? 05:10:13 05:10:16
A. That is correct. 05:10:16
Q. And then the reordered repeated bits are input to a convolutional code, right? 05:10:19 05:10:22
A. I would like to read the description that's actually put in here. 05:10:28 05:10:32
Y3. And he actually doesn't say how this would be done. In general you cannot take all the bits, repeat them, and then simply impose them on the convolutional code. That would not fulfill in general the equations of the convolutional code. 05:11:52 05:11:55 05:11:58 05:12:01 05:12:05
So from the picture itself, it's not apparent exactly how that actually would be done. 05:12:08 05:12:11
Q. Okay. But at least as shown in the picture, the reordered repeated bits are shown as being input to a convolutional code, right? 05:12:14 05:12:16 05:12:19
A. It's not clear that that actually is a valid description of a valid code. 05:12:22 05:12:24
Q. Maybe it's not a valid description and maybe it's not a valid code, but that's what it shows, right? 05:12:26 05:12:28 05:12:30
A. Well, if the picture shows something that is not actually something that exists, I don't understand what that actually would show. 05:12:31 05:12:34 05:12:37

Q. Well, setting aside whether the code exists or whether it doesn't exist, there's a convolutional code at the top, right? 05:12:40 05:12:42 05:12:46
A. There's a box with a convolutional code. Whether or not it's set up in the way he describes it here, actually, you know, can be done in the way that he's describing it is not so clear to me. 05:12:47 05:12:51 05:12:54 05:12:56
Q. Okay. But what the figure shows is that the edges on the permuter go into the convolutional code box, right? 05:12:58 05:13:00 05:13:03
A. There's some connections, but you have to interpret what that actually means, what does such a connection mean. 05:13:03 05:13:05 05:13:10
Q. Okay. Now, keep that open and turn in Divsalar back to Page 5. 05:13:15 05:13:17
An accumulator is a type of convolutional coder, correct? 05:13:28 05:13:31
A. It's a trivial rate 1 convolutional encoder. It's an accumulator. Oh, the repeater, sorry, you're talking about the repeater? 05:13:33 05:13:39 05:13:42
Q. No, I'm talking about an accumulator. 05:13:43
A. Accumulator, yes. 05:13:45
Q. So just so we have a clean question and answer, an accumulator is a type of convolutional coder, right? 05:13:46 05:13:48 05:13:50

A. It's a trivial rate 1 convolutional encoder. 05:13:50 05:14:03
Q. And in Figure 3 of Divsalar, the steps are repeat the bits, interleave the bits in a permuter, and convolutionally encode the bits in accumulator, correct? 05:14:03 05:14:06 05:14:11 05:14:18
A. That is correct. 05:14:18
Q. So let's compare that with Figure 2 of Frey '99. In Figure 2, as shown, the steps are repeat the bits, interleave the bits in a permuter, and then input them to a convolutional code? 05:14:18 05:14:22 05:14:25 05:14:30
A. This cannot actually be done. It's not a mathematically meaningful description in that way. 05:14:33 05:14:36
Q. Oh, really? 05:14:39
A. Yes. 05:14:40
Q. It can be done in Figure 3, but it can't be done in Figure 2; is that your position? 05:14:40 05:14:42
A. In Figure 3, you simply have a system's point of view in which the bits moving in the figure -- in the figure on top, the convolutional encoder -- 05:14:44 05:14:47 05:14:53 05:14:53
THE REPORTER: Wait. Wait. I'm sorry. 05:14:55
THE WITNESS: Let me -- let me start it again. 05:14:55 05:14:55
THE REPORTER: Thank you. I lost you. 05:14:55

Just slower, please. 05:14:55
THE WITNESS: In Figure 3, the final step is simply an accumulator. You can take any sequence of bits and impose them on an accumulator. This is not true for a convolutional encoder. 05:14:56 05:14:58 05:15:00 05:15:04
If you take a standard convolutional encoder, there will be restrictions in which you, you know, this is not clear that that actually can be done in the way that is described. 05:15:05 05:15:08 05:15:11 05:15:13
BY MR. DOWD: 05:15:15
Q. Well, Dr. Urbanke, you just testified that an accumulator is a convolutional encoder, correct? 05:15:15 05:15:18
MR. GLASS: Objection. Mischaracterizes the testimony. 05:15:21 05:15:22
THE WITNESS: And here it's written a convolutional encoder. I can put in here any convolutional code I want. If I put a convolutional code I want, this is not a valid mathematical description. 05:15:23 05:15:25 05:15:28 05:15:31 05:15:33
BY MR. DOWD: 05:15:33
Q. Well, my point is you can put an accumulator in Figure 3 -- I'm sorry -- withdrawn. 05:15:34 05:15:36
You could put an accumulator in Figure 2 of Frey '99 and that would be a convolutional code? 05:15:40 05:15:43
A. It's not described how the bits actually 05:15:45

go into the -- and how the bits would be connected to convolutional code. There is no description in there. I simply see some edges that go to a box that -- 05:15:47 05:15:49 05:15:51 05:15:51

THE REPORTER: Wait. Wait. You need -- no, no, no, no, no. Stop. Repeat your answer, please. Slow down. 05:15:51 05:15:51 05:15:58

THE WITNESS: There's no description in this picture that tells me of what I actually would do with these bits. There's simply a box that says convolutional encoder. What do I do with this bits? 05:15:58 05:16:01 05:16:03 05:16:06

BY MR. DOWD: 05:16:10

Q. Well, my question is, if the convolutional code box of Frey '99 was an accumulator, then it would work, correct? 05:16:11 05:16:13 05:16:18

A. Depends what you do with these bits. Where is the description what is actually done with these bits? How do these bits -- 05:16:19 05:16:22 05:16:22

THE REPORTER: Wait. Slow down. No. Stop. Repeat your answer and slow down. I'll stop you every time. 05:16:22 05:16:22 05:16:28

THE WITNESS: There's no description in this picture of what actually would happen with these bits. There's no indication other than some edges that go to some box. What does that mean? 05:16:28 05:16:32 05:16:34 05:16:37

BY MR. DOWD: 05:16:40
Q. Well, all of the edges that come out of the permuter go to a box called "convolutional codes," right? 05:16:40 05:16:43 05:16:45
A. And what do they do there? 05:16:46
Q. Well, take my question first. You've got to answer my question with the fact. You can't just answer by answering me with a question. So -- 05:16:47 05:16:50 05:16:53
A. Uh-huh. 05:16:56
Q. -- the way this works is, I ask the question, you give me the fact or opinion in response, okay? 05:16:56 05:16:58 05:17:01
A. Yes. 05:17:02
Q. In Figure 2 of Frey '99, all of the edges that exit the permuter go into a box called "convolutional code," correct? 05:17:03 05:17:07 05:17:11
A. The edges or lines that I see going from a box which is called "permuter" to a box that's called "convolutional code"; that's what I see. 05:17:14 05:17:18 05:17:21
Q. Okay. The accumulator of Divsalar is a convolutional code, correct? 05:17:25 05:17:28
A. That is correct. 05:17:30
Q. If I used a -- an accumulator, like in Divsalar, to perform a convolutional encoder -- encoding in the convolutional code box of Frey 05:17:32 05:17:35 05:17:44

Figure 2, that could be done, correct? 05:17:48
MR. GLASS: Objection. Vague. Incomplete 05:17:51
hypothetical. 05:17:53
THE WITNESS: You have not told me what 05:17:53
that means. This -- this figure is meaningless 05:17:54
unless you tell me what the operation actually is 05:17:57
that is performed. It's simply a box with some 05:18:00
lines. This could mean anything. 05:18:02
BY MR. DOWD: 05:18:04
Q. I'm saying, if I perform an accumulation 05:18:04
operation in the convolutional code box of Frey '99, 05:18:08
Figure 2 -- 05:18:15
A. An accumulation of what? 05:18:15
Q. I haven't finished my question. 05:18:16
If I perform an accumulation in the 05:18:18
convolutional code box of Figure 2 of Frey, it could 05:18:22
accumulate the bits output by the permuter, right? 05:18:28
MR. GLASS: Vague. Incomplete 05:18:32
hypothetical. 05:18:33
THE WITNESS: You're saying that I do A, 05:18:33
then it would do A. I agree with that. But it has 05:18:35
nothing to do with the picture. 05:18:38
BY MR. DOWD: 05:18:40
Q. Okay. Let's turn back to Divsalar in 05:18:41
Figure 3. Now, if I wanted to make Divsalar -- 05:18:57

Divsalar's repeat irregular, one way would be to partition the information bits into subblocks and repeat the bits in each block a different number of times, right? 05:19:02 05:19:04 05:19:08 05:19:11

A. One of the many ways of adding irregularity would be to add irregularity in a way of changing the number of times things are repeated. 05:19:12 05:19:18 05:19:22

Q. Okay. 05:19:26

MR. GLASS: And just objection to previous question as calls for a legal conclusion. 05:19:26 05:19:29

Go ahead. 05:19:31

BY MR. DOWD: 05:19:31

Q. And what's shown in Figure 2 of Frey is that you've got a group of bits that you have partitioned into subblocks F1, F2, F3, through FD, and you repeat the bits in each block a different number of times, correct? 05:19:31 05:19:35 05:19:39 05:19:46 05:19:49

MR. GLASS: Same objection. And outside the scope. 05:19:50 05:19:52

THE WITNESS: It shows nodes that have different repetitions -- whatever exactly that means in this paper -- attached to them. 05:19:52 05:19:56 05:20:01

BY MR. DOWD: 05:20:04

Q. So if I took the concept from Frey '99 of partitioning bits into subblocks where I repeat each 05:20:06 05:20:10

subblock a different number of times and I apply 05:20:14
that to the repeater of Divsalar Figure 3, the 05:20:18
result would be an irregular repeat, correct? 05:20:22
MR. GLASS: Objection. Vague. Calls for 05:20:25
a legal conclusion. 05:20:27
THE WITNESS: No, it's false. 05:20:28
MR. GLASS: Calls for a legal conclusion. 05:20:30
Incomplete hypothetical. 05:20:31
Go ahead. 05:20:32
BY MR. DOWD: 05:20:34
Q. So -- 05:20:34
A. It's false. 05:20:33
Q. So are you saying that if I take the input 05:20:35
block to the repeater in Figure 3, divide that into 05:20:40
subblocks and repeat the bits of each subblock 05:20:46
different numbers of times, that's not an irregular 05:20:50
repeat; is that your testimony? 05:20:52
A. That is not what is written -- 05:20:53
MR. GLASS: Same objections. 05:20:53
THE WITNESS: That is not what is written 05:20:54
in Figure 2. What is written in Figure 2 is that 05:20:56
you take the code word bits, which is something 05:20:59
entirely different. 05:21:02
BY MR. DOWD: 05:21:03
Q. Well, try my question. My question is, if 05:21:03