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1	A.　　　　I don't know what this program actually	02:51:15
2	does.　Just because it says:　Repeat-accumulate code	02:51:17
3	simulator, that doesn't mean it actually is a	02:51:21
4	repeat-accumulate simulator or has anything to do.	02:51:24
5	I don't know who, in fact, the author is.　I have no	02:51:28
6	firsthand knowledge.　I have absolutely no idea what	02:51:31
7	this program does.	02:51:34
8	Q.　　　　Fair enough.　I'm actually asking you to	02:51:35
9	set aside the particulars of this program and focus	02:51:37
10	back on Divsalar Figure 3.	02:51:41
11	A.　　　　Okay.	02:51:43
12	Q.　　　　And what I'd like you to assume is that	02:51:43
13	you've got the RA code encoder of Figure 3, okay?	02:51:46
14	A.　　　　Yes.	02:51:54
15	Q.　　　　And you receive an information block of	02:51:56
16	length N into the repeater, okay?	02:51:59
17	A.　　　　Let's assume.	02:52:02
18	Q.　　　　And inside the repeater the block is	02:52:02
19	divided into three subblocks:　Block N1, block N2,	02:52:05
20	block NK, okay?	02:52:11
21	A.　　　　Okay.	02:52:13
22	Q.　　　　And each own of these subblocks is	02:52:13
23	repeated a different number of times, okay?	02:52:16
24	A.　　　　Okay.	02:52:18
25	Q.　　　　If those -- under those facts, the encoder	02:52:19

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

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

1	A. I would say he was working at JPL, if I'm	02:55:48
2	not mistaken, so he would be probably considered	02:55:51
3	towards the standard classical coding group with EE	02:55:55
4	backgrounds.	02:56:03
5	THE REPORTER: If we -- I'm sorry.	02:56:03
6	THE WITNESS: With EE backgrounds.	02:56:03
7	Electric engineering.	02:56:03
8	BY MR. DOWD:	02:56:05
9	Q. Okay. So you were in the classical coding	02:56:05
10	EE background group, right?	02:56:09
11	A. My group was mixed. I myself, have that	02:56:12
12	background. But in -- within Bell Labs, that group	02:56:16
13	was mixed.	02:56:24
14	Q. And Divsalar would have been in the same	02:56:25
15	group as you the way that you've divided the world?	02:56:28
16	A. He has this -- sorry. I would assume	02:56:32
17	without knowing exactly his training that he is	02:56:35
18	trained more classically with EE background.	02:56:38
19	Q. But Dr. MacKay would have been in a	02:56:42
20	different group, according to the way you're looking	02:56:47
21	at the world, right?	02:56:49
22	A. Dr. MacKay played a special role because I	02:56:50
23	believe he was either a student or -- or postdoc of	02:56:54
24	Bob McEliece. He has a background in physics but	02:57:00
25	had strong connections to this group in -- at	02:57:03

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

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

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

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

1   Q.   What does it mean to encode in linear   03:02:08

2   time?   03:02:12

3   A.   What they meant in that paper was that if   03:02:12

4   you take the block length of the code, which   03:02:15

5   sometimes is referred to as N, and if you look at a   03:02:18

6   family of such codes where N is varied and might   03:02:25

7   take on different values, that the effort that is   03:02:30

8   needed to do either the encoding or do the decoding   03:02:34

9   would be a linear function of that parameter N.   03:02:40

10   So perhaps if you had an input that was   03:02:45

11   only 100 long, it would take you, let's say, just   03:02:47

12   100 operations, to keep it simple. But if you had   03:02:50

13   an input that was a thousand long, then it would   03:02:54

14   take you thousands. So it would be proportional to   03:02:57

15   the length of the input.   03:03:00

16   Q.   And that's the same explanation of an   03:03:01

17   encoding and decoding in linear time that you give   03:03:06

18   in your report, right?   03:03:10

19   A.   Yes.   03:03:11

20   Q.   Now, if we go over to the right column --   03:03:16

21   A.   Yes.   03:03:22

22   Q.   -- the last full paragraph in the right   03:03:22

23   column that begins: 03:03:24

24   "Our encoding."   03:03:27

25   Do you have that?   03:03:29

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

1   Q.   Correct.   03:04:32

2   A.   What do you mean with encoding is   03:04:34

3   irregular? You mean whether the code is an   03:04:36

4   irregular code?   03:04:38

5   Q.   Well, let me start there.   03:04:42

6   In Luby '97 the code is an irregular code, 03:04:44

7   correct?   03:04:46

8   A.   It is a very particularly hierarchically 03:04:46

9   structured code in which some of the nodes have 03:04:51

10   irregular degrees, yes.   03:04:55

11   Q.   Okay. And that means that when you're 03:04:57

12   performing an encoding it's an irregular encoding, 03:05:01

13   right?   03:05:07

14   A.   It's not quite clear to me what do you 03:05:07

15   mean by that.   03:05:09

16   Q.   That doesn't make sense to you?   03:05:10

17   A.   No.   03:05:12

18   Q.   Okay. Now, if we continue in the right 03:05:13

19   column, same paragraph, Page 937, it states: 03:05:25

20   "As in many similar applications, the 03:05:29

21   graph is chosen to be sparse, which   03:05:31

22   immediately implies that the encoding and 03:05:34

23   decoding algorithms are fast."   03:05:37

24   Do you see that?   03:05:41

25   A.   Sorry, are we still on the same page?   03:05:41

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

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

1	return to the patents for a second.	03:08:02
2	You've no opinion that the claims of the	03:08:04
3	patents require linear or quadratic, right?	03:08:07
4	A. No.	03:08:11
5	Q. You have no opinion that the claims of the	03:08:12
6	patents actually require that it is a commercially	03:08:14
7	practicable code, right?	03:08:18
8	A. No.	03:08:19
9	Q. Okay. So if we go back to Luby '97, we	03:08:20
10	can agree that Luby '97 does disclose an irregular	03:08:34
11	LDGM; is that correct?	03:08:41
12	A. It enclose -- it -- it discloses a very	03:08:42
13	particular irregular and hierarchical LDGM/LDPC	03:08:46
14	combination.	03:08:51
15	Q. Now, if we turn to Page 930 -- withdrawn.	03:08:52
16	If we go to Page 943, the portion that	03:08:56
17	begins with the heading: "8."	03:09:00
18	A. 943. Section 8?	03:09:04
19	Q. Yes. That first paragraph, if you could	03:09:18
20	just read that to yourself for a moment and then let	03:09:22
21	me know when you've read it.	03:09:25
22	A. Yes, I read it.	03:10:16
23	Q. Okay. The matrix MB that they're	03:10:18
24	describing there, that is the generator matrix in	03:10:22
25	Luby, right?	03:10:27

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

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

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

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

1	A. In hindsight, or in 2015, you might call	03:21:12
2	this a Tanner graph representation, yes.	03:21:15
3	Q. And the graph that they're talking about	03:21:17
4	is shown in Figure 1, right?	03:21:19
5	A. Yes, it's shown in Figure 1A, I believe.	03:21:23
6	Q. Right. Now, Tanner graphs existed before	03:21:28
7	1997, right?	03:21:31
8	A. So Tanner's paper was published, I	03:21:34
9	believe, sometimes in the '80s.	03:21:38
10	But, you know, just from my own	03:21:41
11	experience, in the -- in our own '99 paper in April,	03:21:45
12	when we submitted it to be -- to the journal, we	03:21:49
13	actually do not cite it. And I believe I was at	03:21:52
14	that point actually not aware of the paper. It is	03:21:55
15	in the final 2001 published version.	03:21:59
16	And I don't remember now who alerted me to	03:22:01
17	that paper. But at least in the '99 somehow April	03:22:08
18	time frame, I must have not been aware of that	03:22:13
19	paper.	03:22:16
20	Q. Okay. Well, setting aside what -- what	03:22:17
21	you were or were not aware of, in Luby '97 they're	03:22:19
22	describing a bipartite graph that has message nodes	03:22:27
23	on the left and check bit nodes on the right?	03:22:36
24	Right?	03:22:39
25	A. They're describing exactly the picture	03:22:40

1	that was given in terms in -- gathered during his	03:22:42
2	60s thesis.	03:22:46
3	Q. And what they say is that the graph B has	03:22:48
4	N left nodes and beta N right nodes corresponding to	03:22:51
5	the message bits and the check bits respectively,	03:22:56
6	right?	03:22:59
7	A. That is correct.	03:22:59
8	Q. Now, to make the code irregular, you can	03:23:00
9	have two different degrees for the message nodes on	03:23:06
10	the left? Right?	03:23:13
11	A. To make it irregular what you have to do	03:23:14
12	is to choose, let's say, either variable or check	03:23:16
13	nodes and -- or both and decide that some of these	03:23:22
14	nodes within the same group would have different	03:23:26
15	degrees.	03:23:29
16	Q. And that's what Luby '97 does, right?	03:23:30
17	A. Yes. Within the structure of these	03:23:36
18	cascaded or hierarchical LDGM/LDPC codes, they	03:23:38
19	introduce a notion of irregularity.	03:23:44
20	Q. Now, in Luby '97, the information bit	03:23:58
21	variable nodes have different degree profiles,	03:24:07
22	right?	03:24:13
23	A. In the -- yes, in this picture they have	03:24:13
24	different degrees. So there's a certain fraction of	03:24:35
25	nodes that has a certain degree. And there's	03:24:38

1	something which is called a "degree profile" that	03:24:42
2	describes what fraction of the nodes has what	03:24:46
3	degree.	03:24:48
4	Q. Okay. So there's some fraction of	03:24:48
5	information bit nodes that has one degree and	03:24:53
6	another fraction of information bit nodes that has a	03:24:56
7	different degree, right?	03:25:00
8	A. That is correct. There is a degree	03:25:03
9	profile that describes what fraction of the various	03:25:05
10	nodes has what degree.	03:25:08
11	Q. And what that means is that the first	03:25:10
12	fraction -- withdrawn.	03:25:24
13	What that means is that the information	03:25:25
14	bits of the first fraction will be repeated a	03:25:28
15	different number of times than the information bits	03:25:31
16	of the second fraction?	03:25:33
17	A. What it means is that the degrees, the	03:25:34
18	edges -- the number of edges that one such variable	03:25:36
19	node would have is that that, call it degree, would	03:25:40
20	vary --	03:25:40
21	THE REPORTER: Sorry.	03:25:40
22	"That that..."	03:25:49
23	THE WITNESS: Let me restart it.	03:25:49
24	THE REPORTER: Thank you.	03:25:49
25	THE WITNESS: That what it means is that	03:25:50

#		Time
1	for different variables the number of edges that	03:25:52
2	such a variable would have would depend on to which	03:25:56
3	group this bit belongs to. So there might be some	03:26:01
4	fraction of bits that perhaps has two edges	03:26:05
5	outgoing, there's some edges that perhaps has four	03:26:10
6	bit -- four edges going out, and there's some bits	03:26:13
7	that perhaps has five edges going out.	03:26:15
8	BY MR. DOWD:	03:26:17
9	Q. Okay. And the number of edges that are	03:26:17
10	going out from an information node, that determines	03:26:21
11	how many times the bit of that node is repeated,	03:26:28
12	right?	03:26:31
13	A. "Repeat," unless you give me an exact	03:26:31
14	definition, which I don't think is in this paper	03:26:34
15	here, it simply means that in a graph the number of	03:26:37
16	edges that go out from such a bit is different.	03:26:40
17	That's what it means.	03:26:43
18	Q. So you don't know what "repeat" means?	03:26:44
19	MR. GLASS: Objection. Mischaracterizes	03:26:47
20	the testimony.	03:26:48
21	THE WITNESS: "Repeat" can have many, many	03:26:49
22	different meanings. I don't see, you know, in this	03:26:52
23	paper that the word "repeat" is being used, being	03:26:54
24	used as an edge degree profile or as a variable node	03:26:56
25	degree profile.	03:27:01

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1	in Luby '98 to have some message nodes with a high	03:49:52
2	degree and some message nodes with a low degree and	03:49:57
3	I apply that to the RA graph of Exhibit 10, what you	03:49:58
4	would get is some information nodes at the top have	03:50:04
5	a greater number of edges than others, right?	03:50:08
6	MR. GLASS: Same objection.	03:50:12
7	THE WITNESS: So if you start with the	03:50:13
8	assumption that you represent an RA code in terms of	03:50:16
9	that diagram which was not what was in the	03:50:19
10	state-of-the-art, if in addition you tell me that	03:50:23
11	these nodes have very specific roles which is not in	03:50:26
12	Exhibit 10 nor anywhere else written, if in addition	03:50:30
13	then you tell me which nodes exactly you would like	03:50:34
14	to make irregular and you have a very specific	03:50:36
15	notion of how you do that, then you can arrive at	03:50:39
16	IRA codes.	03:50:44
17	BY MR. DOWD:	03:50:44
18	Q. At an IRA code?	03:50:44
19	A. If you tell me that, make the RA code an	03:50:46
20	IRA code in --	03:50:49
21	THE REPORTER: Wait. Wait. Wait. I	03:50:49
22	didn't get that. Say it again.	03:50:52
23	THE WITNESS: If you tell me take the RA	03:50:52
24	code and make it an IRA code, then you get an IRA	03:50:54
25	code. But that's, again, tautology. You're simply	03:50:57

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

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

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

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1	You see there are -- there are six	03:54:16
2	information nodes actually drawn on the page?	03:54:18
3	A.　　　　There are six nodes on top, yes.	03:54:20
4	Q.　　　　Y3.　And so Figure 12 -- withdrawn.	03:54:23
5	Exhibit 12 shows the Tanner graph of a RA	03:54:28
6	code where three of the information bits have a	03:54:32
7	higher degree than the other three information bits,	03:54:37
8	right?	03:54:41
9	MR. GLASS:　Incomplete hypothetical.	03:54:41
10	THE WITNESS:　In hindsight, and with	03:54:42
11	2015-vision, that can be interpreted in the	03:54:44
12	particular way that you're saying, yes.	03:54:48
13	BY MR. DOWD:	03:54:51
14	Q.　　　　Okay.	03:54:51
15	MR. GLASS:　Actually, would you mind if we	03:55:09
16	go off the record for a minute?	03:55:10
17	MR. DOWD:　Let me just wrap this up and	03:55:12
18	then we can do that.	03:55:14
19	MR. GLASS:　Sure.	03:55:15
20	BY MR. DOWD:	03:55:16
21	Q.　　　　Now, if we go to page -- just to finish up	03:55:25
22	Luby, and then we can take that break, if we go to	03:55:28
23	Page 931.	03:55:33
24	A.　　　　Exhibit 17?	03:55:38
25	Q.　　　　Yes.	03:55:41

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

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

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

1	the edges are mapped onto the check nodes. So it	03:59:42
2	simply means, a priori, that there's more number of	03:59:45
3	edges that are going out, and then that can mean	03:59:49
4	that it contributes to a different number, but it	03:59:53
5	doesn't necessarily have to mean that.	03:59:57
6	Q. Each outgoing edge from an information	03:59:59
7	node is going to connect to a check node, right?	04:00:03
8	A. Yes. But several of them might connect to	04:00:09
9	the same, that's entirely possible.	04:00:12
10	Q. So it could be that you have multiple	04:00:14
11	information node edges connecting to the same check	04:00:19
12	node?	04:00:22
13	A. Yes.	04:00:22
14	Q. But my question is that if you take one	04:00:23
15	information node that has, say, four edges and	04:00:29
16	another information node that has only two edges,	04:00:34
17	the number of check nodes to which those two	04:00:37
18	contribute is different?	04:00:40
19	A. It could be or it could not be.	04:00:41
20	Q. Even though there's only two edges --	04:00:44
21	A. Could be.	04:00:46
22	Q. -- it could contribute to four check	04:00:46
23	nodes?	04:00:51
24	A. No. But it could connect to two and	04:00:51
25	the --	

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

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1	They're using the -- what's called the flipping	04:01:56
2	algorithm, which has very, very bad performance.	04:02:00
3	Now, as we talked about in the '98 paper,	04:02:05
4	the algorithm is a mixture of the flipping and the	04:02:10
5	Gallager A, so it is neither flipping nor is it	04:02:13
6	message passing. Not even the first part is really	04:02:16
7	message passing. The first part is some simplified	04:02:21
8	version of message passing, but the overall decoder	04:02:26
9	is some mixture of that.	04:02:29
10	And so the only conclusion that he can	04:02:30
11	draw is that by using irregular codes, as they have	04:02:33
12	done with this particular type of decoder, and using	04:02:37
13	an irregularity as they have described, they can do	04:02:39
14	better using a different type of decoder than with	04:02:43
15	just the flipping algorithm and regular codes.	04:02:48
16	BY MR. DOWD:	04:02:53
17	Q. Okay. Well, let's set that aside, then,	04:02:53
18	and go down to the last paragraph before the	04:02:55
19	conclusion.	04:02:57
20	Luby '98 says in the summary:	04:02:57
21	"Irregular Codes 14 and 22 appear	04:03:00
22	superior to any regular code in practice	04:03:02
23	and irregular Codes 10 prime and 14 prime	04:03:05
24	are far superior to any regular code."	04:03:08
25	Have I read that correctly?	04:03:12

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

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

1	mentions here. I don't know exactly what is in this	04:06:02
2	progress report.	04:06:05
3	But he at least, you know, had some idea	04:06:06
4	about Divsalar.	04:06:10
5	Q. Okay. And Luby also in '98 was aware of	04:06:13
6	Frey, if you look at Reference 5, right?	04:06:17
7	A. He has Reference 5, yes, that he	04:06:20
8	recollects.	04:06:25
9	Q. And, of course, if you turn the page to	04:06:25
10	934, References 10 through 12 are papers by MacKay,	04:06:28
11	right?	04:06:33
12	A. Yes, there's some references to MacKay in	04:06:33
13	there.	04:06:47
14	Q. So Luby's aware of MacKay's work in '98,	04:06:48
15	right?	04:06:53
16	A. Yes, he has some citation to MacKay's work	04:06:53
17	in '98. I -- I must say that on this paper here I	04:06:57
18	actually don't see the publication date. We're	04:07:00
19	referring to this as Luby '98. Whether or not that	04:07:02
20	actually is the version that came out in '98, I'm	04:07:06
21	not sure.	04:07:10
22	Q. And -- well, you've rendered no opinion	04:07:12
23	that Luby '98 was published on any date other than	04:07:17
24	'98 in your report, correct?	04:07:20
25	A. I don't know if this particular version	04:07:22

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

1	(Urbanke Exhibit 18 was marked for	04:16:29
2	identification and attached to the	04:16:29
3	transcript.)	04:16:29
4	(Urbanke Exhibit 19 was marked for	04:16:29
5	identification and attached to the	04:16:29
6	transcript.)	04:16:29
7	BY MR. DOWD:	04:16:29
8	Q. 18 bears Production No. Caltech 23593,	04:16:30
9	Exhibit 19 bears Caltech Production No. 93390.	04:16:36
10	Do you have those?	04:16:41
11	A. Yes.	04:16:44
12	Q. Okay. Let's start with Exhibit 18. Do	04:16:45
13	you recognize this?	04:16:48
14	A. Yes, that is probably the e-mail that we	04:16:49
15	sent to a small subset of people when we worked on	04:16:54
16	the paper. And it seems to refer to the	04:17:01
17	Richardson '99 paper.	04:17:08
18	Q. Okay. And if we turn to Exhibit 19, do	04:17:10
19	you recognize that?	04:17:13
20	A. Y3, it seems to be essentially the same	04:17:24
21	e-mail -- I don't.	04:17:37
22	Q. Y3, I'll represent to you that it appears	04:17:41
23	to be the same e-mail, and the only difference is	04:17:45
24	that Exhibit 19, Caltech has represented to us, was	04:17:48
25	produced from Dr. McEliece's files?	04:17:51

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

1	it was available there or not. But, you know, if it	04:19:07
2	was written there, you know, there's a -- there's a	04:19:10
3	chance that it was. But I don't have a particular	04:19:13
4	recollection.	04:19:15
5	Q. Would you have -- you see Exhibit 18 is	04:19:18
6	sent to Dr. Divsalar at JPL?	04:19:21
7	A. I see his e-mail address, yes.	04:19:24
8	Q. Would you have told Dr. Divsalar that a	04:19:26
9	preprint of your Richardson '99 paper was available	04:19:28
10	for download at a website if it was not available	04:19:31
11	for download at the website?	04:19:34
12	A. No, I'm sure we had the intention to make	04:19:35
13	it available there. Whether or not it was then	04:19:38
14	actually available, I don't know.	04:19:41
15	Q. So to the best of your recollection,	04:19:43
16	starting in April of 1999, the Richardson 1999 paper	04:19:45
17	was distributed to colleagues?	04:19:53
18	A. We sent --	04:19:56
19	MR. GLASS: Objection. Calls for a legal	04:19:59
20	conclusion.	04:20:00
21	Go ahead.	04:20:01
22	THE WITNESS: As far as I recall, there	04:20:03
23	was a set of people, perhaps 20, perhaps something	04:20:04
24	on this order, that this e-mail was sent to.	04:20:07
25	///	

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

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

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

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

#		
1	version that was published differs in some	04:25:03
2	significant portions from that particular version	04:25:07
3	here from April 6th.	04:25:09
4	Q. All right. Let's go back to Exhibit 15,	04:25:13
5	which is MacKay's Ambleside '99 paper. Let me know	04:25:39
6	when you have that. It's the one that looks like	04:25:49
7	that (indicating). It could be the one that's	04:27:33
8	folded over in front of you there.	04:27:35
9	A. This one? No, this is my report. I see.	04:27:39
10	Yes, that's it.	04:27:41
11	Q. All right. So you now have Exhibit 15?	04:27:42
12	A. Yes, I have Exhibit 15.	04:27:44
13	Q. And don't lose Exhibit 20, your	04:27:46
14	Richardson '99 paper.	04:27:48
15	So in -- in MacKay's Ambleside '99 paper,	04:27:50
16	Exhibit 15, if you turn to the last page, the last	04:28:02
17	reference cited is: Urbanke/Richardson/Shokrollahi	04:28:05
18	1999 design of provably good low-density parity	04:28:09
19	check codes submitted.	04:28:13
20	Do you see that?	04:28:14
21	A. Yes.	04:28:15
22	Q. And that's the same title as Exhibit 20,	04:28:15
23	right?	04:28:20
24	A. Yes.	04:28:20
25	Q. Does that refresh your recollection that	04:28:20

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1   you sent a copy of Exhibit 20 to MacKay?   04:28:23

2   A.   No, I don't know how he got it, but, you   04:28:25

3   know, I'm not shocked that he got it. But I don't   04:28:28

4   have any specific recollection.   04:28:30

5   Q.   So we can agree that Exhibit 20 was   04:28:32

6   publically available in 1999?   04:28:40

7   MR. GLASS: Objection. Calls for a legal   04:28:41

8   conclusion.   04:28:43

9   THE WITNESS: What I know and now see also   04:28:43

10 through the e-mails, that it was sent to a set of   04:28:48

11 people. My recollection, it might be on the order   04:28:51

12 of 20. And we have established that it was sent,   04:28:53

13 obviously, to Divsalar and McEliece. Unfortunately,   04:28:58

14 I don't have a recollection about the other set of   04:29:04

15 people that might have been on that list.   04:29:06

16 BY MR. DOWD: 04:29:08

17 Q.   Okay. But that distribution to the 20   04:29:08

18 people, that was just a distribution to people in   04:29:10

19 the field for them to read and learn what they could   04:29:14

20 from the paper?   04:29:19

21 A.   Yes.   04:29:20

22 Q.   And there was no restriction on their   04:29:20

23 reading it or using it in any way, right?   04:29:22

24 A.   It's understood that if a paper is not   04:29:25

25 published that, you know, for example, you could not   04:29:29

1	go and simply, you know, for example, read through	04:29:32
2	parts of it.	04:29:36
3	So there are some implicit restrictions	04:29:37
4	which are not mentioned in the e-mail which are the	04:29:40
5	standard ones of proper conduct in the field.	04:29:43
6	Q. Fair enough. I -- I don't mean to suggest	04:29:45
7	that they could plagiarize your work or anything	04:29:47
8	like that. I -- I just mean to say that the -- the	04:29:50
9	people to whom you distributed this, you didn't	04:29:53
10	require them to sign some kind of confidentiality	04:29:56
11	agreement before you sent the e-mail?	04:29:58
12	A. I don't see anything in the e-mail that	04:29:59
13	would suggest that, no.	04:30:02
14	Q. Okay. Now, if we go to Paragraph 75 of	04:30:04
15	your report, there's some discussion there and at	04:30:23
16	other places in the report about how in the	04:30:29
17	1999/2000 time frame it would have been	04:30:34
18	counterintuitive that making codes simpler can	04:30:37
19	result in better performance.	04:30:41
20	Do you see that?	04:30:42
21	A. Yes. Sorry, which paragraph are we	04:30:43
22	talking about, 75?	04:30:47
23	Q. I'm pointing specifically to Paragraph 75	04:30:48
24	of your report.	04:30:50
25	A. Yes, okay.	04:30:51

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

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

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

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

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

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

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

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

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

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

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1	benchmark for comparison to determine whether you	04:44:30
2	were a good performing code?	04:44:32
3	MR. GLASS: Objection. Vague.	04:44:33
4	THE WITNESS: Turbo codes were invented in	04:44:34
5	'93, and so they were certainly something that	04:44:37
6	people worked quite actively. And so it would not	04:44:40
7	be uncommon to -- to look at a turbo code, for	04:44:46
8	example, if you wanted to have a comparison. Not	04:44:49
9	necessarily. But it would not be uncommon to do	04:44:51
10	that.	04:44:53
11	BY MR. DOWD:	04:44:53
12	Q. Okay. So a common way to demonstrate that	04:44:54
13	what you'd come up with was a good performing code	04:44:57
14	was to show that it outperformed turbo codes; is	04:45:01
15	that fair?	04:45:04
16	A. Typically, a common way of showing that	04:45:04
17	whatever you do is better is trying to find some	04:45:07
18	prior art that relates to what you're doing and then	04:45:11
19	demonstrating that in some aspect you can be doing	04:45:13
20	better.	04:45:17
21	Q. And -- and the reason that you chose turbo	04:45:17
22	codes was that was regarded as a good performing	04:45:21
23	code, right?	04:45:25
24	A. Turbo codes were good codes, yes.	04:45:26
25	Q. Okay. So if you outperform turbo codes,	04:45:29

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

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Line		Time
1	Video No. 3 in the deposition of	04:47:39
2	Dr. Rüdiger Urbanke. We are off the record at	04:47:42
3	4:47 p.m.	04:47:45
4	(Recess taken at 4:47 p.m.)	04:56:03
5	THE VIDEOGRAPHER: Here begins Video No. 4	04:56:03
6	in the deposition of Dr. Rüdiger Urbanke. We are	04:56:05
7	back on the record at 4:56 p.m.	04:56:10
8	BY MR. DOWD:	04:56:13
9	Q. So, Dr. Urbanke, this morning we were	04:56:14
10	talking about the Divsalar paper and RA codes; do	04:56:18
11	you recall that?	04:56:22
12	A. Yes.	04:56:22
13	Q. And you testified that RA codes are a	04:56:23
14	particular version of a turbo code; do you recall	04:56:27
15	that?	04:56:29
16	A. Yes, it's a very slimmed down version, one	04:56:29
17	that strips away every possible thing to get to the	04:56:33
18	simplest possible version that still somewhat has a	04:56:38
19	flavor of a turbo code in there.	04:56:41
20	Q. Okay. So RA codes, as we've said, are	04:56:44
21	serially -- serial concatenated codes, right?	04:56:51
22	A. One can interpret them as serial	04:56:54
23	concatenated codes.	04:56:58
24	Q. There's an outer coder and an inner coder,	04:56:58
25	correct?	04:57:04

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

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

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

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

1	A. They have obviously read or -- References	05:02:06
2	1 point -- 1 and 3, which have some flavors of	05:02:11
3	irregular LDPC codes in the style of Gallager, yes.	05:02:16
4	Q. Uh-huh. And now they're applying this	05:02:22
5	concept of an irregular code to turbo codes, right?	05:02:25
6	A. They're applying some irregularity to	05:02:28
7	turbo codes. They're making turbo codes in some way	05:02:31
8	irregular.	05:02:35
9	Q. Okay. And he says in the abstract:	05:02:36
10	"Just like regular turbo codes,	05:02:45
11	irregular turbo codes are linear time	05:02:48
12	encodable."	05:02:52
13	Do you see that?	05:02:54
14	A. You're still referring to the first page?	05:02:54
15	Q. I am. It's the last line of the abstract.	05:03:00
16	A. Oh, the abstract. Yes, that's what it	05:03:03
17	says.	05:03:07
18	Q. So Frey '99's irregular turbo codes were	05:03:07
19	linear time encodable, right?	05:03:11
20	A. That is correct.	05:03:13
21	Q. Now, if we go to the second page, Bates	05:03:22
22	page Hughes 1822, he says at the top:	05:03:26
23	"In this paper we show that by	05:03:34
24	tweaking a turbo code so that it is	05:03:37
25	irregular we obtain a coding gain of	05:03:38

1	0.15-DB for a block length of N equals	05:03:40
2	131072."	05:03:48
3	Right?	05:03:49
4	A. Yes, that's what's stated.	05:03:51
5	Q. Now, tweaking something is not making a	05:03:53
6	big change, right?	05:03:58
7	A. That I think is in the eye of the	05:04:01
8	beholder. MacKay is British. That might simply be	05:04:05
9	his British understatement. I would not read too	05:04:09
10	much into that.	05:04:14
11	Q. Okay. But at least we know they didn't --	05:04:15
12	withdrawn.	05:04:15
13	They're not saying they have to create a	05:04:17
14	brand new class of codes, right, they're just saying	05:04:19
15	they're tweaking turbo codes?	05:04:23
16	A. Some people would be boastful about what	05:04:24
17	they're doing; some people would be less boastful.	05:04:28
18	I would not read anything in how they, themselves,	05:04:30
19	describe whatever it took as indicative whether or	05:04:33
20	not this was difficult to do or not.	05:04:35
21	Q. Okay. Now, in a regular turbo code, each	05:04:38
22	bit is repeated exactly the same time -- number of	05:04:45
23	times, right?	05:04:49
24	A. In a regular turbo code you would have a	05:04:54
25	fixed number of branches. And so in each of these	05:04:57

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1	branches there would be one of the bits that follows	05:05:02
2	along these branches, yes.	05:05:05
3	Q. In an irregular turbo code, some of the	05:05:07
4	bits are repeated a different number of times,	05:05:09
5	right?	05:05:14
6	A. So I assume you're referring to Figure 1	05:05:14
7	here?	05:05:18
8	Q. I'm actually not referring to any figure	05:05:19
9	yet.	05:05:26
10	So my question is just, it's a fact that	05:05:26
11	in an irregular turbo code some bits are repeated a	05:05:29
12	different number of times than other bits, right?	05:05:34
13	A. I think, you know, this is difficult to	05:05:37
14	make as a statement without referring to a	05:05:40
15	particular way of viewing such a code. Depending on	05:05:43
16	how you view such a code, there's many different	05:05:46
17	interpretations of what you can think of how this	05:05:50
18	code is constructed.	05:05:53
19	So I think it would be better to refer to	05:05:55
20	a specific way of how you would like to view these	05:05:58
21	codes and then within the specific picture one could	05:06:01
22	talk about the particular concept that you're	05:06:04
23	interested in.	05:06:06
24	Q. Well, let's turn to page Hughes 1824 in	05:06:06
25	Figure 2. Figure 2 is a -- an irregular turbo code,	05:06:11

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

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

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1	world, or the IRA world, what is meant by	05:08:56
2	irregularity and how irregularity's applied can take	05:09:01
3	on very different forms and shapes.	05:09:06
4	He's here referring to code word bits,	05:09:08
5	which would imply that he takes every single bit	05:09:10
6	that later on appears in the code word and repeats	05:09:14
7	them a different number of times.	05:09:17
8	BY MR. DOWD:	05:09:18
9	Q. Okay. And so let's -- let's just walk	05:09:19
10	through what happens when the bits are inputted --	05:09:24
11	input to the repeaters, okay? Do you have that in	05:09:29
12	mind?	05:09:35
13	A. Yes.	05:09:35
14	Q. So the bits in the fraction F2, those bits	05:09:36
15	will be repeated twice, right?	05:09:42
16	A. That's what he says.	05:09:43
17	Q. The bits in the fraction F3 will be	05:09:45
18	repeated three times, right?	05:09:51
19	A. That's what he claims.	05:09:52
20	Q. And then the bits in the fraction FD will	05:09:54
21	be repeated D times, right?	05:09:58
22	A. Yes.	05:10:01
23	Q. Then the repeated bits are input to a	05:10:05
24	permuter, right?	05:10:10
25	A. Yes.	05:10:12

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

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

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

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

1	go into the -- and how the bits would be connected	05:15:47
2	to convolutional code. There is no description in	05:15:49
3	there. I simply see some edges that go to a box	05:15:51
4	that --	05:15:51
5	THE REPORTER: Wait. Wait. You need --	05:15:51
6	no, no, no, no, no. Stop. Repeat your answer,	05:15:51
7	please. Slow down.	05:15:58
8	THE WITNESS: There's no description in	05:15:58
9	this picture that tells me of what I actually would	05:16:01
10	do with these bits. There's simply a box that says	05:16:03
11	convolutional encoder. What do I do with this bits?	05:16:06
12	BY MR. DOWD:	05:16:10
13	Q. Well, my question is, if the convolutional	05:16:11
14	code box of Frey '99 was an accumulator, then it	05:16:13
15	would work, correct?	05:16:18
16	A. Depends what you do with these bits.	05:16:19
17	Where is the description what is actually done with	05:16:22
18	these bits? How do these bits --	05:16:22
19	THE REPORTER: Wait. Slow down. No.	05:16:22
20	Stop. Repeat your answer and slow down. I'll stop	05:16:22
21	you every time.	05:16:28
22	THE WITNESS: There's no description in	05:16:28
23	this picture of what actually would happen with	05:16:32
24	these bits. There's no indication other than some	05:16:34
25	edges that go to some box. What does that mean?	05:16:37

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

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