UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00210
U.S. Patent No. 7,116,710

PETITIONER'S DEMONSTRATIVES FOR ORAL ARGUMENT

Apple Inc., Petitioner
v.
California Institute of Technology, Patent Owner

Petitioner's Demonstrative Slides
U.S. Patent 7,116,710

Case No. IPR2017-00210
United States Patent and Trademark Office
April 19, 2018

Roadmap

- **The Claims Are Invalid**
- **PO's Failure to Cross-Examine**
- **Response to Surreplies**

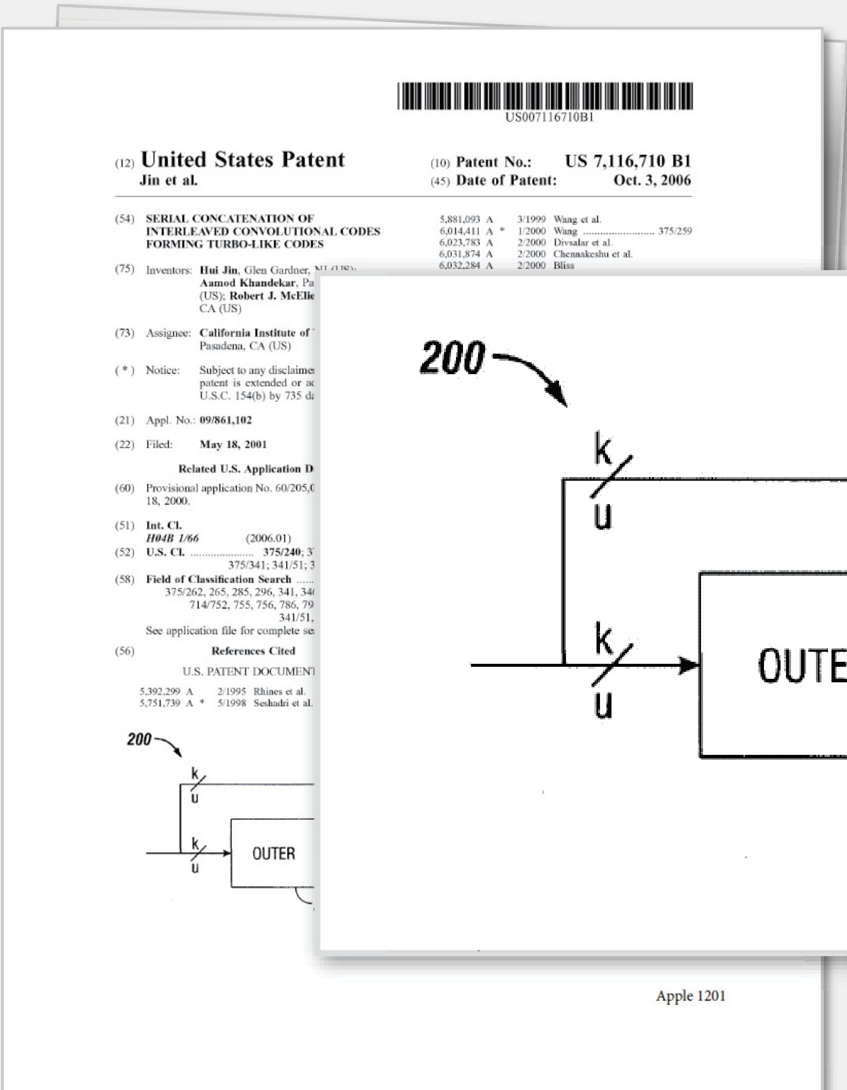
Roadmap

- **The Claims Are Invalid**
- PO's Failure to Cross-Examine
- Response to Surreplies

The Claims Are Invalid

- Claims 1 and 3 are anticipated by Frey
- Claims 1–8 and 11–14 are obvious over Divsalar and Frey
- Claims 15–17, 19–22, and 24–33 are Divsalar, Frey, and Luby97

’710 Patent Claims a Conventional Coder Combined With a Known Irregularity Technique


US007116710B1

(12) United States Patent
Jin et al.

(10) Patent No.: US 7,116,710 B1
(45) Date of Patent: Oct. 3, 2006

(54) SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

(75) Inventors: Hui Jin, Glen Gardner, NJ (US); Aamod Khandekar, Pa (US); Robert J. McEliece CA (US)

(73) Assignee: California Institute of Pasadena, CA (US)

(*) Notice: Subject to any disclaimer patent is extended or ad U.S.C. 154(b) by 735 da

(21) Appl. No.: 09/861,102

(22) Filed: May 18, 2001

Related U.S. Application D

(60) Provisional application No. 60/205,0 18, 2000.

(51) Int. Cl.
H04B 1/66 (2006.01)

(52) U.S. Cl. 375/240; 3 375/341; 341/51; 3

(58) Field of Classification Search ..... 375/262, 265, 285, 296, 341, 34 714/752, 755, 756, 786, 79 341/51, See application file for complete se

(56) References Cited

U.S. PATENT DOCUMENT

5,392,299 A 2/1995 Rhines et al.
5,751,739 A * 5/1998 Seshadri et al.
5,881,093 A 3/1999 Wang et al.
6,014,411 A * 1/2000 Wang 375/259
6,023,783 A 2/2000 Divsalar et al.
6,031,874 A 2/2000 Chennakeshu et al.
6,032,284 A 2/2000 Bliss

Apple 1201

’710 Patent Fig. 2

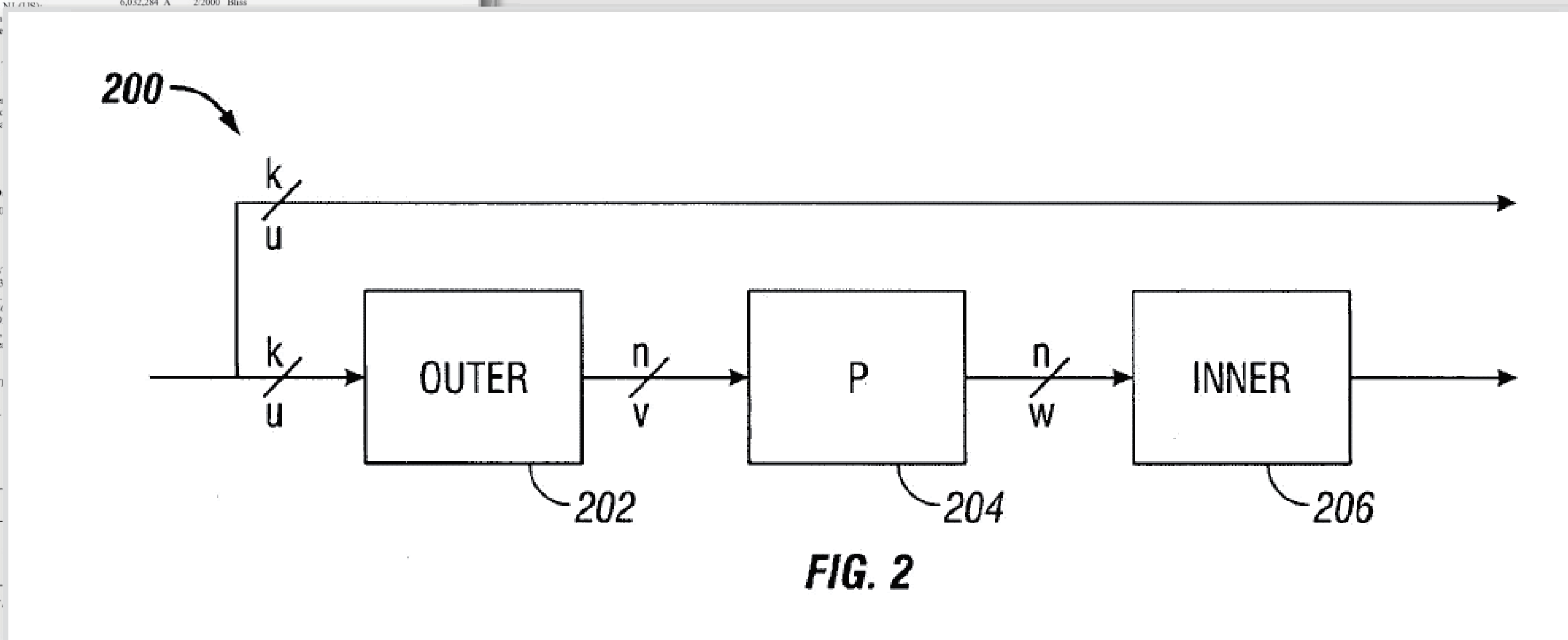


FIG. 2

Ex. 1001 [’710 patent] at Fig. 2

Pet. at 22; Ex. 1006 [Davis Decl.] at ¶¶ 97-98

Divsalar Discloses Every Aspect Except Irregularity

Divsalar Fig. 3

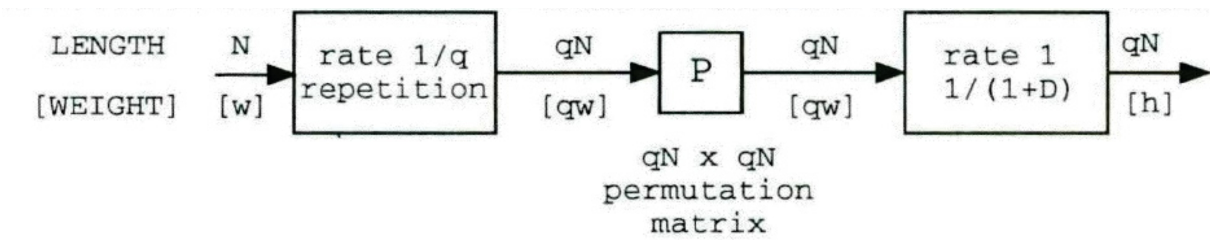


Figure 3. Encoder for a (qN, N) repeat and accumulate code. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block.

Ex. 1003 [Divsalar] at Fig. 3

’710 Patent Fig. 2

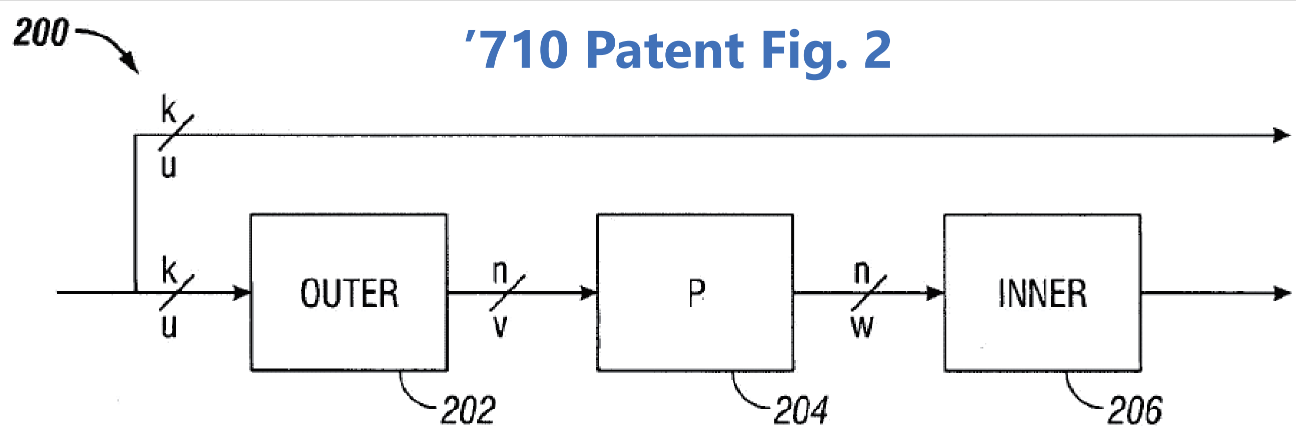


FIG. 2

Ex. 1001 [’710 patent] at Fig. 2

Pet. at 22, 29; Ex. 1006 [Davis Decl.] at ¶¶ 77-78, 97-98, 140-146

Frey Teaches Irregularity

B. J. Frey and D. J. C. MacKay (1999) In *Proceedings o*
on Communication, Control and Computing 1999, Allerto

Irregular Turbocodes

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Abstract

Recently, several groups have increased the coding gain of iteratively decoded Gallager codes (low density parity check codes) by varying the number of parity check equations in which each codeword bit participates. In regular turbocodes, each "systematic bit" participates in exactly 2 trellis sections. We construct irregular turbocodes with systematic bits that participate in varying numbers of trellis sections. These codes can be decoded by the iterative application of the sum-product algorithm (a low-complexity, more general form of the turbodecoding algorithm). By making the original rate 1/2 turbocode of Berrou *et al.* slightly irregular, we obtain a coding gain of 0.15 dB at a block length of $N = 131,072$, bringing the irregular turbocode within 0.3 dB of capacity. Just like regular turbocodes, irregular turbocodes are linear-time encodable.

1 Introduction

Recent work on irregular Gallager codes (low density parit
by making the codeword bits participate in varying numb
significant coding gains can be achieved [1–3]. Although G
to perform better than turbocodes at BERs below 10^{-5} [4][1]
performed over 0.5 dB worse than turbocodes for BERs
in [3], Richardson *et al.* found irregular Gallager codes tha
the original turbocode at BERs greater than 10^{-5} [5] for a

[1] Gallager codes to not exhibit decoding errors, only decoding f
$N > 5,000$.

Apple 1002

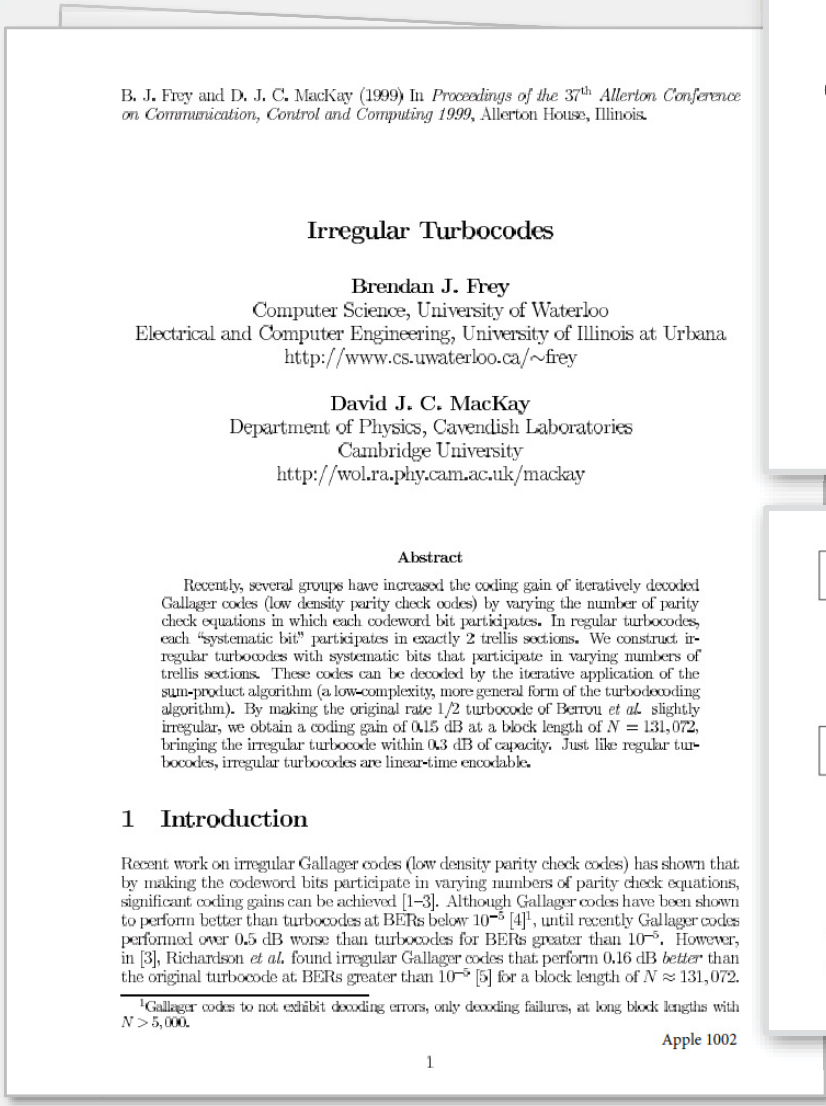
1

More generally, an *irregular turbocode* has the form shown in Fig. 2, which is a type of "trellis-constrained code" as described in [7]. We specify a *degree profile*, $f_d \in [0, 1], d \in \{1, 2, \ldots, D\}$. f_d is the fraction of codeword bits that have degree d and D is the maximum degree. Each codeword bit with degree d is repeated d times before being fed into the permuter. Several classes of permuter lead to linear-time encodable codes. In particular, if the bits in the convolutional code are partitioned into "systematic bits" and "parity bits", then by connecting each parity bit to a degree 1 codeword bit, we can encode in linear time.

Ex. 1002 [Frey] at Title, Abstract

Pet. at 25-28, 43; Ex. 1006 [Davis Decl.] at ¶¶ 63-70, 128

Frey Teaches Irregularity



B. J. Frey and D. J. C. MacKay (1999) In *Proceedings of the 37th Allerton Conference on Communication, Control and Computing 1999*, Allerton House, Illinois.

Irregular Turbocodes

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Abstract

Recently, several groups have increased the coding gain of iteratively decoded Gallager codes (low density parity check codes) by varying the number of parity check equations in which each codeword bit participates. In regular turbocodes, each "systematic bit" participates in exactly 2 trellis sections. We construct irregular turbocodes with systematic bits that participate in varying numbers of trellis sections. These codes can be decoded by the iterative application of the sum-product algorithm (a low-complexity, more general form of the turbodecoding algorithm). By making the original rate 1/2 turbocode of Berrou *et al.* slightly irregular, we obtain a coding gain of 0.15 dB at a block length of $N = 131,072$, bringing the irregular turbocode within 0.3 dB of capacity. Just like regular turbocodes, irregular turbocodes are linear-time encodable.

1 Introduction

Recent work on irregular Gallager codes (low density parity check codes) has shown that by making the codeword bits participate in varying numbers of parity check equations, significant coding gains can be achieved [1–3]. Although Gallager codes have been shown to perform better than turbocodes at BERs below 10^{-5} [4][1], until recently Gallager codes performed over 0.5 dB worse than turbocodes for BERs greater than 10^{-5}. However, in [3], Richardson *et al.* found irregular Gallager codes that perform 0.16 dB *better* than the original turbocode at BERs greater than 10^{-5} [5] for a block length of $N \approx 131,072$.

[1] Gallager codes to not exhibit decoding errors, only decoding failures, at long block lengths with $N > 5,000$.

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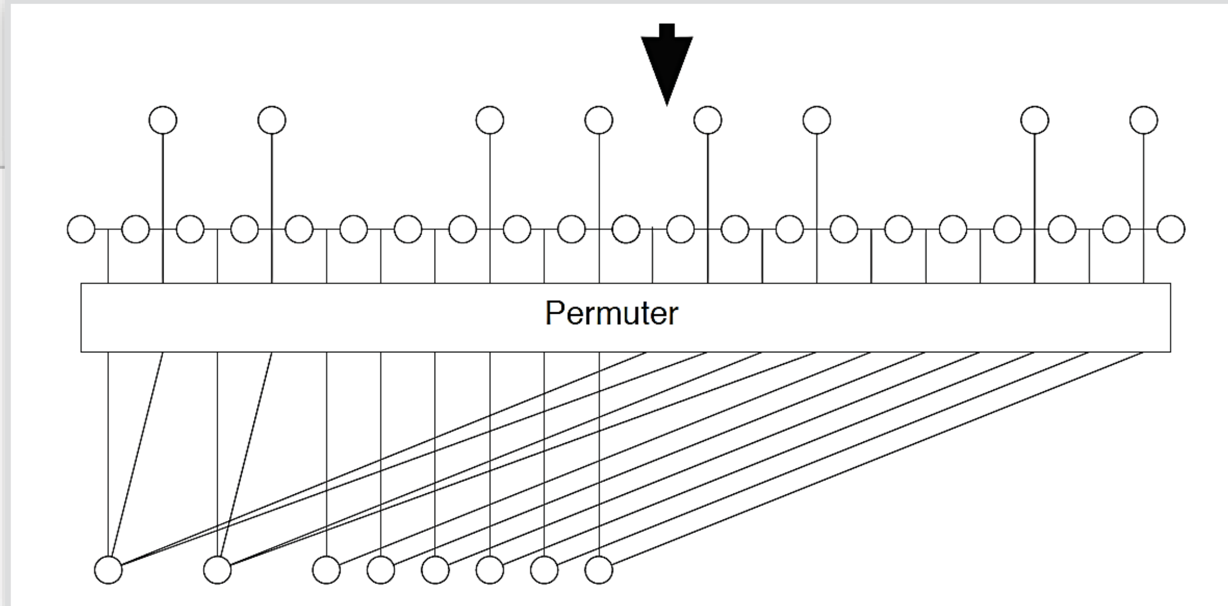

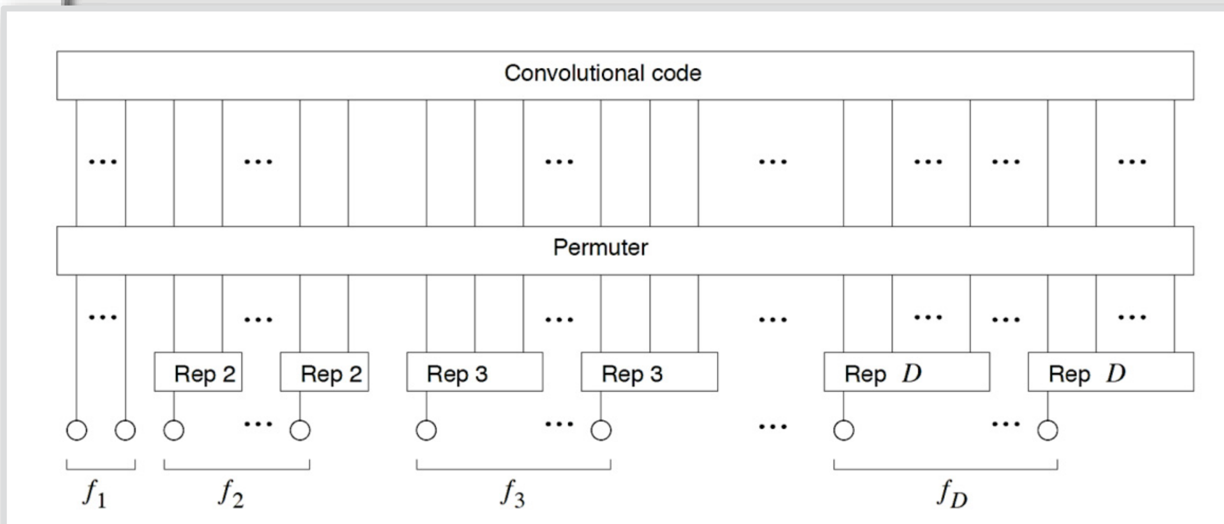

Ex. 1002 [Frey] at Figs. 1, 2

Pet. at 25-28, 46, 58; Ex. 1006 [Davis Decl.] at ¶¶ 63-70, 133, 174-175

Frey Provides Motivations to Combine Irregularity

B. J. Frey and D. J. C. MacKay (1999) In *Proceedings of the 37th Allerton Conference on Communication, Control and Computing 1999*, Allerton House, Illinois.

Irregular Turbocod

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Abstract

Recently, several groups have increased the coding g Gallager codes (low density parity check codes) by vary check equations in which each codeword bit participate each "systematic bit" participates in exactly 2 trellis s regular turbocodes with systematic bits that participa trellis sections. These codes can be decoded by the it sum-product algorithm (a low-complexity, more general algorithm). By making the original rate 1/2 turbocode irregular, we obtain a coding gain of 0.15 dB at a bloc bringing the irregular turbocode within 0.3 dB of capacity. Just like regular turbocodes, irregular turbocodes are linear-time encodable.

1 Introduction

Recent work on irregular Gallager codes (low density parity check codes) has shown that by making the codeword bits participate in varying numbers of parity check equations, significant coding gains can be achieved [1–3]. Although Gallager codes have been shown to perform better than turbocodes at BERs below 10^{-5} [4][1], until recently Gallager codes performed over 0.5 dB worse than turbocodes for BERs greater than 10^{-5}. However, in [3], Richardson *et al.* found irregular Gallager codes that perform 0.16 dB *better* than the original turbocode at BERs greater than 10^{-5} [5] for a block length of $N \approx 131{,}072$.

[1] Gallager codes to not exhibit decoding errors, only decoding failures, at long block lengths with $N > 5{,}000$.

Apple 1002

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In this paper, we show that by tweaking a turbocode so that it is irregular, we obtain a coding gain of 0.15 dB for a block length of $N = 131{,}072$. For example, an $N = 131{,}072$ irregular turbocode achieves $E_b/N_0 = 0.48$ dB at BER $= 10^{-4}$, a performance similar to the best irregular Gallager code published to date [3]. By further optimizing the degree profile, the permuter and the trellis polynomials, we expect to find even better irregular turbocodes. Like their regular cousins, irregular turbocodes exhibit a BER flattening due to low-weight codewords.

The irregular turbocode clearly performs better than the regular turbocode for BER $> 10^{-4}$. At BER $= 10^{-4}$, the $N = 131{,}072$ irregular turbocode is 0.3 dB from capacity, a 0.15 dB improvement over the regular turbocode.

Ex. 1002 [Frey] at 2, 6

Pet. at 25-28, 42-43, 48; Ex. 1006 [Davis Decl.] at ¶¶ 69, 128-130

The Modification Would Have Been Simple

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BEFORE THE PATENT TRIAL AND APP

Apple Inc.,
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Case TBD

**DECLARATION OF JAMES A. DAVI
REGARDING U.S. PATENT NO. 7,1
CLAIMS 1-8. 10-17, and 19-33**

Apple 1006

131. Incorporating the irregular repetition of Frey into the RA codes of Divslar would have required only a minor change to the implementation of the Divsalar encoder. Irregularity could be introduced into the coding schemes of Divsalar simply by modifying the Divsalar repeater, which repeats every information bit the same number of times, with the repeater of Frey, which repeats different information bits different numbers of times. This would have been a trivial modification for a person of ordinary skill in the art to make to an existing RA coder.

Ex. 1006 [Davis Decl.] at ¶ 131

Pet. at 44-45

The Modification Would Have Been Simple

U.S. Patent No. 7,116,710

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UNITED STATES PATENT AND TRAD

BEFORE THE PATENT TRIAL AND

APPLE INC.,
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Patent Owner.

Case IPR2017-00210
Patent 7,116,710

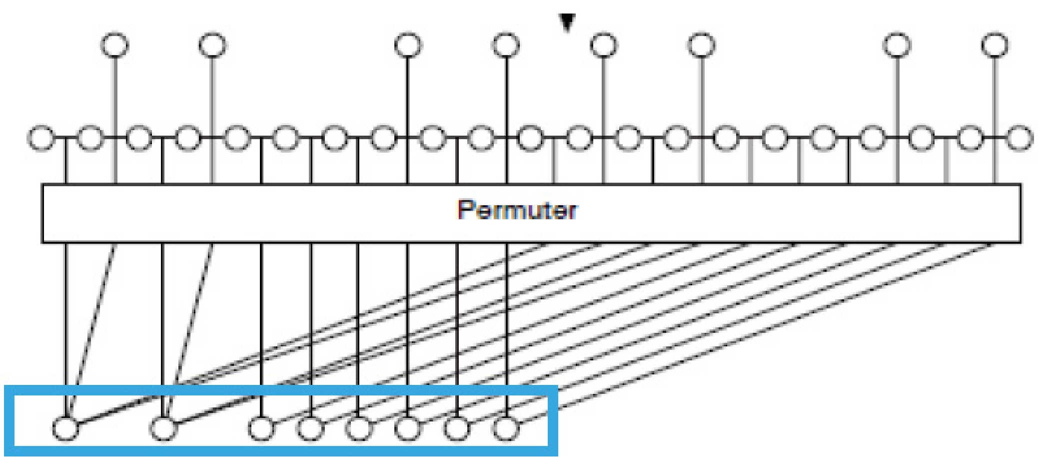
PETITIONER'S REPLY TO PATENT OW

The Petition showed that POSAs would have had a reasonable expectation of success because it was trivial to modify Divsalar to make it irregular by repeating some of the information bits more than others, which meets the limitations of the claimed invention. Pet., 44-47. *Intelligent Bio-Sys., Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1367 (Fed. Cir. 2016) ("The reasonable expectation of success requirement refers to the likelihood of success in combining references to meet the limitations of the claimed invention."). Dr. Mitzenmacher agreed that simply repeating the first two bits in Divsalar "q+10" times and the rest "q" times would make the code irregular. Ex. 1062, 153:11-154:8. Ex. 1065, ¶¶35, 43.

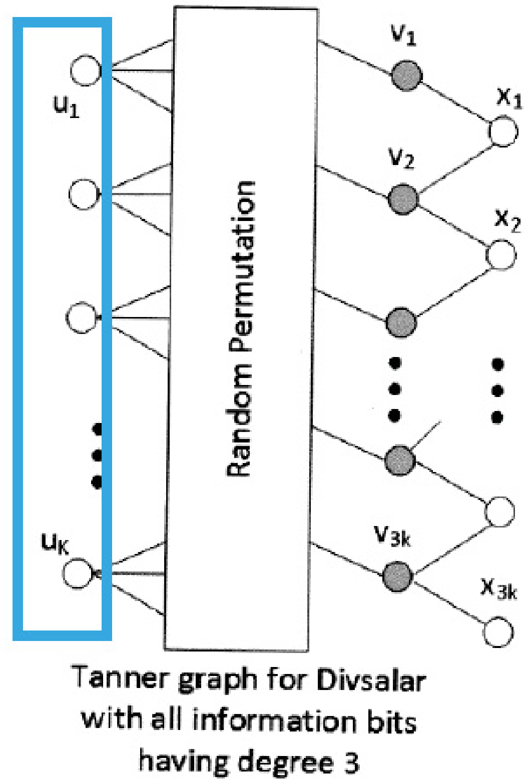
Reply at 9

Pet. at 44-45; Ex. 1006 [Davis Decl.] at ¶ 131

The Modification Would Have Been Simple



Ex. 1002, Fig. 1



Ex. 1046

Reply at 9-10

Pet. at 46, 58; Ex. 1006 [Davis Decl.] at 133, 174-175; Ex. 1065 [Frey Decl.] at ¶ 44; Ex. 1062 [Mitzenmacher Deposition] at 417:16-418:5

Frey Divsalar and Luby97 Render Claims 15-17, 19-22, and 24-33 Obvious

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DECLARATION OF JAMES A. DAVI
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CLAIMS 1-8. 10-17, and 19-33

Apple 1006

(*See generally* Exs. 1003, 1011.) Specifically, a person of ordinary skill in the art would have had the motivation to modify the encoder of Divsalar, using the teachings of Luby97, to receive a "stream" of bits, where the "stream" of bits comprises one or more blocks that are encoded separately.

186. Luby97 describes receiving data to be encoded in a *stream* of data symbols (which could be, for example, bits), where the "*stream* of data symbols [] is partitioned and transmitted in logical units of *blocks*." (Ex. 1011, p. 150, emphasis added.) One of ordinary skill in the art would have known that in

Ex. 1006 [Davis Decl.] at ¶¶ 185-186

Pet. at 31-32, 61-64; Ex. 1006 [Davis Decl.] at ¶¶ 91, 185-187, 194-197; Reply at 13-14; Ex. 1065 [Frey Decl.] at ¶ 62

Roadmap

- The Claims Are Invalid
- **PO's Failure to Cross-Examine**
- Response to Surreplies

PO's Failure to Cross-Examine

- **PO chose to not depose Petitioner's experts**
  - Dr. Frey (Reply Declarant)
  - Dr. Davis (2nd Declaration)

- **PO also chose to not depose Petitioner's other declarants**
  - Stansbury
  - Hajek
  - Basar
  - Sreenivas

Roadmap

- The Claims Are Invalid
- PO's Failure to Cross-Examine
- **Response to Surreplies**

Response to Surreplies

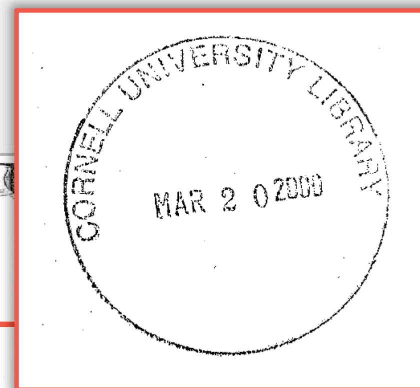
CalTech Surreply Issue	Issue Addressed in Briefing
Frey is prior art	Petition at 25; Reply at 17
Frey's 2nd coder has rate 2/3	Petition at 39-42; Reply at 5-6
Frey teaches partitioning	Petition at 36-37; Reply at 1-4
Frey discloses repetition of information bits	Petition at 9, 25-28, 46, 58; Reply at 1-4
Dr. Frey's experimental data is proper	Petition at 42-48; Reply at 9-11
The Tanner graphs are supported by the petitions	Petition at 19, 28-31, 8; Reply at 9-11
Testimony of Dr. Davis and Dr. Frey is proper	Reply at 2; Ex. 1073 [Davis Decl.]

Frey Is Prior Art

Filed: **May 18, 2001**

Provisional application No. 60/205,095, filed on May 18, 2000.

Ex. 1001 ['710 patent] at 1



Ex. 1015 [Conference Proceedings Table of Contents] at 16

when these items were first made publicly available by the Library. Based upon my review of the Library's records and my knowledge of the Library's standard procedures, **Irregular turbocodes / by Brendan J. Frey and David J. C. MacKay** and **The Serial Concatenation of Rate-1 Codes Through Uniform Random Interleavers / by H. D. Pfister and P. H. Siegel** were publicly available at the Cornell University Library as of March 20, 2000.

Ex. 1031 [Stansbury Decl.] at ¶ 4

Pet. at 25; Ex. 1006 [Davis Decl.] at ¶ 63

Frey is Prior Art

Source Code File	Caltech's Proposed Date	Last Change Made
IRA.cpp	March 10, 2000	Confidential Reply at 20; Ex-1050
IRA.h	March 10, 2000	Confidential Reply at 20; Ex-1051
IRAsimu.cpp	March 20, 2000	Confidential Reply at 20; Ex-1052
GetInter.cpp	March 12, 2000	Confidential Reply at 20; Ex-1053

Exs. 1050 [IRA.cpp], 1051 [IRA.h], 1052 [IRAsimu.cpp], 1054 [GetInter.cpp]; Reply at 17-21

U.S. Patent No. 7,116,710
Apple v. California Institute of Technology

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Case IPR2017-00210
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PETITIONER'S REPLY TO PATENT OWNER'S RESPONSE

and what was added later.[5] Also, critically, these exhibits are agnostic as to whether the code simulated by the software files is an RA code or an IRA code. They rely on the undated parameter files—Exhibits 2025 and 2029—to make this determination. Ex. 1063, 189:7-9, 200:20-204:14. Therefore, these

Reply at 20-21

Dr. Frey's Unchallenged Declaration: Frey's Convolutional Coder Shows a Rate of 2/3

U.S. Patent N
Apple v. California Institute o

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Case IPR2017-00210
Patent 7,116,710

DECLARATION OF BRENDAN FREY, PH.D. REGARDING U.S. PATENT NO. 7,116,710 CLAIMS 1-8, 11-17, 19-22, AND 24-33

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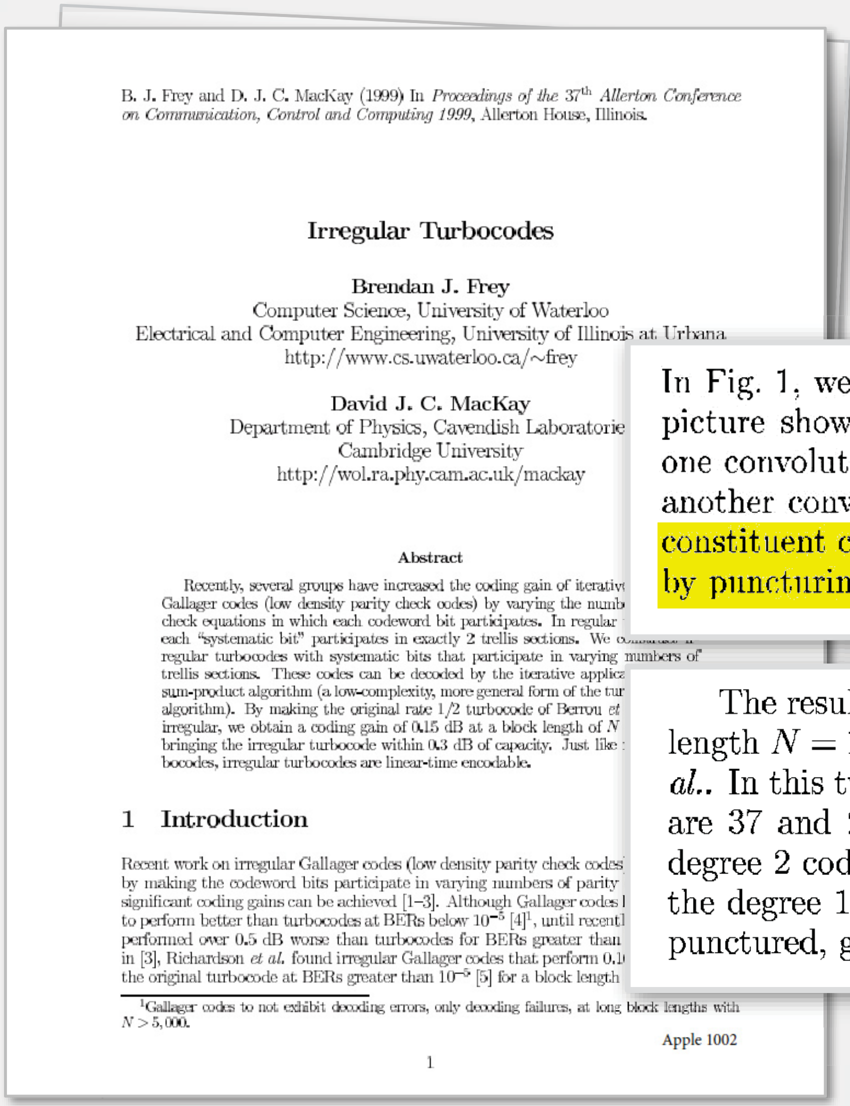
1002 at 245. Instead, the POR argues the rate should be calculated in an unconventional manner that ignores the systematic bits. POR at 24-25. Caltech's

systematic bits. Caltech admits that the rate is 2/3 if the systematic bits are considered. POR at 26 ("The rate of the code is 2/3 *only* if the code is calculated in systematic terms: R = (20/20+10)) = 2/3."); Ex. 1062 at 394:9-18. A POSA would have understood that the output of the second encoder in Frey includes both systematic bits and parity bits because that is the only way to achieve the "rate of R' = 2/3" expressly disclosed in Frey. Dr. Mitzenmacher concedes that convolutional codes can be systematic. Ex. 2004 at 39, n.5. Had I intended the output to include only the parity bits, I would not have stated that the rate is 2/3. A POSA would

Ex. 1065 [Frey Decl.] at ¶¶ 31-32

Pet. at 39-40; Ex. 1006 [Davis Decl.] at ¶¶ 174-176, 120-122; Reply at 5-6

Dr. Frey's Unchallenged Declaration: Frey's Convolutional Coder Shows a Rate of 2/3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Irregular Turbocodes

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Cambridge University
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Abstract

Recently, several groups have increased the coding gain of iterative Gallager codes (low density parity check codes) by varying the numb check equations in which each codeword bit participates. In regular each "systematic bit" participates in exactly 2 trellis sections. We regular turbocodes with systematic bits that participate in varying numbers of trellis sections. These codes can be decoded by the iterative applica sum-product algorithm (a low-complexity, more general form of the tur algorithm). By making the original rate 1/2 turbocode of Berrou *et* irregular, we obtain a coding gain of 0.15 dB at a block length of N bringing the irregular turbocode within 0.3 dB of capacity. Just like bocodes, irregular turbocodes are linear-time encodable.

1 Introduction

Recent work on irregular Gallager codes (low density parity check codes by making the codeword bits participate in varying numbers of parity significant coding gains can be achieved [1–3]. Although Gallager codes to perform better than turbocodes at BERs below 10^{-5} [4][1], until recent performed over 0.5 dB worse than turbocodes for BERs greater than in [3], Richardson *et al.* found irregular Gallager codes that perform 0.1 the original turbocode at BERs greater than 10^{-5} [5] for a block length

[1]Gallager codes to not exhibit decoding errors, only decoding failures, at long block lengths with $N > 5,000$.

Apple 1002

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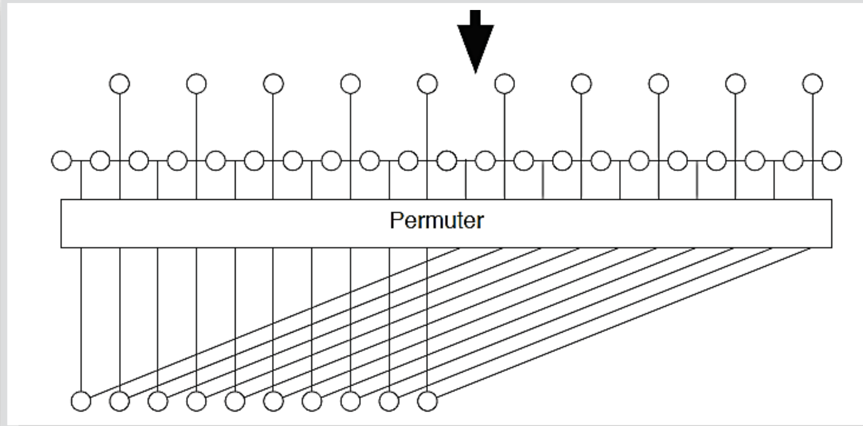

In Fig. 1, we show how to view a turbocode so that it can be made irregular. The first picture shows the set of systematic bits (middle row of discs) being fed directly into one convolutional code (the chain at the top) and being permuted before being fed into another convolutional code (the chain at the bottom). For a rate 1/2 turbocode, each constituent convolutional code should be rate 2/3 (which may, for example, be obtained by puncturing a lower-rate convolutional code).

The results we report in this paper were obtained by making small changes to a block length $N = 10,000$ version of the original rate $R = 1/2$ turbocode proposed by Berrou *et al.*. In this turbocode, $f_1 = f_2 = 1/2$ (see Fig. 2) and the convolutional code polynomials are 37 and 21 (octal). The taps associated with polynomial 37 are connected to the degree 2 codeword bits, 1/2 of the taps associated with polynomial 21 are connected to the degree 1 bits, and the remaining 1/2 of the taps associated with polynomial 21 are punctured, giving the required convolutional code rate of $R' = 2/3$.

Ex. 1002 [Frey] at 3, 2, 5

Pet. at 39-40; Ex. 1006 [Davis Decl.] at ¶¶ 174-176, 120-122; Reply at 5-6; Ex. 1065 [Frey Decl.] at ¶¶ 31-32

Dr. Frey's Unchallenged Declaration: Frey Teaches Partitioning

U.S.
Apple v. California In

UNITED STATES PATENT AND TRADEMARK

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DECLARATION OF BRENDAN FREY, P
REGARDING U.S. PATENT NO. 7,116,710
CLAIMS 1-8, 11-17, 19-22, AND 24-33

Apple v. Caltech
IPR2017-00210
Apple 1065

explains that "[e]ach codeword bit with degree *d* is repeated *d* times before being fed into the permuter." *Id.* (citing Frey at 2) (emphasis omitted). In other words, Frey expressly discloses how input bits are fed into the encoder shown in Fig. 2. They are partitioned into sub-blocks f_1, f_2, f_3, …, f_D and then input into repeaters Rep 2, Rep 3, … Rep D. Ex. 1002, 242, 245. Caltech's expert Dr. Mitzenmacher does not dispute this. He conceded at his deposition that Frey's f_2 bits are repeated two times and the f_D bits are repeated D times. Ex. 1062 at 380:14-381:2.

through f_D. Moreover, during his deposition, Dr. Mitzenmacher admitted that his random number generator would output a sequence that is known in advance. Ex.

Ex. 1065 [Frey Decl.] at ¶¶ 26-27

Pet. at 36; Ex. 1006 [Davis Decl.] at ¶¶ 112-113

Dr. Frey's Unchallenged Declaration: Frey Teaches Partitioning

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http://wol.ra.phy.cam.ac.uk/mackay

Abstract

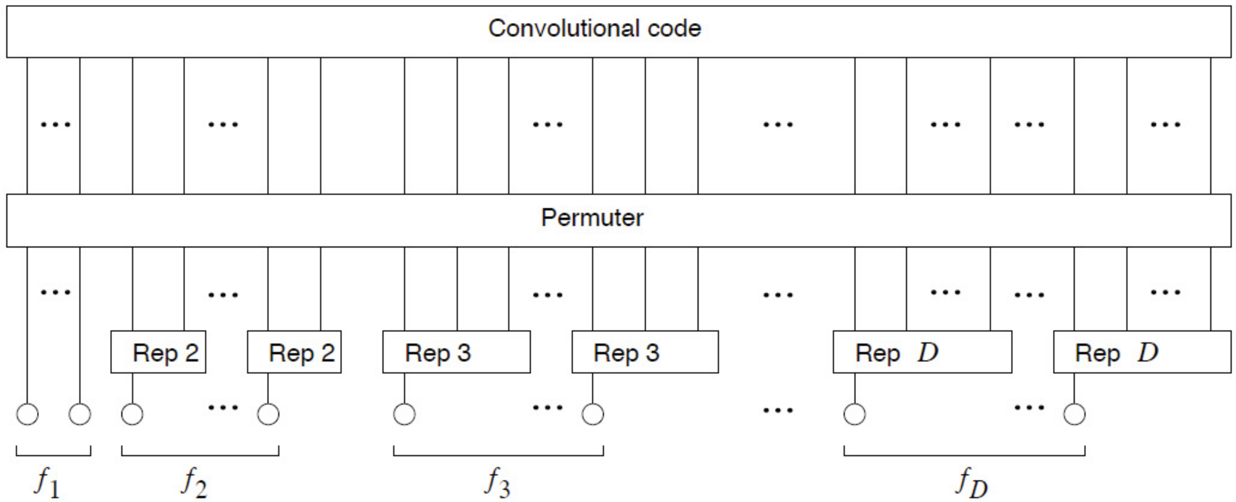
Recently, several groups have increased the coding gain of iteratively de... Gallager codes (low density parity check codes) by varying the number of ... check equations in which each codeword bit participates. In regular turbo... each "systematic bit" participates in exactly 2 trellis sections. We constru... regular turbocodes with systematic bits that participate in varying numb... trellis sections. These codes can be decoded by the iterative application ... sum-product algorithm (a low-complexity, more general form of the turbodec... algorithm). By making the original rate 1/2 turbocode of Berrou *et al.* sl... irregular, we obtain a coding gain of 0.15 dB at a block length of $N = 131$... bringing the irregular turbocode within 0.3 dB of capacity. Just like regula... bocodes, irregular turbocodes are linear-time encodable.

1 Introduction

Recent work on irregular Gallager codes (low density parity check codes) has ... by making the codeword bits participate in varying numbers of parity check ... significant coding gains can be achieved [1–3]. Although Gallager codes have ... to perform better than turbocodes at BERs below 10^{-5} [4][1], until recently Gal... performed over 0.5 dB worse than turbocodes for BERs greater than 10^{-5}. ... in [3], Richardson *et al.* found irregular Gallager codes that perform 0.16 dB *better* than the original turbocode at BERs greater than 10^{-5} [5] for a block length of $N \approx 131{,}072$.

[1]Gallager codes to not exhibit decoding errors, only decoding failures, at long block lengths with $N > 5{,}000$.

Apple 1002



More generally, an *irregular turbocode* has the form shown in Fig. 2, which is a type of "trellis-constrained code" as described in [7]. We specify a *degree profile*, $f_d \in [0,1], d \in \{1, 2, \ldots, D\}$. f_d is the fraction of codeword bits that have degree d and D is the maximum degree. Each codeword bit with degree d is repeated d times before being fed into the permuter. Several classes of permuter lead to linear-time encodable codes. In particular, if the bits in the convolutional code are partitioned into "systematic bits" and "parity bits", then by connecting each parity bit to a degree 1 codeword bit, we can encode in linear time.

Ex. 1002 [Frey] at 4, 2

Pet. at 36; Ex. 1006 [Davis Decl.] at ¶¶ 112-113; Ex. 1065 [Frey Decl.] at ¶ 27; Ex. 1062 [Mitzenmacher Transcript] at 381:3-382:13

Dr. Frey's Unchallenged Declaration: Frey Teaches Repetition of Information Bits

U.S. Patent No. 7,116,710
Apple v. California Institute of Technology

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00210
Patent 7,116,710

DECLARATION OF BRENDAN FREY, PH.D. REGARDING U.S. PATENT NO. 7,116,710 CLAIMS 1-8, 11-17, 19-22, AND 24-33

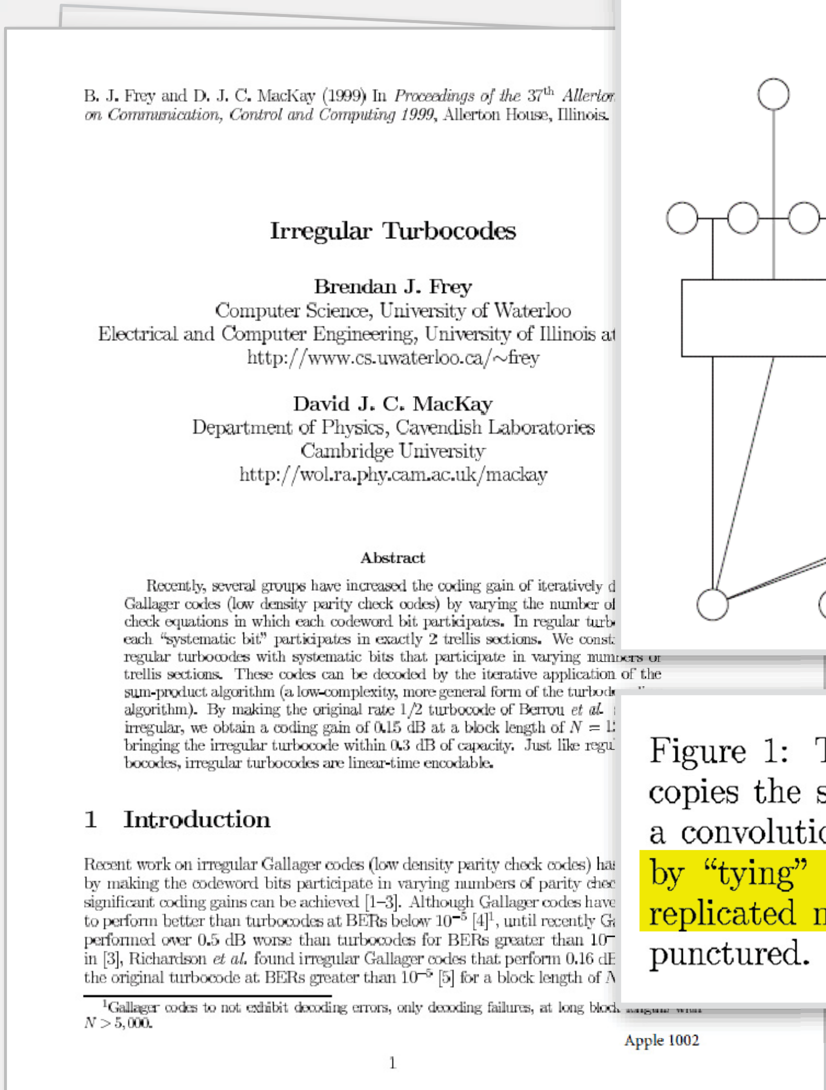
Apple v. Caltech
IPR2017-00210
Apple 1065

22. Caltech has argued that the nodes (shown as circles) at the bottom of Frey's Figure 2 represent output bits – not information or input bits. POR at 20. Caltech goes on to argue that therefore partitioning of those circles does not meet the "partitioning" limitation of claim 1 of the '710 patent. *Id*. Caltech is incorrect. As an initial matter, the code disclosed in Frey is systematic. Ex. 1002 at Abstract (disclosing Frey "construct[s] irregular turbocodes with systematic bits"); Ex. 2004, ¶¶90, 99, 112 (repeatedly confirming "Frey is a systematic code"). In a systematic code, the information bits are part of the codeword. Ex. 1006, ¶31 ("In a systematic code, both parity bits and the original information bits are included in the codeword); Ex. 1062 at 28:8-11 (confirming that "in a systematic code, the input of the code forms part of the code word"). That is, in a systematic code, the information bits are the input to the code, and they also form part of the output of the code. Therefore, the caption in Frey's Figure 2, which refers to codeword bits, merely identifies the circles at the bottom as information bits, which are part of the codeword. The caption does not show that the bits at the bottom of the figure are not input bits – they clearly are bits that are input to the code.

Ex. 1065 [Frey Decl.] at ¶ 22

Pet. at 9, 25-28, 46, 58; Ex. 1006 [Davis Decl.] at ¶¶ 174-176, 120-122

Dr. Frey's Unchallenged Declaration: Frey Teaches Repetition of Information Bits



B. J. Frey and D. J. C. MacKay (1999) In *Proceedings of the 37th Allerton* … *on Communication, Control and Computing 1999*, Allerton House, Illinois.

Irregular Turbocodes

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Electrical and Computer Engineering, University of Illinois at …
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David J. C. MacKay
Department of Physics, Cavendish Laboratories
Cambridge University
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Abstract

Recently, several groups have increased the coding gain of iteratively d… Gallager codes (low density parity check codes) by varying the number of … check equations in which each codeword bit participates. In regular turb… each "systematic bit" participates in exactly 2 trellis sections. We const… regular turbocodes with systematic bits that participate in varying numbers of trellis sections. These codes can be decoded by the iterative application of the sum-product algorithm (a low-complexity, more general form of the turbod… algorithm). By making the original rate 1/2 turbocode of Berrou *et al.* … irregular, we obtain a coding gain of 0.15 dB at a block length of $N = 1$… bringing the irregular turbocode within 0.3 dB of capacity. Just like regu… bocodes, irregular turbocodes are linear-time encodable.

1 Introduction

Recent work on irregular Gallager codes (low density parity check codes) ha… by making the codeword bits participate in varying numbers of parity chec… significant coding gains can be achieved [1–3]. Although Gallager codes have … to perform better than turbocodes at BERs below 10^{-5} [4][1], until recently Ga… performed over 0.5 dB worse than turbocodes for BERs greater than 10^{-}… in [3], Richardson *et al.* found irregular Gallager codes that perform 0.16 dB … the original turbocode at BERs greater than 10^{-5} [5] for a block length of N…

[1]Gallager codes to not exhibit decoding errors, only decoding failures, at long block … $N > 5,000$.

Apple 1002

1

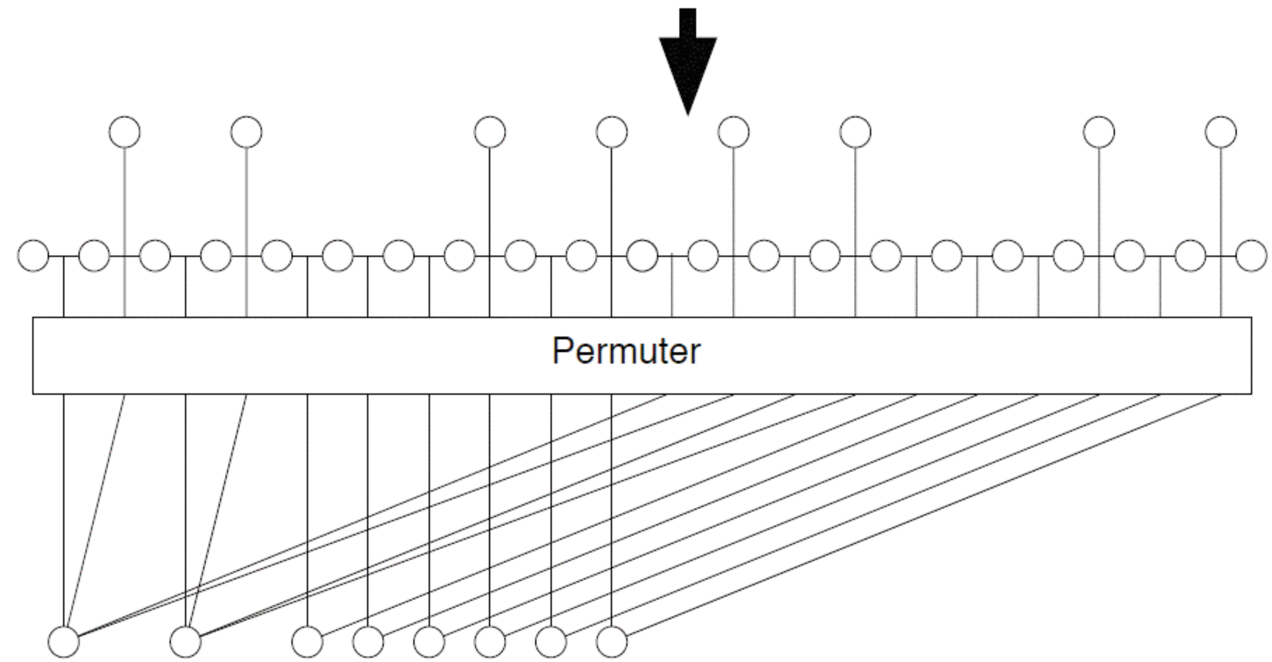

Figure 1: The first 4 pictures show that a turbocode can be viewed as a code that copies the systematic bits, permutes both sets of these bits and then feeds them into a convolutional code. The 5th picture shows how a turbocode can be made irregular by "tying" some of the systematic bits together, *i.e.*, by having some systematic bits replicated more than once. Too keep the rate fixed, some extra parity bits must be punctured. Too keep the block length fixed, we must start with a longer turbocode.

Ex. 1002 [Frey] at 3

Pet. at 9, 25-28, 46, 58; Ex. 1006 [Davis Decl.] at ¶¶ 174-176, 120-122; Ex. 1002 [Frey] at Fig. 2

Experimental Data Is Proper

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DECLARATION OF JAMES A. DAVIS, PH.D.
REGARDING U.S. PATENT NO. 7,116,710
CLAIMS 1-8. 10-17, and 19-33

131. Incorporating the irregular repetition of Frey into the RA codes of Divslar would have required only a minor change to the implementation of the Divsalar encoder. Irregularity could be introduced into the coding schemes of Divsalar simply by modifying the Divsalar repeater, which repeats every information bit the same number of times, with the repeater of Frey, which repeats different information bits different numbers of times. This would have been a trivial modification for a person of ordinary skill in the art to make to an existing RA coder.

132. Also, incorporating the irregular repetition of Frey into the RA codes of Divsalar would have required only a minor change to the code itself. Below is a Tanner graph of an RA code that was included in the thesis of Aamod Khandekar, one of the named inventors on the patent at issue:

Ex. 1006 [Davis Decl.] at ¶¶ 131-132

Pet. at 42-48

Experimental Data Is Proper

U.S. Patent No. 7,11
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UNITED STATES PATENT AND TRADEMARK OFFICE

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CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00210
Patent 7,116,710

DECLARATION OF BRENDAN FREY, PH.D.
REGARDING U.S. PATENT NO. 7,116,710
CLAIMS 1-8, 11-17, 19-22, AND 24-33

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Apple

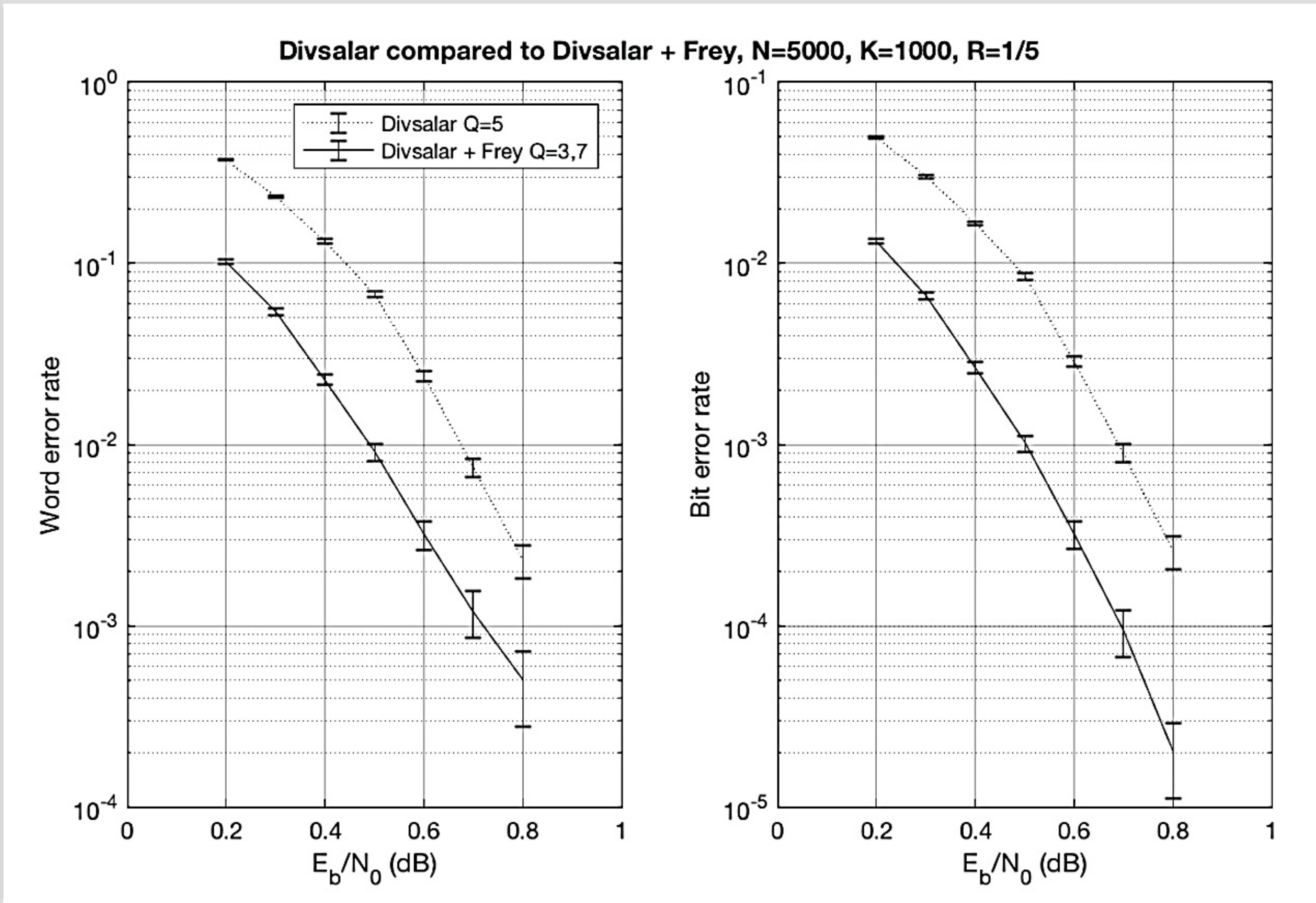
42. Caltech does not dispute that Divsalar could be made irregular by modifying the repeater to repeat different information bits a different number of times. Nor does it dispute that Divsalar could be made irregular by modifying its Tanner graph by redistributing a few edges. Instead it argues that such modifications were not sufficiently described and would not necessarily result in desired performance for particular applications or have a reasonable expectation of success. POR at 41-50. I disagree.

45. To demonstrate the ease with which a POSA could have added Frey's irregularity to Divsalar, I developed three software files in Matlab: (1) Divsalar_K1000_N5000_Q5_Simulate.m, Ex. 1068 at 1-2; (2) Divsalar_Plus_Frey_K1000_N5000_Q37_Simulate.m, *id.* at 3-4; and (3) Divsalar_K4096_N16384_Q4_Simulate.m, *id.* at 6-7.

Ex. 1065 [Frey Decl.] at ¶¶ 42, 45

Pet. at 42-48

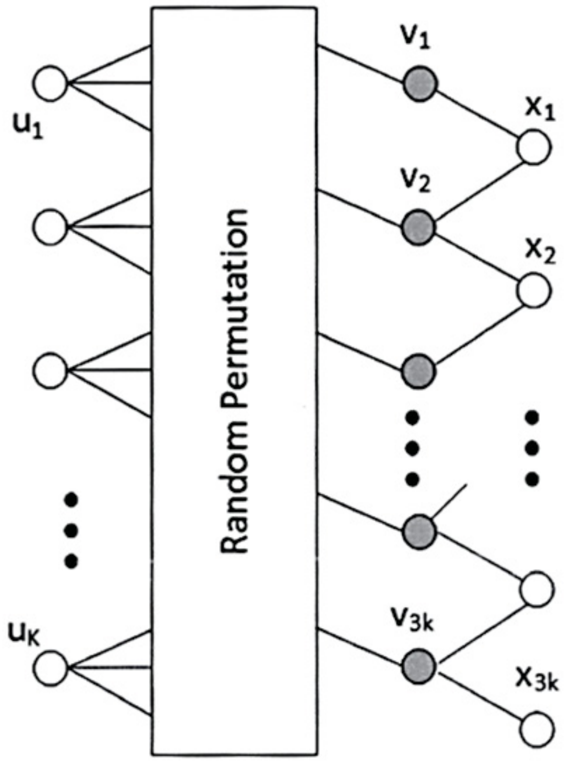
Experimental Data Is Proper



Ex. 1068 [Divsalar Simulation] at 5

Pet. at 42-48; Reply at 10-11; Ex. 1065 [Frey Decl.] at ¶¶ 45-57

Tanner Graphs Are Supported by Petitions



Tanner graph for Divsalar with all information bits having degree 3

Ex. 1046

U.S. Patent 7,116,710
Petition for *Inter Partes* Review

DOCKET NO.: 1033300-00287

UNITED STATES PATENT AND TRADEMARK OFFICE

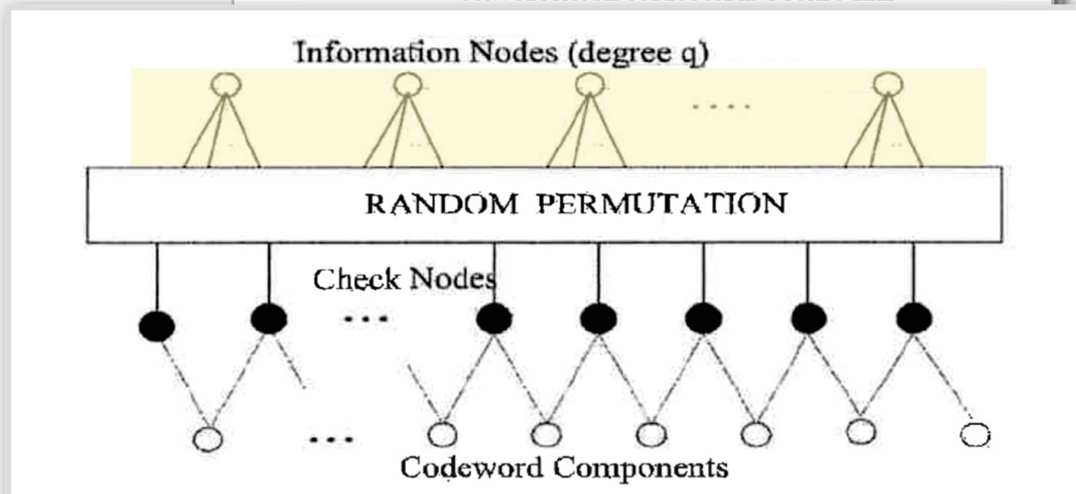
PATENT: 7,116,710

INVENTORS: HUI JIN, AAMOD KHANDEKAR, ROBERT J. MCELIECE

FILED: MAY 18, 2001

ISSUED: OCTOBER 3, 2006

TITLE: SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE



210 Pet. at 45

Ex. 1006 [Davis Decl.] at ¶132

Tanner Graphs Are Supported by Petitions

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Patent Owner.

Case TBD

57. These two mathematical descriptions of linear codes – one using matrices, one using Tanner graphs – are two different ways of describing the same thing. Matrices and Tanner graphs are two different ways of describing the same set of linear codes, in much the same way that "0.5" and "½" are two different ways of describing the same number. Every generator matrix corresponds to a Tanner graph, and vice versa.

Ex. 1006 [Davis Decl.] at ¶ 57

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61. Dr. Divsalar additionally confirmed at his deposition that RA codes in Divsalar could be made irregular by rearranging the edges for information nodes u_1 to u_k so that some nodes have different numbers of edges than other nodes. *Id.* at 95:7-101:22. This demonstrates it would have been simple for a POSA to modify the RA code in Divsalar to arrive at the claimed IRA code. Moreover, not only would it have been simple to obtain an IRA code, but such simple modifications result in improved performance, as the simulation results above demonstrate. And, I disagree with Dr. Divsalar's suggestion that Tanner graphs were innovative at the time of the claimed invention. Ex. 2031, ¶15. Tanner graphs were a standard technique for representing codes, including turbo-like codes. In fact, I used such graphs in Frey to represent the irregular code I later suggested applying to Divsalar.

Ex. 1065 [Frey Decl.] at ¶ 61

Pet at 18-19; Reply at 9-10

Tanner Graphs Are Supported by Petitions

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Patent 7,116,710

**DECLARATION OF BRENDAN FREY, PH.D.
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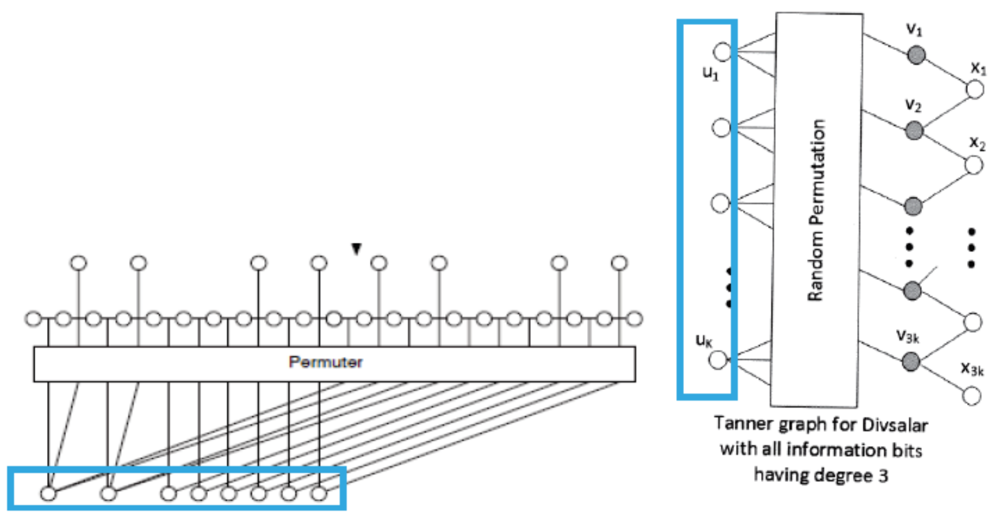
Apple
IPR2
Apple 1065

44. A Tanner graph representation of Divsalar's RA code is shown below. Ex. 1046. This graph graphically illustrates the reasonable expectation of success a POSA would have had when making Divsalar's code irregular. All that is required to make Divsalar's code irregular is to rearrange the edges for information nodes u_1 to u_k so that some nodes have different numbers of edges than other nodes, just like the information nodes shown at the bottom of Fig. 1 of Frey.[1]



Tanner graph for Divsalar
with all information bits
having degree 3

Ex. 1065 [Frey Decl.] at ¶ 44

Pet at 18-19; Ex. 1006 [Davis Decl.] at ¶ 57; Reply at 9-10

Testimony of Dr. Davis and Dr. Frey Is Proper

U.S. Patent No. 7,421,032
Apple v. California Institute of Technology

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-700, IPR2017-00701, IPR2017-728
Patent 7,421,032

DECLARATION OF JAMES A. DAVIS, PH.D.

award, I have been in Europe from January 13, 2018, through to the present. Due to the work I needed to do while still in the US to prepare for this European posting, and the need to focus on Fulbright-related activities while outside of the US, I did not have time to prepare another round of declarations, which I understand would have been due with Replies in February. Petitioner's counsel and I worked to see

Ex. 1073 [Davis Decl.] at ¶ 2

U.S. Patent No. 7,116,710
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Case IPR2017-00210
Patent 7,116,710

DECLARATION OF BRENDAN FREY, PH.D.
REGARDING U.S. PATENT NO. 7,116,710
CLAIMS 1-8, 11-17, 19-22, AND 24-33

16. I have reviewed the Petition and the declaration of Dr. Davis and agree with their explanation of why the instituted claims are invalid. I have also reviewed the institution decision and agree with the Board's reasoning regarding the instituted claims. I have also read Caltech's POPR, its POR, the declaration of Dr. Jin, and the declaration of Caltech's experts, Drs. Mitzenmacher and Divsalar, and disagree with their challenges to the invalidity of the instituted claims.

Ex. 1065 [Frey Decl.] at ¶ 16

Reply at 2

Dated: April 16, 2018

Respectfully Submitted,

/Michael Smith/

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Dominic A. Massa (No. 44,905)
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Mark D. Selwyn (*pro hac vice*)
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Kelvin Chan (No. 71,433)

Attorneys for Petitioner

CERTIFICATE OF SERVICE

I hereby certify that on April 16, 2018, a true and correct copy of the following:

- Petitioner's Demonstratives for Oral Argument

was served via electronic mail upon the following attorneys of record:

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Matthew Argenti (margenti@wsgr.com)
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Kelvin W. Chan (Reg. No. 71,433)