UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,421,032 B2
APPLICATION NO. : 11/542950
DATED : September 2, 2008
INVENTOR(S) : Hui Jin, Aamod Khandekar and Robert J. McEliece

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

Item [63], delete:
"Continuation of application No. 09/861,102, filed on May 18, 2001, now Pat. No. 7,116,710, and a continuation-in-part of application No. 09/922,852, filed on Aug. 18, 2000, now Pat. No. 7,089,477."

And insert:
-- Continuation of application No. 09/861,102, filed on May 18, 2001, now Pat. No. 7,116,710. --

In the Specification

Column 1, Line 8, delete:
"This application is a continuation of U.S. application Ser. No. 09/861,102, filed May 18, 2001, now U.S. Pat. No. 7,116,710, which claims the priority of U.S. provisional application Ser. No. 60/205,095, filed May 18, 2000, and is a continuation-in-part of U.S. application Ser. No. 09/922,852, filed Aug. 18, 2000, now U.S. Pat. No. 7,089,477."

And insert:
-- This application is a continuation of U.S. application Ser. No. 09/861,102, filed May 18, 2001, now U.S. Pat. No. 7,116,710, which claims the priority of U.S. provisional application Ser. No. 60/205,095, filed May 18, 2000. --

Signed and Sealed this
Thirty-first Day of May, 2022

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin		6431

83559 7590 04/06/2022
Bryan Cave Leighton Paisner LLP
1290 Avenue Of the Americas
New York, NY 10104

EXAMINER	
HA, DAC V	

ART UNIT	PAPER NUMBER
2611	

NOTIFICATION DATE	DELIVERY MODE
04/06/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATENTS-NY@bclplaw.com

PTOL-90A (Rev. 04/07)

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

In re Patent No. 7,421,032
Issue Date: September 2, 2008
Application No. 11/542,950
Filing or 371(c) Date: 3 Oct 2006
Attorney Docket No.

DECISION ON PETITION

This is a decision on the petition under 37 CFR 1.182, filed December 13, 2019, requesting issuance of a duplicate Letters Patent and concurrently filed a petition under 1.182 for expedited consideration.

The petition for expedited consideration under 37 CFR 1.182 is **DISMISSED**.
The Office acknowledges the request for expedited handling of the petition for duplicate letters patent. However, as the petition was not accorded expedited handling, the fee therefor has not been charged.

The petition under 37 CFR 1.182 for issuance of a duplicate Letters Patent is **GRANTED**.

The Office of Data Management is directed to issue a duplicate Letters Patent.

Telephone inquiries concerning this decision may be directed to Kimberly Inabinet at (571) 272-4618. Inquiries regarding the issuance of a duplicate Letters Patent may be directed to the Office of Data Management at (571-272-4200).

A copy of this decision is being forwarded to the Publishing Division for issuance of duplicate Letters Patent.

/KIMBERLY A INABINET/
Paralegal Specialist, OPET

cc: Charles C. Hagadorn, III
Wilson, Sonsini, Goodrich & Rosati
650 Page Mill Road
Palo Alto, CA 94304-1050

cc: Rochaun Hardwick (Fax - 571-270-9958)

Transmittal Communication on Petition	**Application/Control No.** 11/542,950	**Applicant(s)/Patent Under Reexamination** Jin et al.	
	Deciding Official HA, DAC V	**Office of Petitions** OPET	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address. --

(ADDITIONAL PARTY'S CORRESPONDENCE ADDRESS)

Charles C. Hagadorn, III
Wilson, Sonsini, Goodrich & Rosati
650 Page Mill Road
Palo Alto, CA 94304-1050

Enclosed is a copy of the latest communication from the United States Patent and Trademark Office in the above-identified Application/Patent.

United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :C48879

Sale Adjustment Accounting Date:04/06/2022

Effective Date	Sale Accounting Date	Sale Item Reference Number
12/13/2019	04/06/2022	11542950

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I202246831401835	1462	PETITION FEE- 37 CFR 1.17(F) (GROUP I)	$400.00	DA

United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :C48879

Refund Accounting Date:04/06/2022

Effective Date	Sale Item Reference Number	Refund Total
12/13/2019	11542950	$400.00

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method	Account Number
I202246831401835	1462	PETITION FEE- 37 CFR 1.17(F) (GROUP I)	$400.00	DA	232415

(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

Page 1 of 1

PATENT NO. : 7,421,032

APPLICATION NO.: 11/542,950

ISSUE DATE : September 2, 2008

INVENTOR(S) : Hui Jin; Aamod Khandekar; Robert J. McEliece

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the cover page in the "Related U.S. Application Data" section, the sentence reading

"Continuation of application No. 09/861,102, filed on May 18, 2001, now Pat. No. 7,116,710, and a continuation-in-part of application No. 09/922,852, filed on Aug. 18, 2000, now Pat. No. 7,089,477."

should read

-- Continuation of application No. 09/861,102, filed on May 18, 2001, now Pat. No. 7,116,710. --

At column 1, line 8, the sentence reading

"This application is a continuation of U.S. application Ser. No. 09/861,102, filed May 18, 2001, now U.S. Pat. No. 7,116,710, which claims the priority of U.S. provisional application Ser. No. 60/205,095, filed May 18, 2000, and is a continuation-in-part of U.S. application Ser. No. 09/922,852, filed Aug. 18, 2000, now U.S. Pat. No. 7,089,477."

should read

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MAILING ADDRESS OF SENDER (Please do not use Customer Number below):
Kevin C. Hooper
BRYAN CAVE LEIGHTON PAISNER LLP
1290 Avenue of the Americas
New York, NY 10104

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	11542950
Filing Date:	03-Oct-2006
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Filer:	Ethan Richard Fitzpatrick/Teresa Rodriguez
Attorney Docket Number:	CIT 3220-C

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
CERTIFICATE OF CORRECTION	1811	1	160	160

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**160**

Electronic Acknowledgement Receipt	
EFS ID:	45280869
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	29690
Filer:	Ethan Richard Fitzpatrick/Teresa Rodriguez
Filer Authorized By:	Ethan Richard Fitzpatrick
Attorney Docket Number:	CIT 3220-C
Receipt Date:	21-MAR-2022
Filing Date:	03-OCT-2006
Time Stamp:	19:17:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$160
RAM confirmation Number	E20223KJ17433529
Deposit Account	024467
Authorized User	Teresa Rodriguez

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	7421032-Request-for-CoC.pdf	130390 4543bbd36b6b7e313f7a1fbe65ee3b27366 8262d	no	3
Warnings:					
Information:					
2	Request for Certificate of Correction	CoC-Form-US7421032.pdf	647216 c29ad86d49650f478cb97b5c6f1c774a573c 92d7	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	38123 d9b88322281fb40d15e5c888db3622225f0 3fdc2	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	815729		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent No. 7,421,032		)	
Inventors:	Hui Jin *et al.*	)	Examiner Dac V. Ha
Issued:	September 2, 2008	)	Art Unit 2611
Serial No.:	11/542,950	)	
Filed:	October 3, 2006	)	
For:	**SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES**	))	

March 21, 2022

REQUEST FOR ISSUANCE OF CERTIFICATE OF CORRECTION

Attention: Certificate of Corrections Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The issuance of a Certificate of Correction for the above-identified patent as set forth on the attached PTO/SB/44 form is requested.

The following correction is requested under 37 CFR § 1.323:

On the cover page in the "Related U.S. Application Data" section, the sentence reading

"Continuation of application No. 09/861,102, filed on May 18, 2001, now Pat. No. 7,116,710, and a continuation-in-part of application No. 09/922,852, filed on Aug. 18, 2000, now Pat. No. 7,089,477."

should read

-- Continuation of application No. 09/861,102, filed on May 18, 2001, now Pat. No. 7,116,710. --

At column 1, line 8, the sentence reading

"This application is a continuation of U.S. application Ser. No. 09/861,102, filed May 18, 2001, now U.S. Pat. No. 7,116,710, which claims the priority of U.S. provisional application Ser. No. 60/205,095, filed May 18, 2000, and is a continuation-in-part of U.S. application Ser. No. 09/922,852, filed Aug. 18, 2000, now U.S. Pat. No. 7,089,477."

should read

-- This application is a continuation of U.S. application Ser. No. 09/861,102, filed May 18, 2001, now U.S. Pat. No. 7,116,710, which claims the priority of U.S. provisional application Ser. No. 60/205,095, filed May 18, 2000. --

REMARKS

A Certificate of Correction is requested to correct the foregoing errors under 37 CFR § 1.323.

The inclusion of a reference to U.S. application Ser. No. 09/922,852 was a clerical mistake/mistake of minor character and its removal does not constitute new matter or require reexamination. Pursuant to Rule 78(h), a corrected Application Data Sheet is not required with this paper. *See* 37 C.F.R. 1.78(h) (The requirement of a specific reference to a prior-filed application is "satisfied by the presentation of such specific reference in the first sentence(s) of the specification following the title in a nonprovisional application filed under 35 U.S.C. 111(a) before September 16, 2012 . . . .")

For the reason set forth above, we submit that a Certificate of Correction is appropriate. Accordingly, correction is requested under 37 CFR 1.323. Please charge the required fee to Deposit Account No. 02-4467.

Prompt issuance of the Certificate of Correction is respectfully requested.

I hereby certify that this correspondence is being transmitted in accordance with 37 CFR §§1.6(a)(4) and 1.8 via the U.S. Patent and Trademark Office (USPTO) electronic filing system (EFS-Web) to: Attention: Certificate of Corrections Branch, Commissioner For Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on March 21, 2022.

/ Teresa C. Rodriguez /
Teresa C. Rodriguez

Respectfully submitted,

By: /Kevin C. Hooper/

Kevin C. Hooper
Registration No. 40,402
BRYAN CAVE LEIGHTON
PAISNER LLP
1290 Avenue of the Americas
New York, NY 10104-3300
Ph: (212) 541-2000
Fx: (212) 541-4630
kchooper@bclplaw.com

PTO/SB/81A (12-08)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it displays a valid OMB control number

PATENT - POWER OF ATTORNEY OR REVOCATION OF POWER OF ATTORNEY WITH A NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS

Patent Number	7,421,032
Issue Date	September 2, 2008
First Named Inventor	Hui JIN
Title	Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes
Attorney Docket No.	

I hereby revoke all previous powers of attorney given in the above-identified patent.

☐ A Power of Attorney is submitted herewith.

OR

■ I hereby appoint Practitioner(s) associated with the Customer Number identified in the box at right as my/our attorney(s) or agent(s) with respect to the patent identified above, and to transact all business in the United States Patent and Trademark Office connected therewith: **83559**

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s) with respect to the patent identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

Practitioner(s) Name	Registration Number

Please recognize or change the correspondence address for the above-identified patent to:

■ The address associated with the above-identified Customer Number.

OR

☐ The address associated with the Customer Number identified in the box at right:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☐ Inventor, having ownership of the patent.

OR

☒ Patent owner.

Statement under 37 CFR 3.73(b) (Form PTO/SB/96) submitted herewith or filed on ________________.

SIGNATURE of Inventor or Patent Owner

Signature		Date	3/18/2022
Name	Fred Farina	Telephone	626-395-3058
Title and Company	Chief Innovation and Corporate Partnerships Officer		

NOTE: Signatures of all the inventors or patent owners of the entire interest or their representative(s) are required. If more than one signature is required, submit multiple forms, check the box below, and identify the total number of forms submitted in the blank below.

■ A total of 1 forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: California Institute of Technology

Application No./Patent No.: 7,421,032 Filed/Issue Date: September 2, 2008

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

California Institute of Technology, a non-profit corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;

2. ☐ an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is ______ %); or

3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 018470, Frame 0321, or a copy* is attached.

OR

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: ______ To: ______
The document was recorded in the United States Patent and Trademark Office at
Reel ______, Frame ______, or a copy* is attached.

2. From: ______ To: ______
The document was recorded in the United States Patent and Trademark Office at
Reel ______, Frame ______, or a copy* is attached.

3. From: ______ To: ______
The document was recorded in the United States Patent and Trademark Office at
Reel ______, Frame ______, or a copy* is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ *As required by 37 CFR 3.73(b)(1)(i), if a copy/copies is/are attached, the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Kevin C. Hooper/ March 21, 2022
Signature Date

Kevin C. Hooper 40,402
Printed or Typed Name Title or Registration Number

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	45276374
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	29690
Filer:	Ethan Richard Fitzpatrick/Teresa Rodriguez
Filer Authorized By:	Ethan Richard Fitzpatrick
Attorney Docket Number:	CIT 3220-C
Receipt Date:	21-MAR-2022
Filing Date:	03-OCT-2006
Time Stamp:	15:02:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	7421032-POA.PDF	615773 b595937d2a4a39af8a21c83135333b9ab855a7ac	no	2

Warnings:

Information:					
2	Assignee showing of ownership per 37 CFR 3.73	7421032-sb0096_2.pdf	171048 230f16c074750f4ee02f9e21c3be7d3f813b1c93	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	786821		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court WESTERN DISTRICT OF TEXAS on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:20-cv-1042	11/11/2020	WESTERN DISTRICT OF TEXAS

PLAINTIFF	DEFENDANT
The CALIFORNIA INSTITUTE OF TECHNOLOGY	DELL TECHNOLOGIES INC. and DELL INC.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 U.S. 7,116,710	10/3/2006	CALIFORNIA INSTITUTE OF TECHNOLOGY
2 U.S. 7,421,032	9/2/2008	CALIFORNIA INSTITUTE OF TECHNOLOGY
3 U.S. 7,916,781	3/29/2011	CALIFORNIA INSTITUTE OF TECHNOLOGY
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Print Save As... Reset

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court WESTERN DISTRICT OF TEXAS on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:20-cv-1041	11/11/2020	WESTERN DISTRICT OF TEXAS

PLAINTIFF	DEFENDANT
The CALIFORNIA INSTITUTE OF TECHNOLOGY	HP INC.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 U.S. 7,116,710	10/3/2006	CALIFORNIA INSTITUTE OF TECHNOLOGY
2 U.S. 7,421,032	9/2/2008	CALIFORNIA INSTITUTE OF TECHNOLOGY
3 U.S. 7,916,781	3/29/2011	CALIFORNIA INSTITUTE OF TECHNOLOGY
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
1		
2		
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5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Print Save As... Reset

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:16-cv-3714	5/26/2016	Central District of California

PLAINTIFF	DEFENDANT
California Institute of Technology	Broadcom Limited, Broadcom Corporation, Avago Technologies Limited, Apple Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,116,710	10/3/2006	California Institute of Technology
2 7,421,032	9/2/2008	California Institute of Technology
3 7,916,781	3/29/2011	California Institute of Technology
4 8,284,833	10/9/2012	California Institute of Technology
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

(12) **INTER PARTES REVIEW CERTIFICATE** (1754th)
United States Patent (10) **Number: US 7,421,032 K1**
Jin et al. (45) **Certificate Issued: May 11, 2020**

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

(75) Inventors: **Hui Jin**; **Aamod Khandekar**; **Robert J. McEliece**

(73) Assignee: **CALIFORNIA INSTITUTE OF TECHNOLOGY**

Trial Numbers:

IPR2017-00700 filed Jan. 20, 2017
IPR2017-00701 filed Jan. 20, 2017
IPR2017-00728 filed Jan. 20, 2017

Inter Partes Review Certificate for:

Patent No.: **7,421,032**
Issued: **Sep. 2, 2008**
Appl. No.: **11/542,950**
Filed: **Oct. 3, 2006**

The results of IPR2017-00700; IPR2017-00701; IPR2017-00728 are reflected in this inter partes review certificate under 35 U.S.C. 318(b).

INTER PARTES REVIEW CERTIFICATE
U.S. Patent 7,421,032 K1
Trial No. IPR2017-00700
Certificate Issued May 11, 2020

1

2

AS A RESULT OF THE INTER PARTES REVIEW PROCEEDING, IT HAS BEEN DETERMINED THAT:

Claims **1**, **4-16** and **18-23** are found patentable.

* * * * *

PATENT
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Current Date March 17, 2020

Application No.: 11/542950

Filed: October 3, 2006

Patent No.: 7421032

Issued: September 2, 2008

CHANGE OF ENTITY STATUS PURSUANT TO 37 C.F.R. §1.27 (g)(2)

Commissioner for Patents
Mail Stop M Correspondence
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This communication hereby notifies the United States Patent and Trademark Office that small entity status is no longer applicable for the above-identified patent.

Respectfully submitted,

Signature

California Institute of Technology
1200 E. California Blvd. M/C 6-32
Pasadena, CA 91125

Hannah Dvorak Carbone
Printed Name

Title: Director for Innovation, Patents & Licensing
OR
Reg. # if US Attorney_____

17 March 2020

MURGITROYD

CIT 3220-C
P163976.US.02/MHunter/Renewals

United States Patent & Trademark Office
Maintenance Division
USA

BY FACSIMILE ONLY - 2 PAGES - 001 571 273 6500

Proprietor	California Institute of Technology	IP Title:	Serial concatenation of interleaved convolutional codes forming turbo-like codes
IP Type	Patent		
Country	United States		
Appn. No.	11/542950		
Pub/Grant No.	7421032	Short Title:	
Year	Last Maintenance Fee	TM Category:	
Due Date	2 March 2020	Class(es):	

Dear Sir/Madam,

With regards to the above referenced US Patent our client is no longer Small Entity, therefore we would like to change to Large Entity rate. I enclose the following;

Declaration of Entitlement to large Entity Status for US Patent number 7421032 signed by Hannah Dvorak-Carbone, Director for Innovation, Patents & Licensing, California Institute of Technology.

I should be grateful if you would process these as appropriate and confirm safe receipt as soon as possible.

Yours faithfully
for Murgitroyd & Company

pp

MARTIN HUNTER
REWNEWALS DEPARTMENT
on behalf of MURGITROYD
renewals@murgitroyd.com

EUROPEAN PATENT AND TRADE MARK ATTORNEYS
UK | GERMANY | FRANCE | ITALY | IRELAND | FINLAND | SWITZERLAND | USA
Scotland House, 165-169 Scotland Street, Glasgow, G5 8PL, UK | +44 (0)141 307 8400 | murgitroyd.com

Attorney Docket No. CIT 3220-C
WSGR No. 38075-700

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent of: Inventors: Hui Jin *et al.* Application No.: 11/542,950 Filed: October 3, 2006 Patent No.: 7,421,032 Issued: September 2, 2008 Title: SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	Confirmation No.: 6431 Examiner: Dac V. Ha Group Art Unit: 2611 Customer No.: 29690 Certificate of Electronic Filing I hereby certify that the attached petition is being deposited by Electronic Filing on **December 13, 2019**, by using the EFS – Web patent filing system and addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450. By: /Hillary Pratt/ Hillary Pratt

Mail Stop Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PETITION UNDER 37 C.F.R. § 1.182 FOR DUPLICATE LETTERS PATENT AND PETITION TO EXPEDITE REVIEW

Dear Sir/Madam:

Pursuant to 37 C.F.R. § 1.182, Applicants hereby respectfully Petition to receive a duplicate Letters Patent for U.S. Patent No. 7,421,032. The undersigned certifies that the original Letters Patent was lost.

It is hereby respectfully petitioned that the Office expedite processing of the Petition Under 37 C.F.R. § 1.182 for duplicate Letters Patent. In support of this petition, Applicants submit the expedited petition fee set forth in 37 C.F.R. § 1.17(f).

The Director is hereby authorized to charge the amount of $800 to cover the fees set forth in 37 C.F.R. § 1.182, plus any deficiency in the fees filed, asserted to be filed or which should have been filed herewith to our Deposit Account No. 23-2415, referencing WSGR No. 38075-700.

Respectfully submitted,

WILSON SONSINI GOODRICH & ROSATI
Professional Corporation

Date: December 13, 2019

By: /Charles C. Hagadorn, III/
Charles C. Hagadorn, III
Registration No. 62,367

650 Page Mill Road
Palo Alto, CA 94304-1050
(650) 493-9300

Electronic Patent Application Fee Transmittal

Application Number:	11542950
Filing Date:	03-Oct-2006
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Filer:	Charles C. Hagadorn III/Hillary Pratt
Attorney Docket Number:	CIT 3220-C

Filed as Large Entity

Filing Fees for **Utility under 35 USC 111(a)**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
PETITION FEE- 37 CFR 1.17(F) (GROUP I)	1462	1	400	400
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**400**

Electronic Acknowledgement Receipt

EFS ID:	38031322
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	29690
Filer:	Charles C. Hagadorn III/Hillary Pratt
Filer Authorized By:	Charles C. Hagadorn III
Attorney Docket Number:	CIT 3220-C
Receipt Date:	13-DEC-2019
Filing Date:	03-OCT-2006
Time Stamp:	19:25:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$400
RAM confirmation Number	E2019BCJ25336062
Deposit Account	232415
Authorized User	Hillary Pratt

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition for review by the Office of Petitions	7_421_032_Petition_1_182.pdf	139303 6914bfe83e46e58494217c5f0fc0a9cf21bbd204	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30462 f8220f6d7c5ec1b6a022820fababc742175fcab2	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	169765		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

NOTE: This disposition is nonprecedential.

United States Court of Appeals for the Federal Circuit

APPLE INC.,
Appellant

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Appellee

2018-2332, 2018-2410, 2018-2411, 2018-2412

Appeals from the United States Patent and Trademark Office, Patent Trial and Appeal Board in Nos. IPR2017-00297, IPR2017-00423, IPR2017-00700, IPR2017-00701, IPR2017-00728.

JUDGMENT

JAMES MURPHY DOWD, Wilmer Cutler Pickering Hale and Dorr LLP, Los Angeles, CA, argued for appellant. Also represented by MARK D. SELWYN, Palo Alto, CA; RUSSELL SPIVAK, New York City, NY; MICHAEL H. SMITH, Washington, DC; MARK CHRISTOPHER FLEMING, LAUREN B. FLETCHER, Boston, MA.

MICHAEL T. ROSATO, Wilson, Sonsini, Goodrich & Rosati, PC, Seattle, WA, argued for appellee. Also represented by MATTHEW A. ARGENTI, Palo Alto, CA; RICHARD TORCZON, Washington, DC.

THIS CAUSE having been heard and considered, it is

ORDERED and ADJUDGED:

PER CURIAM (DYK, TARANTO, and STOLL, *Circuit Judges*).

AFFIRMED. See Fed. Cir. R. 36.

ENTERED BY ORDER OF THE COURT

November 13, 2019	/s/ Peter R. Marksteiner
Date	Peter R. Marksteiner
	Clerk of Court

United States Court of Appeals for the Federal Circuit

APPLE INC.,
Appellant

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Appellee

2018-2332, 2018-2410, 2018-2411, 2018-2412

Appeal from the United States Patent and Trademark Office, Patent Trial and Appeal Board in No. IPR2017-00297, IPR2017-00423, IPR2017-00700, IPR2017-00701, IPR2017-00728.

MANDATE

In accordance with the judgment of this Court, entered November 13, 2019, and pursuant to Rule 41 of the Federal Rules of Appellate Procedure, the formal mandate is hereby issued.

FOR THE COURT

December 20, 2019

/s/ Peter R. Marksteiner
Peter R. Marksteiner
Clerk of Court

Case No. IPR2017-00728
Docket No.: 1033300-00287US11

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Apple Inc.,
Petitioner

v.

California Institute of Technology,
Patent Owner

IPR2017-00728
Patent No. 7,421,032

PETITIONER'S NOTICE OF APPEAL

Director of the United States Patent and Trademark Office
c/o Office of the General Counsel
P.O. Box 1450
Alexandria, VA 22314-5793

Pursuant to 35 U.S.C. §§ 141-44 and 319, and 37 C.F.R. § 90.2-90.3, notice is hereby given that Petitioner Apple Inc. appeals to the United States Court of Appeals for the Federal Circuit from the Final Written Decision entered August 20, 2018 (Paper 63) in IPR2017-00728, and all prior and interlocutory rulings related thereto or subsumed therein.

In accordance with 37 C.F.R. § 90.2(a)(3)(ii), Petitioner further indicates that the issues on appeal include, but are not limited to, whether the Patent Trial and Appeal Board erred in determining that Petitioner had not established by a preponderance of the evidence that claims 18–23 of U.S. Patent No. 7,421,032 are unpatentable under 35 U.S.C. § 103 over the combination of Ping, MacKay, Divsalar, and Luby97; and any finding or determination supporting or related to those issues, as well as all other issues decided adversely to Petitioner in any orders, decisions, rulings, and opinions.

Pursuant to 37 C.F.R. § 90.3, this Notice of Appeal is timely, having been duly filed within 63 days after the date of the Final Written Decision.

A copy of this Notice of Appeal is being filed simultaneously with the Patent Trial and Appeal Board, the Clerk's Office for the United States Court of Appeals for the Federal Circuit, and the Director of the Patent and Trademark Office.

Respectfully submitted,

Date: September 20, 2018

/Michael Smith/

Michael H. Smith
Registration No. 71,190
Counsel for Petitioner

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 90.2(a)(1) and 104.2(a), I hereby certify that, in addition to being filed electronically through the Patent Trial and Appeal Board's End to End (PTAB E2E), a true and correct original version of the foregoing PETITIONER'S NOTICE OF APPEAL is being filed by Express Mail (Express Mail Label EL 815615055 US) on this 20th day of September 2018, with the Director of the United States Patent and Trademark Office, at the following address:

Director of the United States Patent and Trademark Office
c/o Office of the General Counsel
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Pursuant to 37 C.F.R. § 90.2(a)(2) and Federal Circuit Rule 15(a)(1), and Rule 52(a),(e), I hereby certify that a true and correct copy of the foregoing PETITIONER'S NOTICE OF APPEAL is being filed in the United States Court of Appeals for the Federal Circuit using the Court's CM/ECF filing system on this 20th day of September 2018, and the filing fee is being paid electronically using pay.gov.

I hereby certify that on September 20, 2018 I caused a true and correct copy of the PETITIONER'S NOTICE OF APPEAL to be served via e-mail on the following attorneys of record:

Michael Rosato (mrosato@wsgr.com)

Matthew Argenti (margenti@wsgr.com)

Richard Torczon (rtorczon@wsgr.com)

/Michael Smith/

Michael H. Smith
Registration No. 71,190

EXHIBIT A

Trials@uspto.gov
571-272-7822

Paper: 63
Mailed August 20, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00728
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and
JOHN A. HUDALLA, *Administrative Patent Judges.*

BARRETT, *Administrative Patent Judge.*

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1201). Paper 5 ("Pet."). The Petition challenges the patentability of claims 18–23 of the '032 patent on the ground of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp."). We instituted *inter partes* review (Paper 14, "Inst. Dec.") of all the challenged claims based on Ping, MacKay, Divsalar, and Luby97.

Patent Owner filed a Response to the Petition (Paper 32, "PO Resp."), and Petitioner filed a Reply (Paper 45, "Pet. Reply"). Pursuant to our authorization (Paper 43), Patent Owner filed a Sur-Reply (Paper 55, "PO Sur-Reply").

An oral hearing was held on May 8, 2018, and a transcript of the hearing is included in the record. Paper 62 ("Tr.").

As authorized in our Order of February 10, 2018 (Paper 41), Patent Owner filed a motion for sanctions related to Petitioner's cross-examination of Patent Owner's witnesses, Dr. Mitzenmacher and Dr. Divsalar (Paper 42), and Petitioner filed an opposition (Paper 47).

Additionally, Patent Owner filed a Motion to Exclude evidence (Paper 52), to which Petitioner filed an Opposition (Paper 54), and Patent Owner filed a Reply (Paper 58).

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). After consideration of the parties' arguments and evidence, and for the reasons discussed below, we determine that Petitioner has *not* shown by a preponderance of the evidence that claims 18–23 of the '032 patent are unpatentable.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00700, and IPR2017-00701. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." Ex. 1201, [54]. The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

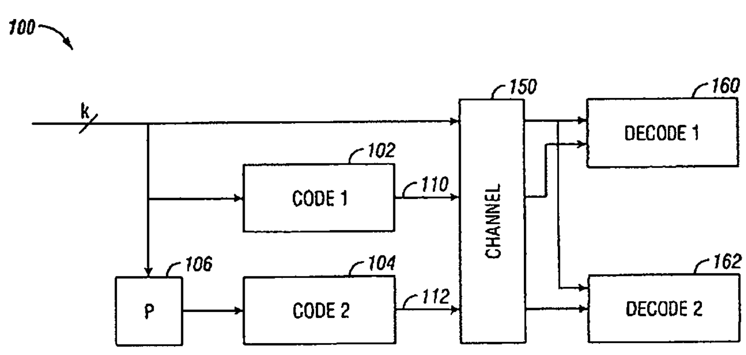

Figure 1 is a schematic diagram of a prior "turbo code" system. *Id.* at 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with reference to Figure 2, reproduced below.

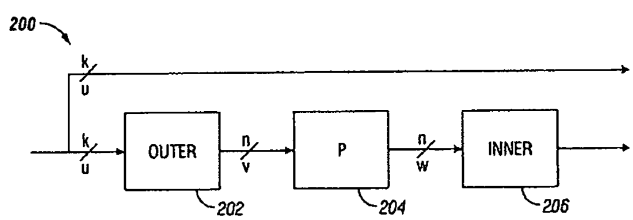

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is

> $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_I w$, where T_I is a nonsingular n×n matrix. The inner coder 210 can have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") coder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

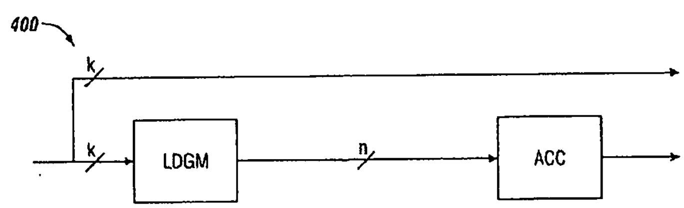

Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a

[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

"sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

"The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code." *Id.* at 3:33–35. Figure 3, shown below, depicts such a Tanner graph.

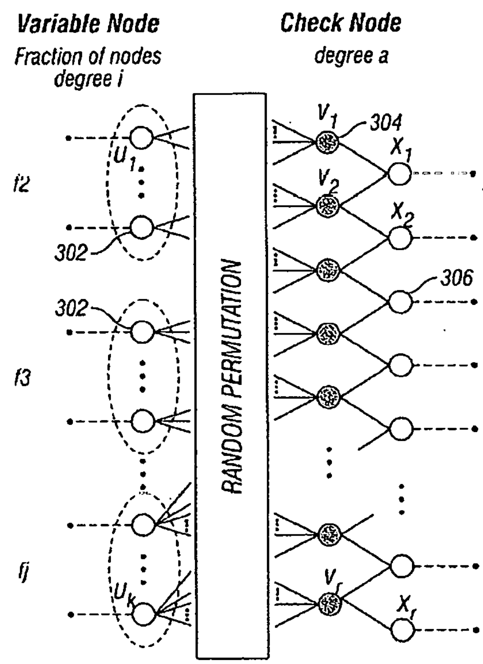

Figure 3 is described as "a Tanner graph for an irregular repeat and accumulate (IRA) coder." *Id.* at 2:20–21. The left-most column of nodes, information nodes 302 (the open circles), are variable nodes that receive information bits. The column of nodes (the filled circles) just to the right of the "RANDOM PERMUTATION" block are check nodes v indicated by reference numeral 304. An information bit node connected to two check nodes represents a repeat of 2. An information node connected to three check nodes represents a repeat of 3. The nodes (the open circles) in the right-most column are parity bit nodes x, referenced by 306. As shown by the edges[2] of the Tanner graph, each parity bit is a function of its previous parity bit and is also a function of information bits (edges connect through check nodes and random permutation to information bit nodes). *Id.* at 3:34–55; *see also* Ex. 1204 ¶ 110 (discussing the relationship between parity bits in the context of the claimed Tanner graph and the '032 patent's specification).

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 18 is the only independent claim. The remaining challenged claims depend directly from claim 18. Claim 18, reproduced below as originally issued and before issuance of a Certificate of Correction dated February 17, 2009, and with paragraphing added, is illustrative:

> 18. A device comprising:
>
> a message passing decoder configured to decode a received data stream that includes a collection of parity bits,
>
> the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes,
>
> wherein the message passing decoder is configured to decode the received data stream that has been encoded in accordance with the following Tanner graph:

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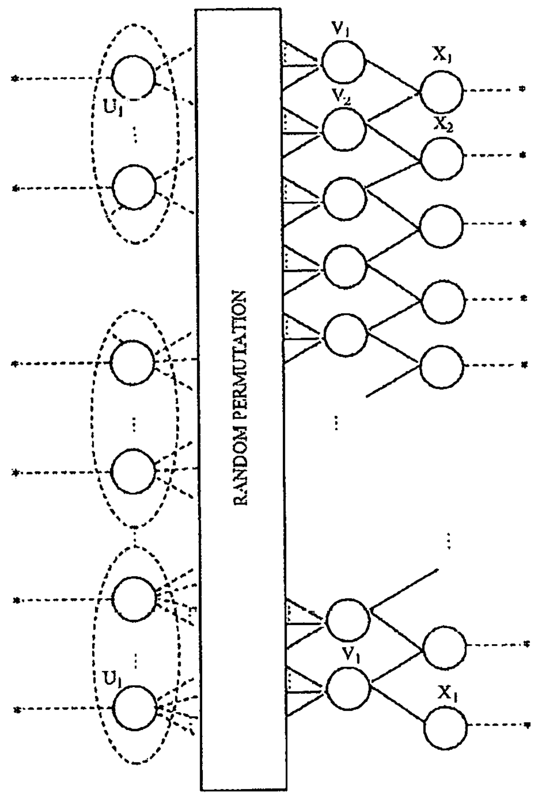
[2] We understand that "edges" are the straight lines that connect one node to another node of a Tanner graph. *See* Ex. 1201, 3:53–54.



Ex. 1201, 9:57–10:42. A Certificate of Correction for the '032 patent replaced the labels V_1, U_1, and X_1 from the lower portion of the Tanner graph in claim 18 with V_r, U_k, and X_r, respectively. *See id.* at Certificate of Correction (Feb. 17, 2009).

E. Evidence

Petitioner relies on the following art references:

Reference	Exhibit No.
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")	Ex. 1202

Reference	Exhibit No.
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")	Ex. 1203
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1208
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")	Ex. 1217

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1204), and the Declaration of Brendan Frey, Ph.D., dated February 21, 2018 (Ex. 1265) in support of its arguments. Patent Owner relies upon the Declaration of Dr. Michael Mitzenmacher, dated November 21, 2017 (Ex. 2004), and the Declaration of Dr. Dariush Divsalar, dated November 7, 2017 (Ex. 2031), in support of its arguments in the Patent Owner Response. The parties rely on other exhibits as discussed below.

F. The Asserted Ground of Unpatentability

The following ground of unpatentability remains at issue in this case (Pet. 41; Inst. Dec. 9, 22 (instituting a trial on all of the challenged claims and on the sole ground presented in the Petition)):

References	Basis	Claim(s)
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	18–23

II. ANALYSIS

A. Principles of Law

Petitioner bears the burden of proving unpatentability of the claims challenged in the Petition, and that burden never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must establish the facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) any objective evidence of non-obviousness.[3] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. The Level of Ordinary Skill in the Art

Petitioner's declarant, Dr. Davis, opines that:

> A person of ordinary skill in the art at the time of the alleged invention of the '032 patent would have had a Ph.D. in mathematics, electrical or computer engineering, or computer science with emphasis in signal processing, communications, or

[3] Although Patent Owner puts forth evidence of objective indicia of non-obviousness (PO Resp. 55–66), we need not reach this evidence based on our disposition below.

> coding, or a master's degree in the above area with at least three years of work experience in this field at the time of the alleged invention.

Ex. 1204 ¶ 98; *see* Pet. 26 (citing the same). Patent Owner's declarant, Dr. Mitzenmacher, applies the same definition offered by Dr. Davis. Ex. 2004 ¶ 66.

We determine that the definition offered by Dr. Davis comports with the qualifications a person would have needed to understand and implement the teachings of the '032 patent and the prior art of record. Accordingly, we apply Dr. Davis's definition of the level of ordinary skill in the art.

C. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee,* 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Tanner Graph

For purposes of our Institution Decision, we adopted the construction for "Tanner graph" set forth in a prior Board decision concerning the '032 patent and for which Petitioner supports the application of the same construction in the present case. Inst. Dec. 10–11 (quoting IPR2015-00060, Paper 18, 12–14; citing Pet. 28–29[4]). That construction is as follows:

> [1] a graph representing an [irregular[5] repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times, and
>
> [2] check nodes, randomly connected to the repeated message bits, enforce constraints that determine the parity bits[, and] . . .
>
> [3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph.

Inst. Dec. 10.

Patent Owner does not express disagreement with the construction but contends that the term "Tanner graph" need not be construed because, *inter alia*, a person of ordinary skill in the art "would have readily understood

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[4] Petitioner contends that this construction is the broadest reasonable interpretation, yet is narrower than that adopted by the District Court in *Caltech v. Hughes Communications Inc.*, No. 2:13-cv-07245 (C.D. Cal.) because the court's construction did not include the constraint regarding parity bit determination (constraint [3]). Pet. 29 (citing Ex. 1213). Petitioner contends that the difference has no substantive effect on the issues before us. *See* Tr. 34:16–35:2.

[5] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 27–28 (advocating the adoption of that construction in this case); IPR2017-00700, Paper 32, 14 (Patent Owner, in a related case, citing Ex. 2004 ¶ 69 and asserting: "Caltech does not believe the term needs to be construed, as the plain and ordinary meaning of irregular repetition is clear. That message bits contribute in differing numbers to parity bits is made clear in the claim language.").

how to encode bits according to the Tanner graph in the claims and in view of the specification." PO Resp. 15; *see also* Ex. 2004 ¶ 73 (Dr. Mitzenmacher not disagreeing with any aspect of the construction but opining that: "[T]here is no need to 'construe' the graph. Any person of ordinary skill could readily comprehend what the graph requires in terms of an encoder or a decoder.").

Regardless as to whether the person of ordinary skill in the art—e.g., a person with a doctorate in mathematics—would understand the claim, we find a verbal description of the graph to be helpful. Accordingly, we again adopt that prior construction for purposes of analyzing Petitioner's challenges before us in this case.

On this record and for purposes of deciding the dispositive issues before us, we determine that no other claim terms require express construction.

D. The Alleged Obviousness over Ping, MacKay, Divsalar, and Luby97

Petitioner alleges that independent claim 18 and dependent claims 19–23 of the '032 patent would have been obvious over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 41–64 (addressing independent claim 18).

Petitioner asserts that Ping discloses much of the subject matter of independent claim 18, but maintains that Ping's outer coder is regular. Pet. 41–42; *see also id.* at 58. Petitioner relies on MacKay for teaching irregularity, *id.* at 41, 43, relies on Divsalar for teaching repetition "if Ping standing alone is not understood to teach, or render obvious, repeating information bits," *id.* at 46, and relies on Luby97 for teaching receiving a source data stream, *id.* at 48. Additionally, Petitioner relies on Divsalar, MacKay, and Luby97 for teaching that message passing decoders were well-known in the art. *See* Pet. 20, 51–52. Patent Owner argues, *inter alia*, that the Petition presents a flawed reason to modify Ping in light of MacKay. PO Resp. 2–3.

1. Ping (Ex. 1203)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1203, 38. In this approach, "only part of [parity check matrix] **H** is generated randomly, and the remaining part is deterministic," which "achieve[s] essentially the same performance as the standard LDPC encoding method with significantly reduced complexity." *Id.* The size of matrix **H** is $(n–k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]^t$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^p, \mathbf{H}^d]$." *Id.* $\mathbf{H}^p$ is defined as follows:

$$\mathbf{H}^{\mathrm{p}} = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^d$ is created such that it "has a column weight of t and a row weight of $kt/(n–k)$ (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H}^{\mathrm{d}} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1204 ¶ 74.[6] For each sub-block of $\mathbf{H}^d$, there is exactly "one element 1 per column and *kt/(n-k)* 1s per row." Ex. 1203, 38. This construction "increase[s] the recurrence distance of each bit in the encoding chain" and "reduces the correlation during the decoding process." *Id.*

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h_{1j}^d d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h_{ij}^d d_j \pmod 2$$

Ex. 1203, 38 (equation (4)).[7]

2. MacKay (Ex. 1202)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1202, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular

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[6] This particular representation of $\mathbf{H}^d$ is taken from Dr. Davis's testimony. Patent Owner's description of $\mathbf{H}^d$ is found at page 8 of its Response.

[7] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1204 ¶ 185.

code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1217)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function $1/(1 + D)$." Ex. 1204 ¶ 89 (quoting Ex. 1217, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

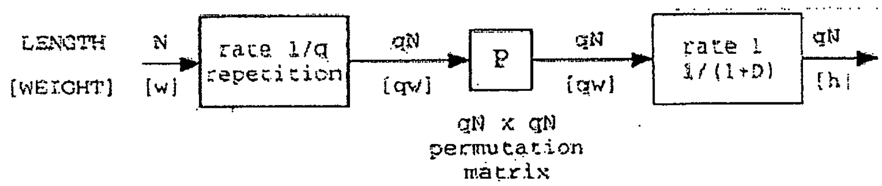

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1217, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. Luby97 (Ex. 1208)

Luby97 describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1208, 150 (Abstr.). Luby97 describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted).

5. The Alleged Obviousness of Claims 18–23

As discussed above in the context of claim construction, independent claim 18 contains a Tanner graph having at least three elements. Petitioner, in articulating its obviousness challenge of claim 18, relies on the testimony of Dr. Davis and maps the teachings of the prior art against those three elements as well as the express recitations of the claim. Pet. 50–64.

Claim 18 recites "a message passing decoder configured to decode a received data stream that includes a collection of parity bits." Petitioner maintains that Divsalar teaches an encoding device and teaches message passing decoding. *Id.* at 51. Petitioner maintains that MacKay and Luby97 also teach forms of message passing decoding. *Id.* at 51–52. Petitioner reasons that, in light of these teachings and "the fact that one of ordinary skill would understand message passing algorithms to be a standard technique for decoding linear error-correcting codes," it would have been obvious to use a message passing decoder to decode the codes of Ping. *Id.* at 52 (citing Ex. 1204 ¶ 194); *see also id.* at 20 (citing Ex. 1204 ¶ 62) (Petitioner asserting that a message passing decoder was a well-known type of decoder). Petitioner points to Luby97's teaching of receiving, in streams, data to be encoded and asserts that the sequence of blocks of symbols transmitted by the encoder of Luby97 constitutes a stream. *Id.* at 48–49. Petitioner asserts that it would have been obvious to use, for Ping's codes, a decoder that can receive encoded bits in a stream where the encoder that encoded those bits outputs them in a stream. *Id.* at 49–50, 52–53; *see* Ex. 1204 ¶¶ 195–200.

Claim 18 next recites "the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes." Relying on, *inter alia*, the testimony of Dr. Davis, Petitioner contends that such a parallel operation would have been obvious because message passing decoding works by passing messages back and forth between variable nodes and check nodes according to a Tanner graph. Pet. 23–24, 53–54; Ex. 1204 ¶¶ 68, 201–203.

As for the Tanner graph of claim 18, Petitioner addresses the three elements of our construction in an order different than that listed above in the claim construction section. For the element "[3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph," Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. Pet. at 30, 55–57; *see also id.* at 58 (maintaining that Ping's inner coder is an accumulator).

The next element of the Tanner graph addressed by Petitioner is "[1] a graph representing an [irregular repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times." Pet. 57–61. Petitioner asserts that a particular code may be represented as matrices or as a Tanner graph, with those being two ways of describing the same thing, and contends that the proposed combination would have been understood by one of ordinary skill in the art to correspond to the claimed Tanner graph. *Id.* at 59–61.

Petitioner contends that, "[i]n Ping's $\mathbf{H}^d$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^d d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 34, 35. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$

contains the same number of 1s – exactly 't' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}^d$ has a column weight of t . . . .'" *Id.* at 43 (quoting Ex. 1203, 38). Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 44 (quoting Ex. 1202, 1449) (emphasis in original); *see also* Pet. Reply 3 (citing Ex. 1265 (Frey Decl.) ¶¶ 20–24) ("MacKay also teaches that codes with such parity check matrices, *i.e.*, matrices with uneven column weights, can outperform their regular counterparts.").

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." Pet. 43. Petitioner proposes modifying Ping's $\mathbf{H}^d$ matrix (or outer coder), which Petitioner characterizes as regular, and contends that one of ordinary skill in the art would have made this modification to improve the performance of Ping's code. Pet. 43; Pet. Reply 4. Petitioner maintains:

> It would have been straightforward for a person of ordinary skill to change Ping's generator $\mathbf{H}^d$ matrix such that not all columns had the same weight – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1202, p. 1451.) This change would result in some information bits contributing to more outer LDPC parity bits than others, and would have made Ping's outer LDPC code irregular. . . . Moreover, MacKay's teaching that the best performing LDPC codes are irregular would also have made this modification obvious (and desirable) to try. (Ex. 1202, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper....") (Ex. 1204, ¶116.)

Pet. 44. According to Petitioner, a person of ordinary skill would not have been motivated to modify $\mathbf{H}^p$ because "it has only a single form and because doing so would have complicated a simple encoder." Pet. Reply 8. Thus, Petitioner contends that the person of ordinary skill "who wanted to obtain the benefit of MacKay's irregularity in Ping would have had only one option—to incorporate MacKay's irregularity into $\mathbf{H}^d$." *Id.*

Petitioner further contends that, "even if Ping standing alone is not understood to teach, or render obvious, repeating information bits, doing so would have been obvious in view of Divsalar's explicit teaching of repeating bits." Pet. 46. Petitioner also argues that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references' teachings. *Id.* at 47–48.

Thus, argues Petitioner, the combination of Ping, MacKay, and Divsalar teaches an irregular repeat accumulate code where message bits are repeated and at least two different subsets of message bits are repeated a different number of times. *Id.* at 59 (citing Ex. 1204 ¶ 139).

Lastly, Petitioner contends that Ping teaches the Tanner graph requirement of "[2] check nodes, randomly connected to the repeated message bits, [which] enforce constraints that determine the parity bits." *Id.* at 61–63. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d \, d_j$$

as teaching check nodes constraining the relationship between information bits and parity bits. *Id.* at 61–63. Petitioner further maintains that Ping, using Divsalar's repetition, teaches that the check nodes are randomly connected to repeated message bits. *Id.* at 63–64.

Patent Owner disputes, *inter alia*, Petitioner's rationale for combining Ping and MacKay—which underlies the overall combination of Ping, MacKay, Divsalar, and Luby97—on a number of bases. *See* PO Resp. 15–16 (summarizing ten arguments regarding Petitioner's ground), 27–28. Patent Owner argues that Ping's parity check matrix **H** is already irregular as defined by MacKay. *See id.* at 28–33. According to Patent Owner, "Ping's parity-check matrix has three different column weights (t, 2, and 1), and two different row weights ($kt/(n-k)+1$ and $kt/(n-k)+2$)." *Id.* at 29 (citing Ex. 2033, 231:11–14); *see also* Ex. 2004 ¶ 92 (same). As such, Patent Owner argues "Ping's parity-check matrix is actually even more 'irregular' than MacKay's irregular codes," so ordinarily skilled artisans "would not have been motivated by MacKay's teachings that irregular codes are an improvement over regular codes." PO Resp. 30–31 (citing Ex. 2004 ¶¶ 94, 95, and 97–99).

Patent Owner also highlights that Petitioner's proposed modifications relate only to a portion of Ping's parity check matrix **H**, namely, sub-matrix $\mathbf{H}^d$. *See id.* at 31–32; *see also* Ex. 2004 ¶ 96. Patent Owner argues "MacKay does not even *consider* modifying submatrices, much less teach that there may be benefits to try." PO Resp. 33. According to Patent Owner, "MacKay teaches that irregular parity-check matrices *as a whole* may define better codes than regular parity-check matrices *as a whole*—it does not teach any improvement from making a submatrix within a parity-check matrix irregular, or from using any other type of irregular matrix (*e.g.*, irregular generator matrices)." *Id.* at 31. Patent Owner argues MacKay does not "suggest that *additional* irregularity should be applied to uniform portions when the overall parity-check matrix is already irregular." *Id.* at 32 (citing Ex. 2004 ¶¶ 96–99) (footnote omitted).

Patent Owner further argues that Petitioner has not established that an ordinarily skilled artisan would have reasonably expected success from the proposed modification of Ping in light of MacKay. *See* PO Resp. 46–51. Patent Owner argues "the petition does not even attempt to analyze a reasonable expectation of success, and for that reason, it is incurably deficient." *Id.* at 46. As further evidence of the lack of anticipated success, Patent Owner emphasizes that constructing error-correction codes "was a highly unpredictable endeavor" that was subject to "extensive trial-and-error and experimentation to determine whether new codes led to an improvement." *Id.* at 4 (citing Ex. 2004 ¶ 46); *see also id.* at 46 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12).

We are persuaded by Patent Owner's arguments. We agree with Patent Owner (*see* PO Resp. 31–32 & n.7) that, although Petitioner may explain how to modify Ping's $\mathbf{H}^d$ sub-matrix in light of MacKay, it does not address why such an ordinarily skilled artisan would have done this. Nor does Petitioner establish that such an artisan reasonably would have expected success from the modification. Based on the entire trial record, we determine that Petitioner has not established a persuasive rationale for modifying Ping in light of MacKay as asserted by Petitioner. Petitioner's additional reliance on Divsalar and Luby97 does not remedy this fundamental flaw in the articulated combination. *See* Pet. 46, 48–50 (relying on Divsalar for the teaching of repeating information bits and Luby97 for the teaching of receiving data to be encoded in a stream).

Petitioner's unpatentability contentions presuppose that an ordinarily skilled artisan would seek to modify a *sub-matrix* in Ping in light of MacKay. *See* Pet. Reply 7 ("Caltech's comparison of Ping's **H** matrix to MacKay's is improper. . . . The proper comparison is between Ping's $\mathbf{H}^d$ matrix . . . and MacKay's matrix."). Yet even if MacKay touts improvements from irregularity in a parity check matrix (e.g., Ping's matrix **H**), MacKay does not suggest that these improvements would have been applicable to *portions* of a parity check matrix (e.g., Ping's sub-matrix $\mathbf{H}^d$). To reach its proposed modification, Petitioner characterizes Ping's sub-matrix $\mathbf{H}^d$ as a generator matrix (or "outer coder") and Ping's sub-matrix $\mathbf{H}^p$ as merely an accumulator (or "inner coder"). Pet. 30, 44; Pet. Reply 10–13. We agree with Patent Owner (*see* PO Resp. 39), however, that Petitioner does not explain adequately why labeling sub-matrix $\mathbf{H}^d$ as a generator matrix supports the proposed modification of $\mathbf{H}^d$ based on MacKay. Indeed, this label does not explain why an ordinarily skilled artisan considering MacKay would have chosen to modify $\mathbf{H}^d$ or any other portion of parity check matrix **H**.

Petitioner's further contentions also are not persuasive. Specifically, Petitioner contends $\mathbf{H}^p$ is an accumulator with only a single, fixed form, so an ordinarily skilled artisan would not have been motivated to modify $\mathbf{H}^p$ because "doing so would have complicated a simple encoder." Pet. Reply 7–8, 13. Yet this rationalization belies the fact that Ping also specifically defines a structure for sub-matrix $\mathbf{H}^d$, which simplifies a portion of the parity check matrix. According to Dr. Mitzenmacher, "the constraints on $\mathbf{H}^d$, including its regularity, were a deliberate design decision that contributes to the improved performance of Ping's code over fully random

LDPC codes—it is a fundamental part of its code." Ex. 2004 ¶ 104. Thus, choosing to modify *any* portion of Ping's matrix would have broken constraints in Ping that were intended to simplify encoding. *See* Ex. 1203, 38 (Ping describing the disclosed approach as a "new method [that] can achieve essentially the same performance as the standard LDPC encoding method with significantly reduced complexity"). This is a strong indication that an ordinarily skilled artisan would not have been motivated to reach within Ping's parity check matrix **H** and modify a sub-matrix.

We also agree with Patent Owner that Ping's parity check matrix **H** is already "irregular," which undermines Petitioner's stated motivation for modifying Ping in view of MacKay. *See* PO Resp. 28–33. Citing Dr. Mitzenmacher, Patent Owner establishes that Ping's matrix **H** has three different column weights (*t*, 2, and 1). *Id.* at 28–29; Ex. 2004 ¶¶ 91–92; *see also* Ex. 2033, 231:11–14 (Dr. Davis acknowledging that Ping's parity check matrix **H** has "different weights for the columns"). We accept this as evidence of "irregularity" based on Petitioner's own acknowledgment that "irregularity" is associated with "uneven column weights." *See* Pet. Reply 12–13. Petitioner does not contest that Ping's parity check matrix **H** is irregular; rather, Petitioner contends that the appropriate comparison is between MacKay's parity check matrix and Ping's sub-matrix $\mathbf{H}^d$. *Id.* at 7. But MacKay is silent on the concept of sub-matrices, so Petitioner's association of MacKay's teaching with sub-matrix $\mathbf{H}^d$ is not apt. Instead, we agree with Patent Owner that "MacKay's teachings are only applicable to full parity check matrices." PO Resp. 15–16. Thus, the record does not establish that an ordinarily skilled artisan would have sought to add irregularity to Ping's parity check matrix **H**—or additional irregularity to a sub-matrix of **H**, such as $\mathbf{H}^d$—because **H** itself is already irregular.

Finally, we agree with Patent Owner that the Petition is silent on whether a person of ordinary skill in the art would have expected success in combining MacKay with Ping. Although Petitioner cites an alleged "straightforward modification of Ping's $\mathbf{H}^d$ matrix" at page 44 of the Petition as supporting the expectation of success (Pet. Reply 13–14), the cited passage only describes the proposed modification, rather than addressing whether an ordinarily skilled artisan would have anticipated success from the modification. *See* Pet. 44. In addition, Petitioner's argument that an ordinarily skilled artisan "would have needed no more specificity to attempt to use MacKay's irregularity in Ping" (Pet. Reply 14) only underscores the lack of evidence in the Petition regarding anticipated success.

Perhaps sensing this deficiency in the Petition, Petitioner introduces new testimony and a new simulation from Dr. Frey with its Reply in which Dr. Frey allegedly "demonstrate[s] the ease with which a [person of ordinary skill in the art] could have added MacKay's irregularity to Ping." Ex. 1265 ¶ 42. According to Petitioner, the results of the simulation "outperform Ping's original code" and "confirm that a [person of ordinary skill in the art] would have been motivated to use MacKay's uneven column weights in Ping's $\mathbf{H}^d$ matrix, and . . . would have had a reasonable expectation of success when doing so." Pet. Reply 15–16. Yet, even if we were to deem the testimony and simulation to be within the proper scope of a reply brief,[8]

[8] We need not reach this issue, because we do not rely on this evidence in a manner adverse to Patent Owner. *See also infra* § II.E. (dismissing Patent Owner's Motion to Exclude as moot on the same basis).

they do not support a reasonable expectation of success *at the time of the invention*. We agree with Patent Owner that "[i]t is irrelevant what Dr. Frey claims he could do in the year 2018 when armed with Caltech's disclosures, [the named-inventor's] original coding work, contemporary resources (*e.g.*, Matlab), and some 18 years of post-filing date knowledge." PO Sur-Reply 7. Because this evidence is not tied to the state of the art at the time of the invention, it is not probative of anticipated success. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1367 (Fed. Cir. 2017) (quoting *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1138 (Fed. Cir. 1985)) ("Those charged with determining compliance with 35 U.S.C. § 103 are required to place themselves in the minds of those of ordinary skill in the relevant art *at the time the invention was made*, to determine whether that which is now plainly at hand would have been obvious at such earlier time." (emphasis added)).

Furthermore, as part of our obviousness analysis, we are charged to consider "the scope and content of the prior art." *See Graham*, 383 U.S. at 17–18. One important aspect of the art in this case is the relative unpredictability of developing error-correction codes. *See* PO Resp. 46 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12) ("New codes appeared from unexpected sources, and developing the precise parameters that could lead to incremental improvements often took a significant amount of time and experimentation."). In its Reply, Petitioner embraces the notion of unpredictability as supporting its combination; Petitioner contends that "rigorous mathematical analysis of codes is difficult, and, as a result, [persons of ordinary skill in the art] routinely develop codes by experimentation." Pet. Reply 14. Petitioner further contends that "running experimental tests on a version of Ping that incorporated MacKay's irregularity would have been routine[,] . . . [and] the modifications suggested by MacKay would have been straightforward and would have taken very little time to implement." *Id.*

Yet we do not agree with Petitioner that the need to run experiments in an unpredictable field, such as error-correction coding, indicates anything about whether such experiments ultimately would have been successful at the time of the invention. Importantly, "[u]npredictability of results equates more with nonobviousness rather than obviousness, whereas that which is predictable is more likely to be obvious." *Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017). In the absence of any argument rooted in the Petition directing us to evidence that substantiates a reasonable expectation of success, Petitioner's reliance on a known need for experimentation is not sufficient to support its obviousness rationale.[9] *See Arctic Cat Inc. v. Bombardier Recreational Prod. Inc.*, 876 F.3d 1350, 1360–61 (Fed. Cir. 2017) ("[W]here a party argues a skilled artisan would have been motivated to combine references, it must show the artisan would have had a reasonable expectation of success from doing so." (internal quotation omitted)).

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[9] Notably, Petitioner does not contend that its proposed combination should be analyzed under obvious-to-try case law. Tr. 15:24–16:4 (Petitioner acknowledging that it was not putting forth an obvious-to-try argument). Nor could Petitioner, because Petitioner does not develop an obvious-to-try theory. Specifically, Petitioner does not establish that the prior art directs which parameters to try and/or guides an inventor toward a particular solution. *See Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1347 (Fed. Cir. 2009).

For these reasons, we are not persuaded that an ordinarily skilled artisan would have been motivated to combine the teachings of Ping and MacKay in the manner suggested by Petitioner. Petitioner's reliance on Divsalar's and Luby97's teachings in the proposed combination does not remedy this underlying flaw. Thus, we determine Petitioner has not shown by a preponderance of the evidence that claim 18 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

Petitioner relies on the same deficient rationale for combining Ping and MacKay with respect to its analysis for dependent claims 19–23. *See* Pet. 64–73. Thus, we also determine Petitioner has not shown by a preponderance of the evidence that claims 19–23 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

E. Patent Owner's Motion to Exclude

Patent Owner moves to exclude Exhibits 1206, 1218, 1219, 1224, 1229–1249, 1257–1261, 1265, 1267, 1268, 1271, 1272, and portions of Exhibits 2038 and 2039. Paper 52, 1. Patent Owner's motion is dismissed as moot with respect to these exhibits, as we do not rely on them in a manner adverse to Patent Owner.

F. Patent Owner's Motion for Sanctions

Patent Owner requests sanctions against Petitioner for allegedly failing to stay within the proper scope of cross-examination during the deposition of Dr. Mitzenmacher and Dr. Divsalar. Paper 42, 1.[10]

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[10] Although Patent Owner cites primarily to Exhibit 1064 as the transcript of Dr. Divsalar's deposition, the pertinent exhibit in this case is Exhibit 2039. *See* Paper 42, 4.

Specifically, Patent Owner details questioning of Dr. Mitzenmacher that allegedly "ventured into various topics beyond the scope of the witness' direct testimony." *Id.* at 7–9. For example, Patent Owner cites "extensive questioning regarding Tanner graphs and figures newly created by Petitioner's lawyers, but absent from any petition materials or the witness' direct testimony." *Id.* at 8. Similarly, Patent Owner asserts that Dr. Divsalar was questioned regarding subject matter not discussed in his declaration including the Allerton Conference, Tanner graphs, and certain references. *Id.* at 3–7. As sanctions, Patent Owner asks us to: (1) strike the out-of-scope testimony elicited by Petitioner; (2) hold the direct testimony of Dr. Mitzenmacher and Dr. Divsalar to be facts established in this proceeding; and (3) impose "reasonable compensatory expenses, including attorney fees, for costs reasonably related to excessive questioning and deposition time." *Id.* at 9–10.

Petitioner contends that "each question posed by Petitioner during Dr. Mitzenmacher's deposition pertained directly to topics and opinions in his declaration." Paper 47, 5. Regarding the Tanner graphs and figures, Petitioner contends these were properly served upon Petitioner at Dr. Mitzenmacher's deposition in accordance with 37 C.F.R. § 42.53(f)(3). *Id.* at 6. According to Petitioner, Patent Owner's proposed sanctions are unwarranted, particularly because Patent Owner suffered no harm. *Id.* at 7–8.

The "Board may impose a sanction against a party for misconduct." 37 C.F.R. § 42.12(a); *see also* 35 U.S.C. § 316(a)(6) (requiring regulations prescribing sanctions). As the moving party, Patent Owner has the burden to persuade the Board that sanctions are warranted. *See* 37 C.F.R. § 42.20(c).

In general, a motion for sanctions should address three factors: (i) whether a party has performed conduct that warrants sanctions; (ii) whether the moving party has suffered harm from that conduct; and (iii) whether the sanctions requested are proportionate to the harm suffered by the moving party. *See Square, Inc. v. Think Comput. Corp.*, Case CBM2014-00159, slip op. at 2 (PTAB Nov. 27, 2015) (Paper 48) (citing *Ecclesiastes 9:10-11-12, Inc. v. LMC Holding Co.*, 497 F.3d 1135, 1143 (10th Cir. 2007)).

Having reviewed the relevant portions of Dr. Mitzenmacher's deposition, we agree with Petitioner that sanctions are not warranted. Petitioner's attempts to elicit testimony regarding the Tanner graphs and figures, while inartful, did not rise to the level of sanctionable conduct because they were reasonably related to Dr. Mitzenmacher's direct testimony.

As to Dr. Divsalar, Patent Owner characterizes his direct testimony (Ex. 2031) as merely taking the form of "a short declaration addressing only a few discrete points relating specifically to the Divsalar reference." Paper 42, 3. Patent Owner contends Petitioner's questions about the Allerton Conference, Tanner Graphs, and certain other references went beyond the "limited scope of Dr. Divsalar's 16-page declaration." *Id.* at 3–7.

Petitioner cites certain direct testimony from Dr. Divsalar regarding the perspective of a person of ordinary skill in the art, Tanner graphs, and certain "contemporaneous literature" and contends that it was permissible to question Dr. Divsalar at the deposition about the foundation and validity of his opinions on these topics. Paper 47, 3–5 (quoting Ex. 2031 ¶ 10 and citing Ex. 2031 ¶¶ 9–11, 26, 28–30, and 33–36). Petitioner further contends that "in his declaration, Dr. Divsalar discussed having submitted a paper 'in connection with the Allerton conference in 1998' [and] Petitioner thus properly asked questions about what 'in connection with the Allerton conference' means." Paper 47, 3 (citing Ex. 2031 ¶ 19).

We again agree with Petitioner that sanctions concerning the deposition of Dr. Divsalar are not warranted. In fact, Patent Owner acknowledges that Dr. Divsalar offered opinion testimony going to the heart of the dispute in this case. Paper 42, 3. In that respect, Patent Owner states:

> Dr. Divsalar expressed his view that modifying an RA [repeat-accumulate] code to include irregular repetition of information bits would not make sense on the basis that it would add unnecessary difficulty and complexity at odds with the stated objective in the paper, with no expectation of a corresponding benefit. [Ex. 2031 (Divsalar Declaration)] at ¶¶ 33-36. Dr. Divsalar was also asked to address the hypothetical modification suggested by Petitioner, which he explained was nonsensical and at odds with a key conclusion in the Divsalar paper. *Id.* at ¶ 37.

Id.; *see also* Ex. 2031 ¶ 9 (Dr. Divsalar, under the heading "Summary of Opinions," testifying: "I do not believe it would have been trivial or obvious to modify RA codes by making them 'irregular' in order to arrive at IRA codes, nor would a person of ordinary skill in the art be motivated to make such a modification."). In light of this, we are persuaded by Petitioner that its questions were reasonably related to Dr. Divsalar's direct testimony—including the opinion testimony—and were not so far afield as to warrant sanctions.

Furthermore, we agree with Petitioner that Patent Owner suffered no harm with respect to the depositions of Dr. Mitzenmacher and Dr. Divsalar, particularly in light of our disposition of the challenged claims. For these reasons, we deny Patent Owner's motion for sanctions.

III. CONCLUSION

Petitioner has *not* demonstrated by a preponderance of the evidence that claims 18–23 of the '032 patent are unpatentable as obvious over Ping, MacKay, Divsalar, and Luby97.

IV. ORDER

For the foregoing reasons, it is

ORDERED that claims 18–23 of the '032 patent have *not* been proven to be unpatentable;

FURTHER ORDERED that Patent Owner's Motion to Exclude is *dismissed as moot*;

FURTHER ORDERED that Patent Owner's Motion for Sanctions is *denied*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Case No. IPR2017-00701
Docket No.: 1033300-00287US7

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Apple Inc.,
Petitioner

v.

California Institute of Technology,
Patent Owner

IPR2017-00701
Patent No. 7,421,032

PETITIONER'S NOTICE OF APPEAL

Director of the United States Patent and Trademark Office
c/o Office of the General Counsel
P.O. Box 1450
Alexandria, VA 22314-5793

Pursuant to 35 U.S.C. §§ 141-44 and 319, and 37 C.F.R. § 90.2-90.3, notice is hereby given that Petitioner Apple Inc. appeals to the United States Court of Appeals for the Federal Circuit from the Final Written Decision entered August 2, 2018 (Paper 67) in IPR2017-00701, and all prior and interlocutory rulings related thereto or subsumed therein.

In accordance with 37 C.F.R. § 90.2(a)(3)(ii), Petitioner further indicates that the issues on appeal include, but are not limited to, whether the Patent Trial and Appeal Board erred in determining that Petitioner had not established by a preponderance of the evidence that claims 1 and 4–10 of U.S. Patent No. 7,421,032 are unpatentable under 35 U.S.C. § 103 over the combination of Ping, MacKay, Divsalar, and Luby97; and any finding or determination supporting or related to those issues, as well as all other issues decided adversely to Petitioner in any orders, decisions, rulings, and opinions.

Pursuant to 37 C.F.R. § 90.3, this Notice of Appeal is timely, having been duly filed within 63 days after the date of the Final Written Decision.

A copy of this Notice of Appeal is being filed simultaneously with the Patent Trial and Appeal Board, the Clerk's Office for the United States Court of Appeals for the Federal Circuit, and the Director of the Patent and Trademark Office.

Respectfully submitted,

Date: September 20, 2018

/Michael Smith/

Michael H. Smith
Registration No. 71,190
Counsel for Petitioner

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 90.2(a)(1) and 104.2(a), I hereby certify that, in addition to being filed electronically through the Patent Trial and Appeal Board's End to End (PTAB E2E), a true and correct original version of the foregoing PETITIONER'S NOTICE OF APPEAL is being filed by Express Mail (Express Mail Label EL 815615016 US) on this 20th day of September 2018, with the Director of the United States Patent and Trademark Office, at the following address:

Director of the United States Patent and Trademark Office
c/o Office of the General Counsel
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Pursuant to 37 C.F.R. § 90.2(a)(2) and Federal Circuit Rule 15(a)(1), and Rule 52(a),(e), I hereby certify that a true and correct copy of the foregoing PETITIONER'S NOTICE OF APPEAL is being filed in the United States Court of Appeals for the Federal Circuit using the Court's CM/ECF filing system on this 20th day of September 2018, and the filing fee is being paid electronically using pay.gov.

I hereby certify that on September 20, 2018 I caused a true and correct copy of the PETITIONER'S NOTICE OF APPEAL to be served via e-mail on the following attorneys of record:

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EXHIBIT A

Trials@uspto.gov
571-272-7822

Paper 67
Entered: August 2, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00701
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1101). Paper 3 ("Pet."). The Petition challenges the patentability of claims 1–10 of the '032 patent on the ground of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp."). We instituted *inter partes* review (Paper 14, "Inst. Dec.") of claims 1 and 4–10 based on Ping, MacKay, Divsalar, and Luby97. However, the instituted review did not include Petitioner's obviousness challenge of claims 2 and 3 based on those same references.

Patent Owner filed a Response to the Petition (Paper 32, "PO Resp."), and Petitioner filed a Reply (Paper 45, "Pet. Reply"). Pursuant to our authorization (Paper 43), Patent Owner filed a Sur-Reply (Paper 55, "PO Sur-Reply").

An oral hearing was held on May 8, 2018, and a transcript of the hearing is included in the record. Paper 66 ("Tr.").

As authorized in our Order of February 10, 2018 (Paper 41), Patent Owner filed a motion for sanctions related to Petitioner's cross-examination of Patent Owner's witnesses, Dr. Mitzenmacher and Dr. Divsalar (Paper 42), and Petitioner filed an opposition (Paper 47).

Additionally, Patent Owner filed a Motion to Exclude evidence (Paper 52), to which Petitioner filed an Opposition (Paper 54), and Patent Owner filed a Reply (Paper 58).

On April 24, 2018, the Supreme Court held that a decision to institute under 35 U.S.C. § 314 may not institute on fewer than all claims challenged in the petition. *SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348 (U.S. Apr. 24, 2018). On May 3, 2018, we issued an order modifying our institution decision to institute on all of the challenged claims and all of the grounds presented in the Petition. Paper 60. Subsequently, the parties filed a joint motion to limit the Petition to the claims and grounds that were originally instituted. Paper 64. We granted the motion. Paper 65. As a result, the remaining instituted claims and grounds are the same as they had been at the time of the Institution Decision. *See id.* at 3.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). After consideration of the parties' arguments and evidence, and for the reasons discussed below, we determine that Petitioner has *not* shown by a preponderance of the evidence that claims 1 and 4–10 of the '032 patent are unpatentable.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00700, and IPR2017-00728. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." Ex. 1101, [54]. The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

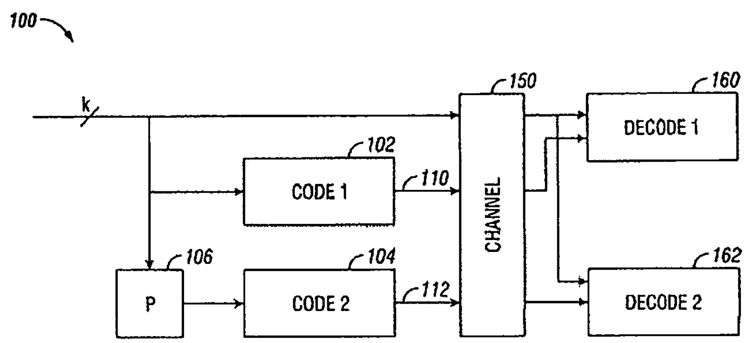

Figure 1 is a schematic diagram of a prior "turbo code" system. *Id.* at 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with reference to Figure 2, reproduced below.

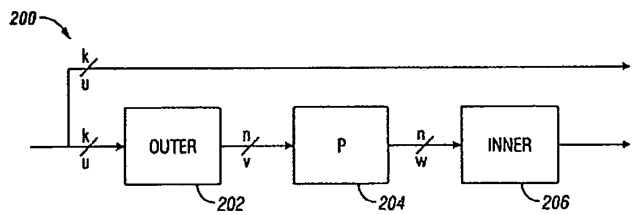

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") coder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

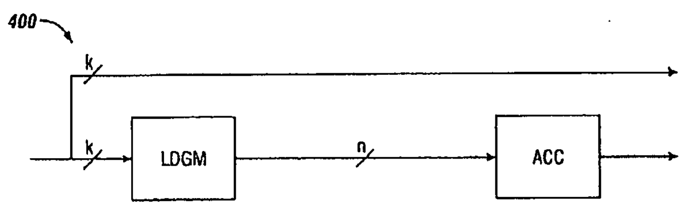

Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 1 is the only independent claim. The remaining challenged claims depend directly or indirectly from claim 1. Claim 1, reproduced below as corrected by a Certificate of Correction dated July 27, 2010, is illustrative:

> 1. A method comprising:
>
> receiving a collection of message bits having a first sequence in a source data stream;
>
> generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula

$$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$

where
"x_{j-1}" is the value of a parity bit "j-1," and

$$\sum_{i=1}^{a} v_{(j-1)a+i}$$

is the value of a sum of "a" randomly chosen irregular[2] repeats of the message bits; and

making the sequence of parity bits available for transmission in a transmission data stream.

Ex. 1101, 7:63–8:20; *id.*, Certificate of Correction (July 27, 2010) (replacing the two formulas).

E. Evidence

Petitioner relies on the following art references:

Reference	Exhibit No.
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")	Ex. 1102

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[2] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 23–24 (advocating the adoption of that construction in this case); PO Resp. 14 (citing Ex. 2004 ¶ 69 and asserting: "Caltech does not believe the term needs to be construed, as the plain and ordinary meaning of irregular repetition is clear. That message bits contribute in differing numbers to parity bits is made clear in the claim language.").

Reference	Exhibit No.
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")	Ex. 1103
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1108
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")	Ex. 1117

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1104), and the Declaration of Brendan Frey, Ph.D., dated February 21, 2018 (Ex. 1165) in support of its arguments. Patent Owner relies upon the Declaration of Dr. Michael Mitzenmacher, dated November 21, 2017 (Ex. 2004), and the Declaration of Dr. Dariush Divsalar, dated November 7, 2017 (Ex. 2031), in support of its arguments in the Patent Owner Response. The parties rely on other exhibits as discussed below.

F. Remaining Asserted Ground of Unpatentability

The following ground of unpatentability remains at issue in this case (Pet. 37; Paper 65 (granting joint motion to limit the Petition)):

References	Basis	Claims
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	1 and 4–10

II. ANALYSIS

A. Principles of Law

Petitioner bears the burden of proving unpatentability of the claims challenged in the Petition, and that burden never shifts to Patent Owner.

Dynamic Drinkware, LLC v. Nat'l Graphics, Inc., 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must establish the facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) any objective evidence of non-obviousness.[3] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. The Level of Ordinary Skill in the Art

Petitioner's declarant, Dr. Davis, opines that:

> A person of ordinary skill in the art at the time of the alleged invention of the '032 patent would have had a Ph.D. in mathematics, electrical or computer engineering, or computer science with emphasis in signal processing, communications, or coding, or a master's degree in the above area with at least three years of work experience in this field at the time of the alleged invention.

[3] Although Patent Owner puts forth evidence of objective indicia of non-obviousness (PO Resp. 51–62), we need not reach this evidence based on our disposition below.

Ex. 1104 ¶ 91; *see* Pet. 21–22 (citing the same). Patent Owner's declarant, Dr. Mitzenmacher, applies the same definition offered by Dr. Davis. Ex. 2004 ¶ 66.

We determine that the definition offered by Dr. Davis comports with the qualifications a person would have needed to understand and implement the teachings of the '032 patent and the prior art of record. Accordingly, we apply Dr. Davis's definition of the level of ordinary skill in the art.

C. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

We determine that no terms require explicit construction. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy").

D. The Alleged Obviousness over Ping, MacKay, and Divsalar

Petitioner alleges that independent claim 1 and dependent claims 4–10 of the '032 patent would have been obvious over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 37–55 (addressing independent claim 1).

Petitioner asserts that Ping discloses much of the subject matter of independent claim 1, but maintains that Ping's outer coder is regular.

Pet. 39. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 37, 39, relies on Divsalar for the teaching of repetition "if Ping alone is not understood to teach, or render obvious, repeating information bits," *id.* at 42, and relies on Luby97 for the teaching of receiving a source data stream "to the extent Ping is not understood to teach encoding bits in a 'stream,'" *id.* at 44. Patent Owner argues, *inter alia*, that the Petition presents a flawed reason to modify Ping in light of MacKay. PO Resp. 2–3.

1. Ping (Ex. 1103)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1103, 38. In this approach, "only part of [parity check matrix] **H** is generated randomly, and the remaining part is deterministic," which "achieve[s] essentially the same performance as the standard LDPC encoding method with significantly reduced complexity." *Id.* The size of matrix **H** is $(n-k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]'$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^p, \mathbf{H}^d]$." *Id.* $\mathbf{H}^p$ is defined as follows:

$$\mathbf{H}^p = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^d$ is created such that it "has a column weight of t and a row weight of $kt/(n-k)$ (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H^d} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1104 ¶ 67.[4] For each sub-block of $\mathbf{H^d}$, there is exactly "one element 1 per column and *kt/(n-k)* 1s per row." Ex. 1103, 38. This construction "increase[s] the recurrence distance of each bit in the encoding chain" and "reduces the correlation during the decoding process." *Id.*

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h^d_{1j}\, d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h^d_{ij}\, d_j \pmod 2$$

Ex. 1103, 38 (equation (4)).[5]

2. MacKay (Ex. 1102)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1102, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check

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[4] This particular representation of $\mathbf{H^d}$ is taken from Dr. Davis's testimony. Patent Owner's description of $\mathbf{H^d}$ is found at page 8 of its Response.
[5] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1104 ¶ 180.

matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. *Divsalar (Ex. 1117)*

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1104 ¶ 82 (quoting Ex. 1117, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

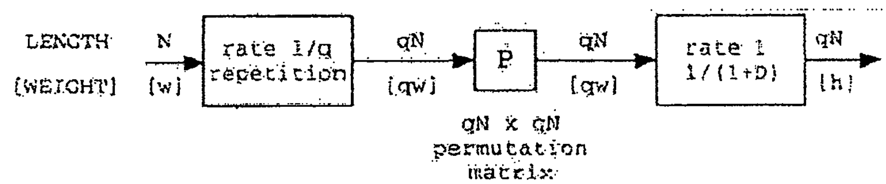

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1117, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. *Luby97 (Ex. 1108)*

Luby97 describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1108, 150 (Abstr.). Luby97 describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted).

5. The Alleged Obviousness of Claim 1

Petitioner, in articulating its obviousness challenge of claim 1, relies on the testimony of Dr. Davis and maps the teachings of the prior art against the limitations of the claim. Pet. 45–55.

Petitioner maintains that Ping, either alone or in light of Luby97, teaches a method including the step of "receiving a collection of message bits having a first sequence in a source data stream." *Id.* at 45–47 (citing Ex. 1104 ¶¶ 120–125). Specifically, Petitioner cites the information bits in Ping denoted by vector **d** for the "receiving" step. *Id.* at 46. (citing Ex. 1103, 38). Petitioner contends that Ping provides equations from which parity bits **p** can easily be calculated from information bits **d**, and that one of ordinary skill in the art would recognize that "message bits" and "information bits" are synonymous. *Id.* at 46–47. Petitioner points to Luby97's teaching of receiving data streams and asserts, "[e]ven if Ping is understood to teach only block encoding, and not encoding bits in [the claimed] 'a source data stream,' it would have been obvious to adapt Ping's coder to work with incoming data streams." *Id.* at 47; *see id.* at 44. Petitioner reasons that it would have been obvious to incorporate the stream teaching of Luby97 into Ping because coders that receive streams were common, *id.* at 44, 47, and the resulting incorporation would "make the encoder [of Ping] capable of receiving and processing 'streams' as opposed to blocks." *Id.* at 47; *see id.* at 44–45.

Petitioner next addresses the "generating" step (Pet. 48–53), which provides:

> generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula

> $$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$
>
> where
> "x_{j-1}" is the value of a parity bit "j-1," and
>
> $$\sum_{i=1}^{a} v_{(j-1)a+i}$$
>
> is the value of a sum of "a" randomly chosen irregular repeats of the message bits.

Ex. 1101, 7:66–8:17.

Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. Pet. at 24–25, 49–50. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d d_j$$

as teaching the calculation of a parity bit as the sum of the prior parity bit and a summation of message bits. *Id.* at 49–50. Petitioner argues that Ping also teaches the "randomly chosen" aspect of the limitation, asserting:

> Ping randomly determines which values of h_{ij}^d equal "1" and which values of h_{ij}^d equal "0." Specifically, Ping teaches generating $\mathbf{H}^d$ by partitioning it into "t equal sub-blocks," as shown in Equation (3), reproduced below:
>
> $$\mathbf{H}^d = \begin{pmatrix} \mathbf{H}^{d1} \\ \vdots \\ \mathbf{H}^{dt} \end{pmatrix}$$
>
> Ex. 1103, p. 38
>
> As Ping explains, "[i]n each sub-block $\mathbf{H}^{di}$, i = 1, 2 … t, we <u>*randomly*</u> create exactly one element 1 per column and *kt/(n-k)* 1s per row" (Ex. 1103, p. 38, emphasis added.) The positions of the 1s in $\mathbf{H}^d$ are used to determine which information bits are included in each summation $\sum_j h_{ij}^d d_j$. By placing the 1s into

> $\mathbf{H}^{d}$ "randomly," Ping ensures that the information bits contributing to each of the summations $\sum_j h_{ij}^{d} d_j$ are randomly chosen. (Ex. 1104, ¶137.)

Pet. 51.

Petitioner further contends that "it would have been obvious to one of ordinary skill to implement Ping by repeating every message bit [but] . . . , to the extent Ping does not itself teach, or render obvious, repeating every message bit, Divsalar does so explicitly." *Id.* at 52; *see id.* at 42. Petitioner also argues that the use of a repeater in an outer coder was common in the art, that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references' teachings. *Id.* at 42–43.

In addressing the "irregular repeats" aspect of claim 1, Petitioner contends that, "[i]n Ping's $\mathbf{H}^{d}$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^{d} d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 30. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^{d}$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}_d$ has a column weight of *t* . . . .'" *Id.* at 39 (quoting Ex. 1103, 38); *see id.* at 52–53. Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 40 (quoting Ex. 1102, 1449) (emphasis in original); *see also* Pet. Reply 3 (citing Ex. 1165 (Frey Decl.)

¶¶ 20–24) ("MacKay also teaches that codes with such parity check matrices, *i.e.*, matrices with uneven column weights, can outperform their regular counterparts.").

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." Pet. 39. Petitioner proposes modifying Ping's $\mathbf{H}^{\mathbf{d}}$ matrix (or outer coder), which Petitioner characterizes as regular, and contends that one of ordinary skill in the art would have made this modification to improve the performance of Ping's code. Pet. 39; Pet. Reply 4. Specifically, Petitioner maintains:

> It would have been straightforward for one of ordinary skill to change Ping's generator $\mathbf{H}^{\mathbf{d}}$ matrix such that different columns had different weights – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1102, p. 1451.) This would result in some information bits contributing to more outer LDPC parity bits than others, making Ping's outer LDPC code irregular. This would have been an easy way for one of ordinary skill to incorporate the irregularity disclosed by MacKay into Ping. Moreover, MacKay's teaching that the best performing LDPC codes are irregular would have made this modification obvious (and desirable). (Ex. 1102, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper….") (Ex. 1104, ¶108.)

Pet. 40. According to Petitioner, a person of ordinary skill would not have been motivated to modify $\mathbf{H}^{\mathbf{p}}$ because "it has only a single form and because doing so would have complicated a simple encoder." Pet. Reply 10. Thus, Petitioner contends that the person of ordinary skill "who wanted to obtain the benefit of MacKay's irregularity in Ping would have had only one option—to incorporate MacKay's irregularity into $\mathbf{H}^{\mathbf{d}}$." *Id.* Petitioner summarizes its position on this aspect of the claim by asserting that, given the teachings of MacKay, "it would have been obvious to one of ordinary skill to incorporate the non-uniform column weight of MacKay into the LDPC-accumulate codes of Ping [and] [t]his would result in some information bits being repeated more than others, satisfying the 'irregular repeats' requirement of claim 1." Pet. 53 (citing Ex. 1104 ¶ 142).

The last step of claim 1 recites "making the sequence of parity bits available for transmission in a transmission data stream." Ex. 1101, 8:19–20. Petitioner asserts that Ping, in discussing the performance of the codes, teaches the transmission of parity bits. Pet. 54. Petitioner again points to Luby97's teaching of data streams and argues that one of ordinary skill would have understood that bits commonly are transmitted in streams and that "[i]t would also have been obvious to one of ordinary skill that an encoder receiving bits in a stream would have output bits in a stream, and that the corresponding decoder would have received encoded bits in a stream." *Id.* (citing Ex. 1108, 150; Ex. 1104, ¶ 146).

Patent Owner disputes, *inter alia*, Petitioner's rationale for combining Ping and MacKay—which underlies the overall combination of Ping, MacKay, Divsalar, and Luby97—on a number of bases. *See* PO Resp. 15–16 (summarizing eight arguments regarding Petitioner's Ground), 24. Patent Owner argues that Ping's parity check matrix **H** is already irregular as defined by MacKay. *See id.* at 24–29. According to Patent Owner, "Ping's parity-check matrix has three different column weights (t, 2, and 1), and two different row weights ($kt/(n-k)+1$ and $kt/(n-k)+2$)." *Id.* at 25 (citing Ex. 2033, 231:11–14); *see also* Ex. 2004 ¶ 92 (same). As such, Patent Owner argues "Ping's parity-check matrix is actually even more 'irregular' than MacKay's irregular codes," so ordinarily skilled artisans "would not have been motivated by MacKay's teachings that irregular codes are an improvement over regular codes." PO Resp. 26–27 (citing Ex. 2004 ¶¶ 94, 95, and 97–99).

Patent Owner also highlights that Petitioner's proposed modifications relate only to a portion of Ping's parity check matrix **H**, namely, sub-matrix $\mathbf{H}^d$. *See id.* at 27–28; *see also* Ex. 2004 ¶ 96. Patent Owner argues "MacKay does not even *consider* modifying submatrices, much less teach that there may be benefits to try." PO Resp. 29. According to Patent Owner, "MacKay teaches that irregular parity-check matrices <u>*as a whole*</u> may define better codes than regular parity-check matrices <u>*as a whole*</u>—it does not teach any improvement from making a submatrix within a parity-check matrix irregular, or from using any other type of irregular matrix (e.g., irregular generator matrices)." *Id.* at 27. Patent Owner argues MacKay does not "suggest that *additional* irregularity should be applied to individual portions when the overall parity-check matrix is already irregular." *Id.* at 28 (citing Ex. 2004 ¶¶ 96–99) (footnote omitted).

Patent Owner further argues that Petitioner has not established that an ordinarily skilled artisan would have reasonably expected success from the proposed modification of Ping in light of MacKay. *See* PO Resp. 42–47. Patent Owner argues "the petition does not even attempt to analyze a reasonable expectation of success, and for that reason, it is incurably deficient." *Id.* at 42. As further evidence of the lack of anticipated success, Patent Owner emphasizes that constructing error-correction codes "was a highly unpredictable endeavor" that was subject to "extensive trial-and-error and experimentation to determine whether new codes led to an improvement." *Id.* at 4 (citing Ex. 2004 ¶ 46); *see also id.* at 42–43 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12).

We are persuaded by Patent Owner's arguments. We agree with Patent Owner (*see* PO Resp. 27–28 & n.7) that, although Petitioner may explain how to modify Ping's $\mathbf{H}^d$ sub-matrix in light of MacKay, it does not address why such an ordinarily skilled artisan would have done this. Nor does Petitioner establish that such an artisan reasonably would have expected success from the modification. Based on the entire trial record, we determine that Petitioner has not established a persuasive rationale for modifying Ping in light of MacKay as asserted by Petitioner. Petitioner's additional reliance on Divsalar and Luby97 does not remedy this fundamental flaw in the articulated combination. *See* Pet. 42, 44–45 (relying on Divsalar for the teaching of repeating information bits and Luby97 for the teaching of encoding bits in a stream if Ping is not understood to teach these aspects).

Petitioner's unpatentability contentions presuppose that an ordinarily skilled artisan would seek to modify a *sub-matrix* in Ping in light of MacKay. *See* Pet. Reply 10 ("Caltech's comparison of Ping's **H** matrix to MacKay's is improper. . . . The proper comparison is between Ping's $\mathbf{H}^d$ matrix . . . and MacKay's matrix."). Yet even if MacKay touts improvements from irregularity in a parity check matrix (e.g., Ping's matrix **H**), MacKay does not suggest that these improvements would have been applicable to *portions* of a parity check matrix (e.g., Ping's sub-matrix $\mathbf{H}^d$). To reach its proposed modification, Petitioner characterizes Ping's sub-matrix $\mathbf{H}^d$ as a generator matrix (or "outer coder") and Ping's sub-matrix $\mathbf{H}^p$ as merely an accumulator (or "inner coder"). Pet. 24–25, 41;

Pet. Reply 7, 13–16. We agree with Patent Owner (*see* PO Resp. 35), however, that Petitioner does not explain adequately why labeling sub-matrix $\mathbf{H}^d$ as a generator matrix supports the proposed modification of $\mathbf{H}^d$ based on MacKay. Indeed, this label does not explain why an ordinarily skilled artisan considering MacKay would have chosen to modify $\mathbf{H}^d$ or any other portion of parity check matrix **H**.

Petitioner's further contentions also are not persuasive. Specifically, Petitioner contends $\mathbf{H}^p$ is an accumulator with only a single, fixed form, so an ordinarily skilled artisan would not have been motivated to modify $\mathbf{H}^p$ because "doing so would have complicated a simple encoder." Pet. Reply 10, 17. Yet this rationalization belies the fact that Ping also specifically defines a structure for sub-matrix $\mathbf{H}^d$, which simplifies a portion of the parity check matrix. According to Dr. Mitzenmacher, "the constraints on $\mathbf{H}^d$, including its regularity, were a deliberate design decision that contributes to the improved performance of Ping's code over fully random LDPC codes—it is a fundamental part of its code." Ex. 2004 ¶ 104. Thus, choosing to modify *any* portion of Ping's matrix would have broken constraints in Ping that were intended to simplify encoding. *See* Ex. 1103, 38 (Ping describing the disclosed approach as a "new method [that] can achieve essentially the same performance as the standard LDPC encoding method with significantly reduced complexity"). This is a strong indication that an ordinarily skilled artisan would not have been motivated to reach within Ping's parity check matrix **H** and modify a sub-matrix.

We also agree with Patent Owner that Ping's parity check matrix **H** is already "irregular," which undermines Petitioner's stated motivation for modifying Ping in view of MacKay. *See* PO Resp. 24–29. Citing

Dr. Mitzenmacher, Patent Owner establishes that Ping's matrix **H** has three different column weights (t, 2, and 1). *Id.* at 25–29; Ex. 2004 ¶¶ 91–92; *see also* Ex. 2033, 231:11–14 (Dr. Davis acknowledging that Ping's parity check matrix **H** has "different weights for the columns"). We accept this as evidence of "irregularity" based on Petitioner's own acknowledgment that "irregularity" is associated with "uneven column weights." *See* Pet. Reply 16. Petitioner does not contest that Ping's parity check matrix **H** is irregular; rather, Petitioner contends that the appropriate comparison is between MacKay's parity check matrix and Ping's sub-matrix $\mathbf{H}^d$. Pet. Reply 10. But MacKay is silent on the concept of sub-matrices, so Petitioner's association of MacKay's teaching with sub-matrix $\mathbf{H}^d$ is not apt. Instead, we agree with Patent Owner that "MacKay's teachings are only applicable to full parity check matrices." PO Resp. 15–16. Thus, the record does not establish that an ordinarily skilled artisan would have sought to add irregularity to Ping's parity check matrix **H**—or additional irregularity to a sub-matrix of **H**, such as $\mathbf{H}^d$—because **H** itself is already irregular.

Finally, we agree with Patent Owner that the Petition is silent on whether a person of ordinary skill in the art would have expected success in combining MacKay with Ping. Although Petitioner cites an alleged "straightforward modification of Ping's $\mathbf{H}^d$ matrix" at page 40 of the Petition as supporting the expectation of success (Pet. Reply 17), the cited passage only describes the proposed modification, rather than addressing whether an ordinarily skilled artisan would have anticipated success from the modification. *See* Pet. 40. In addition, Petitioner's argument that an ordinarily skilled artisan "would have needed no more specificity to attempt to use MacKay's irregularity in Ping" (Pet. Reply 17) only underscores the lack of evidence in the Petition regarding anticipated success.

Perhaps sensing this deficiency in the Petition, Petitioner introduces new testimony and a new simulation from Dr. Frey with its Reply in which Dr. Frey allegedly "demonstrate[s] the ease with which a [person of ordinary skill in the art] could have added MacKay's irregularity to Ping." Ex. 1165 ¶ 44. According to Petitioner, the results of the simulation "outperform Ping's original code" and "confirm that a [person of ordinary skill in the art] would have been motivated to use MacKay's uneven column weights in Ping's $\mathbf{H}^d$ matrix, and . . . would have had a reasonable expectation of success when doing so." Pet. Reply 19–20. Yet, even if we were to deem the testimony and simulation to be within the proper scope of a reply brief,[6] they do not support a reasonable expectation of success *at the time of the invention*. We agree with Patent Owner that "[i]t is irrelevant what Dr. Frey claims he could do in the year 2018 when armed with Caltech's disclosures, [the named-inventor's] original coding work, contemporary resources (e.g., Matlab), and some 18 years of post-filing date knowledge." PO Sur-Reply 6–7 (footnote omitted). Because this evidence is not tied to the state of the art at the time of the invention, it is not probative of anticipated success. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1367 (Fed. Cir. 2017) (quoting *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1138 (Fed. Cir. 1985)) ("Those charged with determining compliance with 35 U.S.C. § 103 are required to place themselves in the minds of those

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[6] We need not reach this issue, because we do not rely on this evidence in a manner adverse to Patent Owner. *See also infra* § II.E. (dismissing Patent Owner's Motion to Exclude as moot on the same basis).

of ordinary skill in the relevant art *at the time the invention was made*, to determine whether that which is now plainly at hand would have been obvious at such earlier time." (emphasis added)).

Furthermore, as part of our obviousness analysis, we are charged to consider "the scope and content of the prior art." *See Graham*, 383 U.S. at 17–18. One important aspect of the art in this case is the relative unpredictability of developing error-correction codes. *See* PO Resp. 42–43 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12) ("New codes appeared from unexpected sources, and developing the precise parameters that could lead to incremental improvements often took a significant amount of time and experimentation."). In its Reply, Petitioner embraces the notion of unpredictability as supporting its combination; Petitioner contends that "rigorous mathematical analysis of codes is difficult, and, as a result, [persons of ordinary skill in the art] routinely develop codes by experimentation." Pet. Reply 17–18. Petitioner further contends that "running experimental tests on a version of Ping that incorporated MacKay's irregularity would have been routine[,] . . . [and] the modifications suggested by MacKay would have been straightforward and would have taken very little time to implement." *Id.* at 18.

Yet we do not agree with Petitioner that the need to run experiments in an unpredictable field, such as error-correction coding, indicates anything about whether such experiments ultimately would have been successful at the time of the invention. Importantly, "[u]npredictability of results equates more with nonobviousness rather than obviousness, whereas that which is predictable is more likely to be obvious." *Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017). In the absence of any argument rooted in the Petition directing us to evidence that substantiates a reasonable expectation of success, Petitioner's reliance on a known need for experimentation is not sufficient to support its obviousness rationale.[7] *See Arctic Cat Inc. v. Bombardier Recreational Prod. Inc.*, 876 F.3d 1350, 1360–61 (Fed. Cir. 2017) ("[W]here a party argues a skilled artisan would have been motivated to combine references, it must show the artisan would have had a reasonable expectation of success from doing so." (internal quotation omitted)).

For these reasons, we are not persuaded that an ordinarily skilled artisan would have been motivated to combine the teachings of Ping and MacKay in the manner suggested by Petitioner. Petitioner's reliance on Divsalar's and Luby97's teachings in the proposed combination does not remedy this underlying flaw. Thus, we determine Petitioner has not shown by a preponderance of the evidence that claim 1 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

Petitioner relies on the same deficient rationale for combining Ping and MacKay with respect to its analysis for dependent claims 4–10. *See* Pet. 61–74. Thus, we also determine Petitioner has not shown by a

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[7] Notably, Petitioner does not contend that its proposed combination should be analyzed under obvious-to-try case law. Tr. 15:24–16:4 (Petitioner acknowledging that it was not putting forth an obvious-to-try argument). Nor could Petitioner, because Petitioner does not develop an obvious-to-try theory. Specifically, Petitioner does not establish that the prior art directs which parameters to try and/or guides an inventor toward a particular solution. *See Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1347 (Fed. Cir. 2009).

preponderance of the evidence that claims 4–10 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

E. Patent Owner's Motion to Exclude

Patent Owner moves to exclude Exhibits 1106, 1118, 1119, 1124, 1129-1149, 1157-1161, 1165, 1167, 1168, 1171, 1172 and portions of Exhibits 2038 and 2039. Paper 52, 1. Patent Owner's motion is dismissed as moot with respect to these exhibits, as we do not rely on them in a manner adverse to Patent Owner.

F. Patent Owner's Motion for Sanctions

Patent Owner requests sanctions against Petitioner for allegedly failing to stay within the proper scope of cross-examination during the deposition of Dr. Mitzenmacher and Dr. Divsalar. Paper 42, 1.[8] Specifically, Patent Owner details questioning of Dr. Mitzenmacher that allegedly "ventured into various topics beyond the scope of the witness' direct testimony." *Id.* at 7–9. For example, Patent Owner cites "extensive questioning regarding Tanner graphs and figures newly created by Petitioner's lawyers, but absent from any petition materials or the witness' direct testimony." *Id.* at 8. Similarly, Patent Owner asserts that Dr. Divsalar was questioned regarding subject matter not discussed in his declaration including the Allerton Conference, Tanner graphs, and certain references. *Id.* at 3–7. As sanctions, Patent Owner asks us to: (1) strike the out-of-scope testimony elicited by Petitioner; (2) hold the direct testimony of

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[8] Although Patent Owner cites primarily to Exhibit 1064 as the transcript of Dr. Divsalar's deposition, the pertinent exhibit in this case is Exhibit 2039. *See* Paper 42, 4.

Dr. Mitzenmacher and Dr. Divsalar to be facts established in this proceeding; and (3) impose "reasonable compensatory expenses, including attorney fees, for costs reasonably related to excessive questioning and deposition time." *Id.* at 9–10.

Petitioner contends that "each question posed by Petitioner during Dr. Mitzenmacher's deposition pertained directly to topics and opinions in his declaration." Paper 47, 5. Regarding the Tanner graphs and figures, Petitioner contends these were properly served upon Petitioner at Dr. Mitzenmacher's deposition in accordance with 37 C.F.R. § 42.53(f)(3). *Id.* at 6. According to Petitioner, Patent Owner's proposed sanctions are unwarranted, particularly because Patent Owner suffered no harm. *Id.* at 7–8.

The "Board may impose a sanction against a party for misconduct." 37 C.F.R. § 42.12(a); *see also* 35 U.S.C. § 316(a)(6) (requiring regulations prescribing sanctions). As the moving party, Patent Owner has the burden to persuade the Board that sanctions are warranted. *See* 37 C.F.R. § 42.20(c). In general, a motion for sanctions should address three factors: (i) whether a party has performed conduct that warrants sanctions; (ii) whether the moving party has suffered harm from that conduct; and (iii) whether the sanctions requested are proportionate to the harm suffered by the moving party. *See Square, Inc. v. Think Comput. Corp.*, Case CBM2014-00159, slip op. at 2 (PTAB Nov. 27, 2015) (Paper 48) (citing *Ecclesiastes 9:10-11-12, Inc. v. LMC Holding Co.*, 497 F.3d 1135, 1143 (10th Cir. 2007)).

Having reviewed the relevant portions of Dr. Mitzenmacher's deposition, we agree with Petitioner that sanctions are not warranted. Petitioner's attempts to elicit testimony regarding the Tanner graphs and figures, while inartful, did not rise to the level of sanctionable conduct because they were reasonably related to Dr. Mitzenmacher's direct testimony.

As to Dr. Divsalar, Patent Owner characterizes his direct testimony (Ex. 2031) as merely taking the form of "a short declaration addressing only a few discrete points relating specifically to the Divsalar reference." Paper 42, 3. Patent Owner contends Petitioner's questions about the Allerton Conference, Tanner Graphs, and certain other references went beyond the "limited scope of Dr. Divsalar's 16-page declaration." *Id.* at 3–7.

Petitioner cites certain direct testimony from Dr. Divsalar regarding the perspective of a person of ordinary skill in the art, Tanner graphs, and certain "contemporaneous literature" and contends that it was permissible to question Dr. Divsalar at the deposition about the foundation and validity of his opinions on these topics. Paper 47, 3–4 (quoting Ex. 2031 ¶ 10 and citing Ex. 2031 ¶¶ 9–11, 26, 28–30, and 33–36). Petitioner further contends that "in his declaration, Dr. Divsalar discussed having submitted a paper 'in connection with the Allerton conference in 1998' [and] Petitioner thus properly asked questions about what 'in connection with the Allerton conference' means." Paper 47, 3 (citing Ex. 2031 ¶ 19).

We again agree with Petitioner that sanctions concerning the deposition of Dr. Divsalar are not warranted. In fact, Patent Owner acknowledges that Dr. Divsalar offered opinion testimony going to the heart of the dispute in this case. Paper 42, 3. In that respect, Patent Owner states:

> Dr. Divsalar expressed his view that modifying an RA [repeat-accumulate] code to include irregular repetition of information bits would not make sense on the basis that it would add

> unnecessary difficulty and complexity at odds with the stated objective in the paper, with no expectation of a corresponding benefit. [Ex. 2031 (Divsalar Declaration)] at ¶¶ 33-36. Dr. Divsalar was also asked to address the hypothetical modification suggested by Petitioner, which he explained was nonsensical and at odds with a key conclusion in the Divsalar paper. *Id.* at ¶ 37.

Id.; *see also* Ex. 2031 ¶ 9 (Dr. Divsalar, under the heading "Summary of Opinions," testifying: "I do not believe it would have been trivial or obvious to modify RA codes by making them 'irregular' in order to arrive at IRA codes, nor would a person of ordinary skill in the art be motivated to make such a modification."). In light of this, we are persuaded by Petitioner that its questions were reasonably related to Dr. Divsalar's direct testimony—including the opinion testimony—and were not so far afield as to warrant sanctions.

Furthermore, we agree with Petitioner that Patent Owner suffered no harm with respect to the depositions of Dr. Mitzenmacher and Dr. Divsalar, particularly in light of our disposition of the challenged claims. For these reasons, we deny Patent Owner's motion for sanctions.

III. CONCLUSION

Petitioner has *not* demonstrated by a preponderance of the evidence that claims 1 and 4–10 of the '032 patent are unpatentable as obvious over Ping, MacKay, Divsalar, and Luby97.

IV. ORDER

For the foregoing reasons, it is

ORDERED that claims 1 and 4–10 of the '032 patent have *not* been proven to be unpatentable;

FURTHER ORDERED that Patent Owner's Motion to Exclude is *dismissed as moot*;

FURTHER ORDERED that Patent Owner's Motion for Sanctions is *denied*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Case No. IPR2017-00700
Docket No.: 1033300-00287US6

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Apple Inc.,
Petitioner

v.

California Institute of Technology,
Patent Owner

IPR2017-00700
Patent No. 7,421,032

PETITIONER'S NOTICE OF APPEAL

Director of the United States Patent and Trademark Office
c/o Office of thc General Counsel
P.O. Box 1450
Alexandria, VA 22314-5793

Pursuant to 35 U.S.C. §§ 141-44 and 319, and 37 C.F.R. § 90.2-90.3, notice is hereby given that Petitioner Apple Inc. appeals to the United States Court of Appeals for the Federal Circuit from the Final Written Decision entered August 2, 2018 (Paper 67) in IPR2017-00700, and all prior and interlocutory rulings related thereto or subsumed therein.

In accordance with 37 C.F.R. § 90.2(a)(3)(ii), Petitioner further indicates that the issues on appeal include, but are not limited to, whether the Patent Trial and Appeal Board erred in determining that Petitioner had not established by a preponderance of the evidence that claims 11, 12, and 14–16 of U.S. Patent No. 7,421,032 are unpatentable under 35 U.S.C. § 103 over the combination of Ping, MacKay, and Divsalar; that claim 13 of U.S. Patent No. 7,421,032 is unpatentable under 35 U.S.C. § 103 over the combination of Ping, MacKay, Divsalar, and Luby97; and any finding or determination supporting or related to those issues, as well as all other issues decided adversely to Petitioner in any orders, decisions, rulings, and opinions.

Pursuant to 37 C.F.R. § 90.3, this Notice of Appeal is timely, having been duly filed within 63 days after the date of the Final Written Decision.

A copy of this Notice of Appeal is being filed simultaneously with the Patent Trial and Appeal Board, the Clerk's Office for the United States Court of Appeals for the Federal Circuit, and the Director of the Patent and Trademark Office.

Respectfully submitted,

Date: September 20, 2018

/Michael Smith/

Michael H. Smith
Registration No. 71,190
Counsel for Petitioner

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 90.2(a)(1) and 104.2(a), I hereby certify that, in addition to being filed electronically through the Patent Trial and Appeal Board's End to End (PTAB E2E), a true and correct original version of the foregoing PETITIONER'S NOTICE OF APPEAL is being filed by Express Mail (Express Mail Label EL 749915697 US) on this 20th day of September 2018, with the Director of the United States Patent and Trademark Office, at the following address:

Director of the United States Patent and Trademark Office
c/o Office of the General Counsel
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Pursuant to 37 C.F.R. § 90.2(a)(2) and Federal Circuit Rule 15(a)(1), and Rule 52(a),(e), I hereby certify that a true and correct copy of the foregoing PETITIONER'S NOTICE OF APPEAL is being filed in the United States Court of Appeals for the Federal Circuit using the Court's CM/ECF filing system on this 20th day of September 2018, and the filing fee is being paid electronically using pay.gov.

I hereby certify that on September 20, 2018 I caused a true and correct copy of the PETITIONER'S NOTICE OF APPEAL to be served via e-mail on the following attorneys of record:

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EXHIBIT A

ActiveUS 169546204

Trials@uspto.gov
571-272-7822

Paper 67
Entered: August 2, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00700
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1001). Paper 5 ("Pet."). The Petition challenges the patentability of claims 11–17 of the '032 patent on various grounds of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp."). We instituted *inter partes* review (Paper 14, "Inst. Dec.") of claims 11, 12, and 14–16 based on Ping, MacKay, and Divsalar, and of claim 13 based on Ping, MacKay, Divsalar, and Luby97. However, the instituted review did not include Petitioner's obviousness challenge of claim 17 based on Ping, MacKay, Divsalar, and Pfister Slides.

Patent Owner filed a Response to the Petition (Paper 32, "PO Resp."), and Petitioner filed a Reply (Paper 45, "Pet. Reply"). Pursuant to our authorization (Paper 43), Patent Owner filed a Sur-Reply (Paper 55, "PO Sur-Reply").

An oral hearing was held on May 8, 2018, and a transcript of the hearing is included in the record. Paper 66 ("Tr.").

As authorized in our Order of February 10, 2018 (Paper 41), Patent Owner filed a motion for sanctions related to Petitioner's cross-examination of Patent Owner's witnesses, Dr. Mitzenmacher and Dr. Divsalar (Paper 42), and Petitioner filed an opposition (Paper 47).

Additionally, Patent Owner filed a Motion to Exclude evidence (Paper 52), to which Petitioner filed an Opposition (Paper 54), and Patent Owner filed a Reply (Paper 58).

On April 24, 2018, the Supreme Court held that a decision to institute under 35 U.S.C. § 314 may not institute on fewer than all claims challenged in the petition. *SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348 (U.S. Apr. 24, 2018). On May 3, 2018, we issued an order modifying our institution decision to institute on all of the challenged claims and all of the grounds presented in the Petition. Paper 60. Subsequently, the parties filed a joint motion to limit the Petition to the claims and grounds that were originally instituted. Paper 64. We granted the motion. Paper 65. As a result, the remaining instituted claims and grounds are the same as they had been at the time of the Institution Decision. *See id.* at 3.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). After consideration of the parties' arguments and evidence, and for the reasons discussed below, we determine that Petitioner has *not* shown by a preponderance of the evidence that claims 11–16 of the '032 patent are unpatentable.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00701, and IPR2017-00728. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." Ex. 1001, [54]. The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

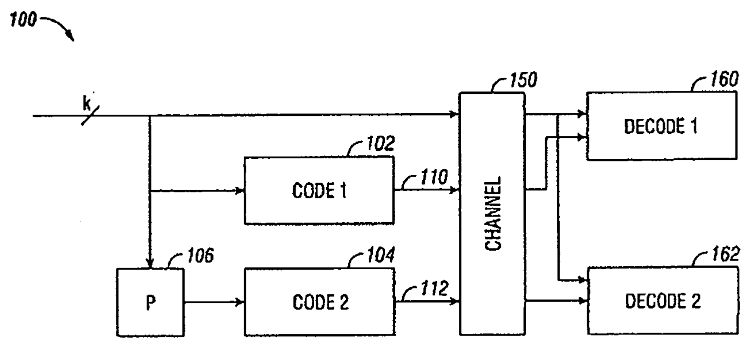


Figure 1 is a schematic diagram of a prior "turbo code" system. *Id.* at 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with reference to Figure 2, reproduced below.

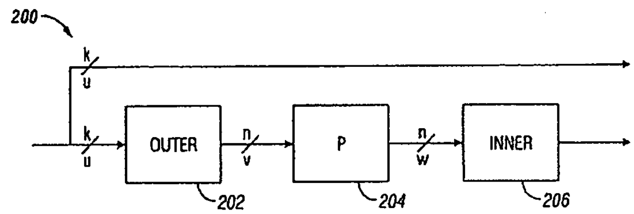


Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

---

[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") coder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

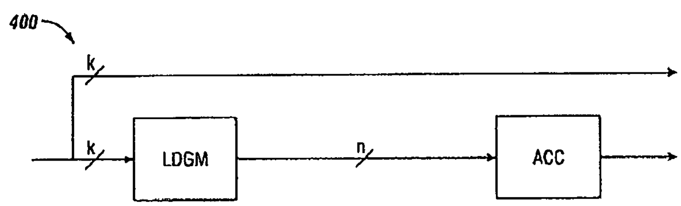


Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

"The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code." *Id.* at 3:33–35. Figure 3, shown below, depicts such a Tanner graph.

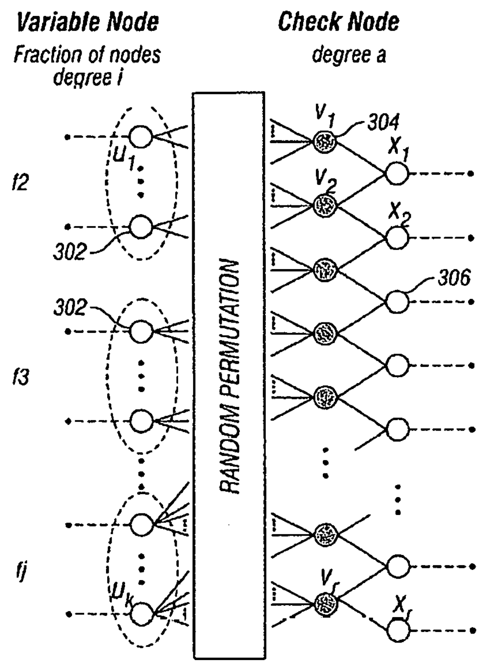


Figure 3 is described as a "Tanner graph for an irregular repeat and accumulate (IRA) coder." *Id.* at 2:20–21. The left-most column of nodes, information nodes 302 (the open circles), are variable nodes that receive information bits. The column of nodes (the filled circles) just to the right of the "RANDOM PERMUTATION" block are check nodes v indicated by reference numeral 304. An information bit node connected to two check nodes represents a repeat of 2. An information node connected to three check nodes represents a repeat of 3. The nodes (the open circles) in the right-most column are parity bit nodes x, referenced by 306. As shown by the edges[2] of the Tanner graph, each parity bit is a function of its previous parity bit and is also a function of information bits (edges connect through

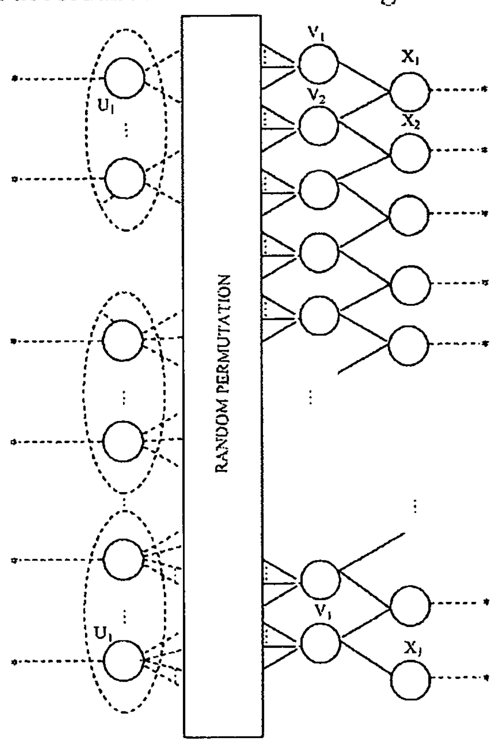
[2] We understand that "edges" are the straight lines that connect one node to another node of a Tanner graph. *See* Ex. 1001, 3:53–54.

check nodes and random permutation to information bit nodes). *Id.* at 3:34–55; *see also* Ex. 1004 ¶ 110 (discussing the relationship between parity bits in the context of the claimed Tanner graph and the '032 patent's specification).

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 11 is the only independent claim. The remaining challenged claims depend directly or indirectly from claim 11. Claim 11, reproduced below as originally issued and before issuance of a Certificate of Correction dated February 17, 2009, is illustrative:

> 11. A device comprising:
>
> an encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits in accordance with the following Tanner graph:



Ex. 1001, 8:63–9:34. A Certificate of Correction for the '032 patent replaced the labels V_I, U_I, and X_I from the lower portion of the Tanner graph in claim 11 with V_r, U_k, and X_r, respectively. *See id.* at Certificate of Correction (Feb. 17, 2009).

E. Evidence

Petitioner relies on the following art references:

Reference	Exhibit No.
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")	Ex. 1002
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")	Ex. 1003
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1008
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")	Ex. 1017

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1004), and the Declaration of Brendan Frey, Ph.D., dated February 21, 2018 (Ex. 1065) in support of its arguments. Patent Owner relies upon the Declaration of Dr. Michael Mitzenmacher, dated November 21, 2017 (Ex. 2004), and the Declaration of Dr. Dariush Divsalar, dated November 7, 2017 (Ex. 2031), in support of its arguments in the Patent Owner Response. The parties rely on other exhibits as discussed below.

F. Remaining Asserted Grounds of Unpatentability

The following grounds of unpatentability remain at issue in this case (Pet. 39, 64, 71; Paper 65 (granting joint motion to limit the Petition)):

References	Basis	Claim(s)
Ping, MacKay, and Divsalar	§ 103(a)	11, 12, and 14–16
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	13

II. ANALYSIS

A. Principles of Law

Petitioner bears the burden of proving unpatentability of the claims challenged in the Petition, and that burden never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must establish the facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3)

the level of skill in the art; and (4) any objective evidence of non-obviousness.[3] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. The Level of Ordinary Skill in the Art

Petitioner's declarant, Dr. Davis, opines that:

> A person of ordinary skill in the art at the time of the alleged invention of the '032 patent would have had a Ph.D. in mathematics, electrical or computer engineering, or computer science with emphasis in signal processing, communications, or coding, or a master's degree in the above area with at least three years of work experience in this field at the time of the alleged invention.

Ex. 1004 ¶ 98; *see* Pet. 23 (citing the same). Patent Owner's declarant, Dr. Mitzenmacher, applies the same definition offered by Dr. Davis. Ex. 2004 ¶ 66.

We determine that the definition offered by Dr. Davis comports with the qualifications a person would have needed to understand and implement the teachings of the '032 patent and the prior art of record. Accordingly, we apply Dr. Davis's definition of the level of ordinary skill in the art.

C. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary

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[3] Although Patent Owner puts forth evidence of objective indicia of non-obviousness (PO Resp. 54–66), we need not reach this evidence based on our disposition below.

skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Tanner Graph

For purposes of our Institution Decision, we adopted the construction for "Tanner graph" set forth in a prior Board decision concerning the '032 patent and for which Petitioner supports the application of the same construction in the present case. Inst. Dec. 9–10 (quoting IPR2015-00060, Paper 18, 12–14; citing Pet. 26[4]). The prior construction was specifically addressing the Tanner graph of claim 18, but is equally applicable to claim 11, at issue in this case, because the Tanner graph is the same in both claims. *See* Ex. 1004 ¶ 99 (Dr. Davis); Ex. 2001 ¶ 20 (Dr. Tanner); Tr. 49:18–21, 62:10–13. That construction is as follows:

> [1] a graph representing an [irregular[5] repeat accumulate] IRA code as a set of parity checks where every message bit is

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[4] Petitioner contends that this construction is the broadest reasonable interpretation, yet is narrower than that adopted by the District Court in *Caltech v. Hughes Communications Inc.*, No. 2:13-cv-07245 (C.D. Cal.) because the court's construction did not include the constraint regarding parity bit determination (constraint [3]). Pet. 26 (citing Ex. 1013). Petitioner contends that the difference has no substantive effect on the issues before us. *See* Tr. 34:16–35:2.

[5] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 24 (advocating the adoption of that construction in this case); PO Resp. 14 (citing Ex. 2004 ¶ 69 and asserting: "Caltech does not believe the term needs to be construed, as the plain and ordinary meaning of irregular repetition is clear. That message bits contribute in differing numbers to parity bits is made clear in the claim language.").

> repeated, at least two different subsets of message bits are repeated a different number of times, and
>
> [2] check nodes, randomly connected to the repeated message bits, enforce constraints that determine the parity bits[, and] . . .
>
> [3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph.

Inst. Dec. 9–10.

Patent Owner does not express disagreement with the construction but contends that the term "Tanner graph" need not be construed because, *inter alia*, a person of ordinary skill in the art "would have readily understood how to encode bits according to the Tanner graph in the claims and in view of the specification." PO Resp. 16; *see also* Ex. 2004 ¶ 73 (Dr. Mitzenmacher not disagreeing with any aspect of the construction but opining that: "[T]here is no need to 'construe' the graph. Any person of ordinary skill could readily comprehend what the graph requires in terms of an encoder or a decoder.").

Regardless as to whether the person of ordinary skill in the art—e.g., a person with a doctorate in mathematics—would understand the claim, we find a verbal description of the graph to be helpful. Accordingly, we again adopt that prior construction for purposes of analyzing Petitioner's challenges before us in this case.

On this record and for purposes of deciding the dispositive issues before us, we determine that no other claim terms require express construction.

D. The Alleged Obviousness over Ping, MacKay, and Divsalar

Petitioner alleges that independent claim 11 and dependent claims 12, and 14–16 of the '032 patent would have been obvious over Ping, MacKay, and Divsalar. *See* Pet. 39–57 (addressing independent claim 11).

Petitioner asserts that Ping discloses much of the subject matter of independent claim 11, but maintains that Ping's outer coder is regular. Pet. 41; *see also id.* at 51. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 39, 41, and relies on Divsalar for the teaching of repetition "if Ping standing alone is not understood to teach, or render obvious, repeating information bits," *id.* at 44. Patent Owner argues, *inter alia*, that the Petition presents a flawed reason to modify Ping in light of MacKay. PO Resp. 2–3.

1. Ping (Ex. 1003)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1003, 38. In this approach, "only part of [parity check matrix] **H** is generated randomly, and the remaining part is deterministic," which "achieve[s] essentially the same performance as the standard LDPC encoding method with significantly reduced complexity." *Id.* The size of matrix **H** is $(n\text{–}k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]'$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^{\mathbf{p}}, \mathbf{H}^{\mathbf{d}}]$." *Id.* $\mathbf{H}^{\mathbf{p}}$ is defined as follows:

$$\mathbf{H}^{\mathrm{p}} = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^{\mathrm{d}}$ is created such that it "has a column weight of *t* and a row weight of *kt*/(*n*–*k*) (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H}^{\mathrm{d}} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1004 ¶ 74.[6] For each sub-block of $\mathbf{H}^{\mathrm{d}}$, there is exactly "one element 1 per column and *kt/(n-k)* 1s per row." Ex. 1003, 38. This construction "increase[s] the recurrence distance of each bit in the encoding chain" and "reduces the correlation during the decoding process." *Id.*

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h^d_{1j}\, d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h^d_{ij}\, d_j \pmod 2$$

Ex. 1003, 38 (equation (4)).[7]

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[6] This particular representation of $\mathbf{H}^{\mathrm{d}}$ is taken from Dr. Davis's testimony. Patent Owner's description of $\mathbf{H}^{\mathrm{d}}$ is found at page 8 of its Response.
[7] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is

2. MacKay (Ex. 1002)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1002, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1017)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1004 ¶ 89 (quoting Ex. 1017, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

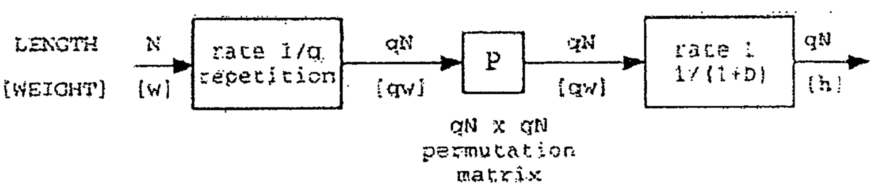

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1017, 5. The numbers above the input-output lines

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defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1004 ¶ 185.

indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. The Alleged Obviousness of Claim 11

As discussed above in the context of claim construction, independent claim 11 contains a Tanner graph having at least three elements. Petitioner, in articulating its obviousness challenge of claim 11, relies on the testimony of Dr. Davis and maps the teachings of the prior art against those three elements as well as the express recitations of the claim. Pet. 46–57.

Petitioner maintains that Ping teaches the recited "encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits." *Id.* at 46–47 (citing Ex. 1004 ¶¶ 127–128). Specifically, Petitioner contends that Ping provides equations from which parity bits **p** can easily be calculated from information bits **d**, and that one of ordinary skill in the art would recognize that "message bits" and "information bits" are synonymous. *Id.*

As for the Tanner graph, Petitioner addresses the three elements but in an order different than that listed above in the claim construction section. For the element "[3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph," Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. *Id.* at 27, 48–50; *see also id.* at 51–52 (maintaining that Ping's inner coder is an accumulator).

The next element of the Tanner graph addressed by Petitioner is "[1] a graph representing an [irregular repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times." Pet. 50–54. Petitioner asserts that a particular code may be represented as matrices or as a Tanner graph, with those being two ways of describing the same thing, and contends that the proposed combination would have been understood by one of ordinary skill in the art to correspond to the claimed Tanner graph. *Id.* at 52–54.

Petitioner contends that, "[i]n Ping's $\mathbf{H^d}$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^d d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 31, 32. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H^d}$ contains the same number of 1s – exactly 't' 1s," and notes that "Ping thus states that matrix '$\mathbf{H_d}$ has a column weight of t . . . .'" *Id.* at 41 (quoting Ex. 1003, 38). Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 41 (quoting Ex. 1102, 1449) (emphasis in original); *see also* Pet. Reply 3 (citing Ex. 1065 (Frey Decl.) ¶¶ 20–24) ("MacKay also teaches that codes with such parity check matrices, *i.e.*, matrices with uneven column weights, can outperform their regular counterparts.").

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." Pet. at 41. Petitioner proposes modifying Ping's $\mathbf{H^d}$ matrix (or outer coder), which Petitioner characterizes as regular, and contends that one of ordinary skill in the art would have made this modification to improve the performance of Ping's code. Pet. 41; Pet. Reply 4. Specifically, Petitioner maintains:

> It would have been straightforward for a person of ordinary skill to change Ping's generator $\mathbf{H}^d$ matrix such that not all columns had the same weight – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1002, p. 1451.) This change would result in some information bits contributing to more outer LDPC parity bits than others, and would have made Ping's outer LDPC code irregular. . . . Moreover, MacKay's teaching that the best performing LDPC codes are irregular would also have made this modification obvious (and desirable) to try. (Ex. 1002, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper….") (Ex. 1004, ¶116.)

Pet. 42. According to Petitioner, a person of ordinary skill would not have been motivated to modify $\mathbf{H}^p$ because "it has only a single form and because doing so would have complicated a simple encoder." Pet. Reply 8. Thus, Petitioner contends that the person of ordinary skill "who wanted to obtain the benefit of MacKay's irregularity in Ping would have had only one option—to incorporate MacKay's irregularity into $\mathbf{H}^d$." *Id.*

Petitioner further contends that, "even if Ping standing alone is not understood to teach, or render obvious, repeating information bits, doing so would have been obvious in view of Divsalar's explicit teaching of repeating bits." Pet. 44. Petitioner also argues that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references teachings. *Id.* at 44–45.

Thus, argues Petitioner, the combination of Ping, MacKay, and Divsalar teaches an irregular repeat accumulate code where message bits are repeated and at least two different subsets of message bits are repeated a different number of times. *Id.* at 52 (citing Ex. 1004 ¶ 139).

Lastly, Petitioner contends that Ping teaches the Tanner graph requirement of "[2] check nodes, randomly connected to the repeated message bits, [which] enforce constraints that determine the parity bits." *Id.* at 54–57. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d \, d_j$$

as teaching check nodes constraining the relationship between information bits and parity bits. *Id.* at 54–56. Petitioner further maintains that Ping, using Divsalar's repetition, teaches that the check nodes are randomly connected to repeated message bits. *Id.* at 56–57.

Patent Owner disputes, *inter alia*, Petitioner's rationale for combining Ping and MacKay—which underlies the overall combination of Ping, MacKay, and Divsalar—on a number of bases. *See* PO Resp. 17–18 (summarizing eight arguments regarding Petitioner's Ground 1), 26. Patent Owner argues that Ping's parity check matrix **H** is already irregular as defined by MacKay. *See id.* at 26–30. According to Patent Owner, "Ping's parity-check matrix has three different column weights (t, 2, and 1), and two different row weights ($kt/(n\text{-}k)+1$ and $kt/(n\text{-}k)+2$)." *Id.* at 28 (citing Ex. 2033, 231:11–14); *see also* Ex. 2004 ¶ 92 (same). As such, Patent Owner argues "Ping's parity-check matrix is actually even more 'irregular' than MacKay's irregular codes," so ordinarily skilled artisans "would not have been motivated by MacKay's teachings that irregular codes are an improvement over regular codes." PO Resp. 28–29 (citing Ex. 2004 ¶¶ 94, 95, and 97–99).

Patent Owner also highlights that Petitioner's proposed modifications relate only to a portion of Ping's parity check matrix **H**, namely, sub-matrix $\mathbf{H}^d$. *See id.* at 29–30; *see also* Ex. 2004 ¶ 96. Patent Owner argues "MacKay does not even *consider* modifying submatrices, much less teach that there may be benefits to try." PO Resp. 31. According to Patent Owner, "MacKay teaches that irregular parity-check matrices *as a whole* may define better codes than regular parity-check matrices *as a whole*—it does not teach any improvement from making a submatrix within a parity-check matrix irregular, or from using any other type of irregular matrix (e.g., irregular generator matrices)." *Id.* at 30. Patent Owner argues MacKay does not "suggest that *additional* irregularity should be applied to individual portions when the overall parity-check matrix is already irregular." *Id.* (citing Ex. 2004 ¶¶ 96–99) (footnote omitted).

Patent Owner further argues that Petitioner has not established that an ordinarily skilled artisan would have reasonably expected success from the proposed modification of Ping in light of MacKay. *See* PO Resp. 44–49. Patent Owner argues "the petition does not even attempt to analyze a reasonable expectation of success, and for that reason, it is incurably deficient." *Id.* at 44. As further evidence of the lack of anticipated success, Patent Owner emphasizes that constructing error-correction codes "was a highly unpredictable endeavor" that was subject to "extensive trial-and-error and experimentation to determine whether new codes led to an improvement." *Id.* at 4 (citing Ex. 2004 ¶ 46); *see also id.* at 45 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12).

We are persuaded by Patent Owner's arguments. We agree with Patent Owner (*see* PO Resp. 30–31 & n.7) that, although Petitioner may explain how to modify Ping's $\mathbf{H}^d$ sub-matrix in light of MacKay, it does not address why such an ordinarily skilled artisan would have done this. Nor does Petitioner establish that such an artisan reasonably would have expected success from the modification. Based on the entire trial record, we determine that Petitioner has not established a persuasive rationale for modifying Ping in light of MacKay as asserted by Petitioner. Petitioner's additional reliance on Divsalar does not remedy this fundamental flaw in the articulated combination. *See* Pet. 44 (relying on Divsalar for the teaching of repeating information bits if Ping is not understood to teach this aspect).

Petitioner's unpatentability contentions presuppose that an ordinarily skilled artisan would seek to modify a *sub-matrix* in Ping in light of MacKay. *See* Pet. Reply 7 ("Caltech's comparison of Ping's **H** matrix to MacKay's is improper. . . . The proper comparison is between Ping's $\mathbf{H}^d$ matrix . . . and MacKay's matrix."). Yet even if MacKay touts improvements from irregularity in a parity check matrix (e.g., Ping's matrix **H**), MacKay does not suggest that these improvements would have been applicable to *portions* of a parity check matrix (e.g., Ping's sub-matrix $\mathbf{H}^d$). To reach its proposed modification, Petitioner characterizes Ping's sub-matrix $\mathbf{H}^d$ as a generator matrix (or "outer coder") and Ping's sub-matrix $\mathbf{H}^p$ as merely an accumulator (or "inner coder"). Pet. 27, 42; Pet. Reply 10–13. We agree with Patent Owner (*see* PO Resp. 37), however, that Petitioner does not explain adequately why labeling sub-matrix $\mathbf{H}^d$ as a generator matrix supports the proposed modification of $\mathbf{H}^d$ based on MacKay. Indeed, this label does not explain why an ordinarily skilled artisan considering

MacKay would have chosen to modify $\mathbf{H}^d$ or any other portion of parity check matrix **H**.

Petitioner's further contentions also are not persuasive. Specifically, Petitioner contends $\mathbf{H}^p$ is an accumulator with only a single, fixed form, so an ordinarily skilled artisan would not have been motivated to modify $\mathbf{H}^p$ because "doing so would have complicated a simple encoder." Pet. Reply 7–8, 14. Yet this rationalization belies the fact that Ping also specifically defines a structure for sub-matrix $\mathbf{H}^d$, which simplifies a portion of the parity check matrix. According to Dr. Mitzenmacher, "the constraints on $\mathbf{H}^d$, including its regularity, were a deliberate design decision that contributes to the improved performance of Ping's code over fully random LDPC codes it is a fundamental part of its code." Ex. 2004 ¶ 104. Thus, choosing to modify *any* portion of Ping's matrix would have broken constraints in Ping that were intended to simplify encoding. *See* Ex. 1003, 38 (Ping describing the disclosed approach as a "new method [that] can achieve essentially the same performance as the standard LDPC encoding method with significantly reduced complexity"). This is a strong indication that an ordinarily skilled artisan would not have been motivated to reach within Ping's parity check matrix **H** and modify a sub-matrix.

We also agree with Patent Owner that Ping's parity check matrix **H** is already "irregular," which undermines Petitioner's stated motivation for modifying Ping in view of MacKay. *See* PO Resp. 26–31. Citing Dr. Mitzenmacher, Patent Owner establishes that Ping's matrix **H** has three different column weights (t, 2, and 1). *Id.* at 27–28; Ex. 2004 ¶¶ 91–92; *see also* Ex. 2033, 231:11–14 (Dr. Davis acknowledging that Ping's parity check matrix **H** has "different weights for the columns"). We accept this as evidence of "irregularity" based on Petitioner's own acknowledgment that "irregularity" is associated with "uneven column weights." *See* Pet. Reply 13. Petitioner does not contest that Ping's parity check matrix **H** is irregular; rather, Petitioner contends that the appropriate comparison is between MacKay's parity check matrix and Ping's sub-matrix $\mathbf{H}^d$. Pet. Reply 7. But MacKay is silent on the concept of sub-matrices, so Petitioner's association of MacKay's teaching with sub-matrix $\mathbf{H}^d$ is not apt. Instead, we agree with Patent Owner that "MacKay's teachings are only applicable to full parity check matrices." PO Resp. 17. Thus, the record does not establish that an ordinarily skilled artisan would have sought to add irregularity to Ping's parity check matrix **H**—or additional irregularity to a sub-matrix of **H**, such as $\mathbf{H}^d$—because **H** itself is already irregular.

Finally, we agree with Patent Owner that the Petition is silent on whether a person of ordinary skill in the art would have expected success in combining MacKay with Ping. Although Petitioner cites an alleged "straightforward modification of Ping's $\mathbf{H}^d$ matrix" at page 42 of the Petition as supporting the expectation of success (Pet. Reply 14), the cited passage only describes the proposed modification, rather than addressing whether an ordinarily skilled artisan would have anticipated success from the modification. *See* Pet. 42. In addition, Petitioner's argument that an ordinarily skilled artisan "would have needed no more specificity to attempt to use MacKay's irregularity in Ping" (Pet. Reply 14) only underscores the lack of evidence in the Petition regarding anticipated success.

Perhaps sensing this deficiency in the Petition, Petitioner introduces new testimony and a new simulation from Dr. Frey with its Reply in which Dr. Frey allegedly "demonstrate[s] the ease with which a [person of ordinary skill in the art] could have added MacKay's irregularity to Ping." Ex. 1065 ¶ 42. According to Petitioner, the results of the simulation "outperform Ping's original code" and "confirm that a [person of ordinary skill in the art] would have been motivated to use MacKay's uneven column weights in Ping's $\mathbf{H}^d$ matrix, and . . . would have had a reasonable expectation of success when doing so." Pet. Reply 16–17. Yet, even if we were to deem the testimony and simulation to be within the proper scope of a reply brief,[8] they do not support a reasonable expectation of success *at the time of the invention*. We agree with Patent Owner that "[i]t is irrelevant what Dr. Frey claims he could do in the year 2018 when armed with Caltech's disclosures, [the named-inventor's] original coding work, contemporary resources (e.g., Matlab), and some 18 years of post-filing date knowledge." PO Sur-Reply 7. Because this evidence is not tied to the state of the art at the time of the invention, it is not probative of anticipated success. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1367 (Fed. Cir. 2017) (quoting *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1138 (Fed. Cir. 1985)) ("Those charged with determining compliance with 35 U.S.C. § 103 are required to place themselves in the minds of those of ordinary skill in the relevant art *at the time the invention was made*, to determine whether that which is now plainly at hand would have been obvious at such earlier time." (emphasis added)).

Furthermore, as part of our obviousness analysis, we are charged to consider "the scope and content of the prior art." *See Graham*, 383 U.S.

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[8] We need not reach this issue, because we do not rely on this evidence in a manner adverse to Patent Owner. *See also infra* § II.F. (dismissing Patent Owner's Motion to Exclude as moot on the same basis).

at 17–18. One important aspect of the art in this case is the relative unpredictability of developing error-correction codes. *See* PO Resp. 45 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12) ("New codes appeared from unexpected sources, and developing the precise parameters that could lead to incremental improvements often took a significant amount of time and experimentation."). In its Reply, Petitioner embraces the notion of unpredictability as supporting its combination; Petitioner contends that "rigorous mathematical analysis of codes is difficult, and, as a result, [persons of ordinary skill in the art] routinely develop codes by experimentation." Pet. Reply 14. Petitioner further contends that "running experimental tests on a version of Ping that incorporated MacKay's irregularity would have been routine[,] . . . [and] the modifications suggested by MacKay would have been straightforward and would have taken very little time to implement." *Id.*

Yet we do not agree with Petitioner that the need to run experiments in an unpredictable field, such as error-correction coding, indicates anything about whether such experiments ultimately would have been successful at the time of the invention. Importantly, "[u]npredictability of results equates more with nonobviousness rather than obviousness, whereas that which is predictable is more likely to be obvious." *Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017). In the absence of any argument rooted in the Petition directing us to evidence that substantiates a reasonable expectation of success, Petitioner's reliance on a known need for experimentation is not sufficient to support its obviousness rationale.[9] *See Arctic Cat Inc. v. Bombardier Recreational Prod. Inc.*, 876 F.3d 1350, 1360–61 (Fed. Cir. 2017) ("[W]here a party argues a skilled artisan would have been motivated to combine references, it must show the artisan would have had a reasonable expectation of success from doing so." (internal quotation omitted)).

For these reasons, we are not persuaded that an ordinarily skilled artisan would have been motivated to combine the teachings of Ping and MacKay in the manner suggested by Petitioner. Petitioner's reliance on Divsalar's teachings in the proposed combination does not remedy this underlying flaw. Thus, we determine Petitioner has not shown by a preponderance of the evidence that claim 11 would have been obvious over the combination of Ping, MacKay, and Divsalar.

Petitioner relies on the same deficient rationale for combining Ping and MacKay with respect to its analysis for dependent claims 12 and 14–16. *See, e.g.*, Pet. 60–61, 63–64. Thus, we also determine Petitioner has not shown by a preponderance of the evidence that claims 12 and 14–16 would have been obvious over the combination of Ping, MacKay, and Divsalar.

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[9] Notably, Petitioner does not contend that its proposed combination should be analyzed under obvious-to-try case law. Tr. 15:24–16:4 (Petitioner acknowledging that it was not putting forth an obvious-to-try argument). Nor could Petitioner, because Petitioner does not develop an obvious-to-try theory. Specifically, Petitioner does not establish that the prior art directs which parameters to try and/or guides an inventor toward a particular solution. *See Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1347 (Fed. Cir. 2009).

E. The Alleged Obviousness of Claim 13 over Ping, MacKay, Divsalar, and Luby97

Dependent claim 13 specifies that the encoder comprises a low density generator matrix (LDGM) coder and an accumulator. Ex. 1001, 9:38–45. The LDGM coder is "configured to perform an irregular repeat on message bits having a first sequence in a source data stream." *Id.* at 9:39–41. Luby97 (Ex. 1008) describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1008, 150 (Abstr.). Luby97 also describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted). Petitioner relies on Luby97 for the teachings of receiving message bits in a stream (Pet. 66, 69), but does not rely on Luby97 in a manner that cures the defects of the Ping-MacKay-Divsalar combination discussed above (*see* Pet. 65 ("As explained above for Ground 1, one of ordinary skill would have been motivated to use MacKay's irregularity and Divsalar's repetition in Ping."); *id.* at 67 ("As explained above, the combination of Ping in view of MacKay and Divsalar discloses every claim limitation of claim 11.").

Accordingly, we determine Petitioner has not shown by a preponderance of the evidence that claim 13 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

F. Patent Owner's Motion to Exclude

Patent Owner moves to exclude Exhibits 1006, 1018, 1019, 1024, 1029–1049, 1057–1061, 1065, 1067, 1068, 1071, 1072 and portions of Exhibits 2038 and 2039. Paper 52, 1. Patent Owner's motion is dismissed as moot with respect to these exhibits, as we do not rely on them in a manner adverse to Patent Owner.

G. Patent Owner's Motion for Sanctions

Patent Owner requests sanctions against Petitioner for allegedly failing to stay within the proper scope of cross-examination during the deposition of Dr. Mitzenmacher and Dr. Divsalar. Paper 42, 1.[10] Specifically, Patent Owner details questioning of Dr. Mitzenmacher that allegedly "ventured into various topics beyond the scope of the witness' direct testimony." *Id.* at 7–9. For example, Patent Owner cites "extensive questioning regarding Tanner graphs and figures newly created by Petitioner's lawyers, but absent from any petition materials or the witness' direct testimony." *Id.* at 8. Similarly, Patent Owner asserts that Dr. Divsalar was questioned regarding subject matter not discussed in his declaration including the Allerton Conference, Tanner graphs, and certain references. *Id.* at 3–7. As sanctions, Patent Owner asks us to: (1) strike the out-of-scope testimony elicited by Petitioner; (2) hold the direct testimony of Dr. Mitzenmacher and Dr. Divsalar to be facts established in this proceeding; and (3) impose "reasonable compensatory expenses, including attorney fees, for costs reasonably related to excessive questioning and deposition time." *Id.* at 9–10.

Petitioner contends that "each question posed by Petitioner during Dr. Mitzenmacher's deposition pertained directly to topics and opinions in his declaration." Paper 47, 5. Regarding the Tanner graphs and figures,

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[10] Although Patent Owner cites primarily to Exhibit 1064 as the transcript of Dr. Divsalar's deposition, the pertinent exhibit in this case is Exhibit 2039. *See* Paper 42, 4.

Petitioner contends these were properly served upon Petitioner at Dr. Mitzenmacher's deposition in accordance with 37 C.F.R. § 42.53(f)(3). *Id.* at 6. According to Petitioner, Patent Owner's proposed sanctions are unwarranted, particularly because Patent Owner suffered no harm. *Id.* at 7–8.

The "Board may impose a sanction against a party for misconduct." 37 C.F.R. § 42.12(a); *see also* 35 U.S.C. § 316(a)(6) (requiring regulations prescribing sanctions). As the moving party, Patent Owner has the burden to persuade the Board that sanctions are warranted. *See* 37 C.F.R. § 42.20(c). In general, a motion for sanctions should address three factors: (i) whether a party has performed conduct that warrants sanctions; (ii) whether the moving party has suffered harm from that conduct; and (iii) whether the sanctions requested are proportionate to the harm suffered by the moving party. *See Square, Inc. v. Think Comput. Corp.*, Case CBM2014-00159, slip op. at 2 (PTAB Nov. 27, 2015) (Paper 48) (citing *Ecclesiastes 9:10-11-12, Inc. v. LMC Holding Co.*, 497 F.3d 1135, 1143 (10th Cir. 2007)).

Having reviewed the relevant portions of Dr. Mitzenmacher's deposition, we agree with Petitioner that sanctions are not warranted. Petitioner's attempts to elicit testimony regarding the Tanner graphs and figures, while inartful, did not rise to the level of sanctionable conduct because they were reasonably related to Dr. Mitzenmacher's direct testimony.

As to Dr. Divsalar, Patent Owner characterizes his direct testimony (Ex. 2031) as merely taking the form of "a short declaration addressing only a few discrete points relating specifically to the Divsalar reference." Paper 42, 3. Patent Owner contends Petitioner's questions about the

Allerton Conference, Tanner Graphs, and certain other references went beyond the "limited scope of Dr. Divsalar's 16-page declaration." *Id.* at 3–7.

Petitioner cites certain direct testimony from Dr. Divsalar regarding the perspective of a person of ordinary skill in the art, Tanner graphs, and certain "contemporaneous literature" and contends that it was permissible to question Dr. Divsalar at the deposition about the foundation and validity of his opinions on these topics. Paper 47, 3–4 (quoting Ex. 2031 ¶ 10 and citing Ex. 2031 ¶¶ 9–11, 26, 28–30, and 33–36). Petitioner further contends that "in his declaration, Dr. Divsalar discussed having submitted a paper 'in connection with the Allerton conference in 1998' [and] Petitioner thus properly asked questions about what 'in connection with the Allerton conference' means." Paper 47, 3 (citing Ex. 2031 ¶ 19).

We again agree with Petitioner that sanctions concerning the deposition of Dr. Divsalar are not warranted. In fact, Patent Owner acknowledges that Dr. Divsalar offered opinion testimony going to the heart of the dispute in this case. Paper 42, 3. In that respect, Patent Owner states:

> Dr. Divsalar expressed his view that modifying an RA [repeat-accumulate] code to include irregular repetition of information bits would not make sense on the basis that it would add unnecessary difficulty and complexity at odds with the stated objective in the paper, with no expectation of a corresponding benefit. [Ex. 2031 (Divsalar Declaration)] at ¶¶ 33-36. Dr. Divsalar was also asked to address the hypothetical modification suggested by Petitioner, which he explained was nonsensical and at odds with a key conclusion in the Divsalar paper. *Id.* at ¶ 37.

Id.; *see also* Ex. 2031 ¶ 9 (Dr. Divsalar, under the heading "Summary of Opinions," testifying: "I do not believe it would have been trivial or obvious to modify RA codes by making them 'irregular' in order to arrive at IRA codes, nor would a person of ordinary skill in the art be motivated to make such a modification."). In light of this, we are persuaded by Petitioner that its questions were reasonably related to Dr. Divsalar's direct testimony—including the opinion testimony—and were not so far afield as to warrant sanctions.

Furthermore, we agree with Petitioner that Patent Owner suffered no harm with respect to the depositions of Dr. Mitzenmacher and Dr. Divsalar, particularly in light of our disposition of the challenged claims. For these reasons, we deny Patent Owner's motion for sanctions.

III. CONCLUSION

Petitioner has *not* demonstrated by a preponderance of the evidence that claims 11, 12, and 14–16 of the '032 patent are unpatentable as obvious over Ping, MacKay, and Divsalar, and has *not* demonstrated by a preponderance of the evidence that claim 13 is unpatentable as obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

IV. ORDER

For the foregoing reasons, it is

ORDERED that claims 11–16 of the '032 patent have *not* been proven to be unpatentable;

FURTHER ORDERED that Patent Owner's Motion to Exclude is *dismissed as moot*;

FURTHER ORDERED that Patent Owner's Motion for Sanctions is *denied*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Paper: 63
Mailed August 20, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00728
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1201). Paper 5 ("Pet."). The Petition challenges the patentability of claims 18–23 of the '032 patent on the ground of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp."). We instituted *inter partes* review (Paper 14, "Inst. Dec.") of all the challenged claims based on Ping, MacKay, Divsalar, and Luby97.

Patent Owner filed a Response to the Petition (Paper 32, "PO Resp."), and Petitioner filed a Reply (Paper 45, "Pet. Reply"). Pursuant to our authorization (Paper 43), Patent Owner filed a Sur-Reply (Paper 55, "PO Sur-Reply").

An oral hearing was held on May 8, 2018, and a transcript of the hearing is included in the record. Paper 62 ("Tr.").

As authorized in our Order of February 10, 2018 (Paper 41), Patent Owner filed a motion for sanctions related to Petitioner's cross-examination of Patent Owner's witnesses, Dr. Mitzenmacher and Dr. Divsalar (Paper 42), and Petitioner filed an opposition (Paper 47).

Additionally, Patent Owner filed a Motion to Exclude evidence (Paper 52), to which Petitioner filed an Opposition (Paper 54), and Patent Owner filed a Reply (Paper 58).

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). After consideration of the parties' arguments and evidence, and for the reasons discussed below, we determine that Petitioner has *not* shown by a preponderance of the evidence that claims 18–23 of the '032 patent are unpatentable.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00700, and IPR2017-00701. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." Ex. 1201, [54]. The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

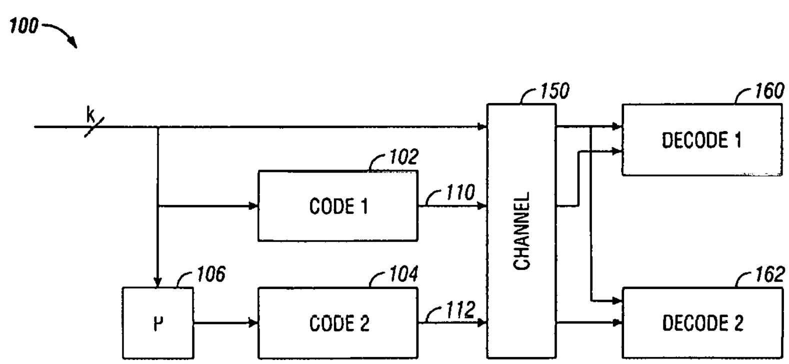

Figure 1 is a schematic diagram of a prior "turbo code" system. *Id.* at 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with reference to Figure 2, reproduced below.

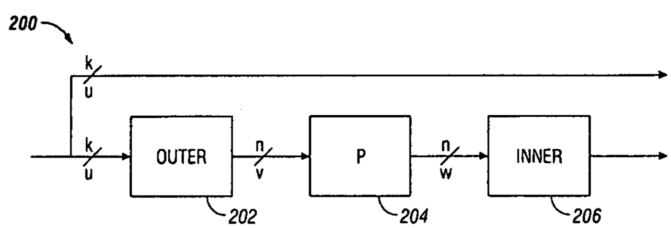

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is

> $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") coder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

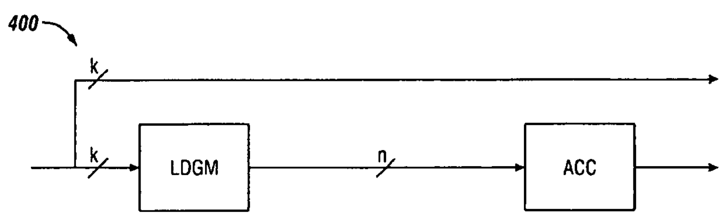

Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a

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[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

"sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

"The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code." *Id.* at 3:33–35. Figure 3, shown below, depicts such a Tanner graph.

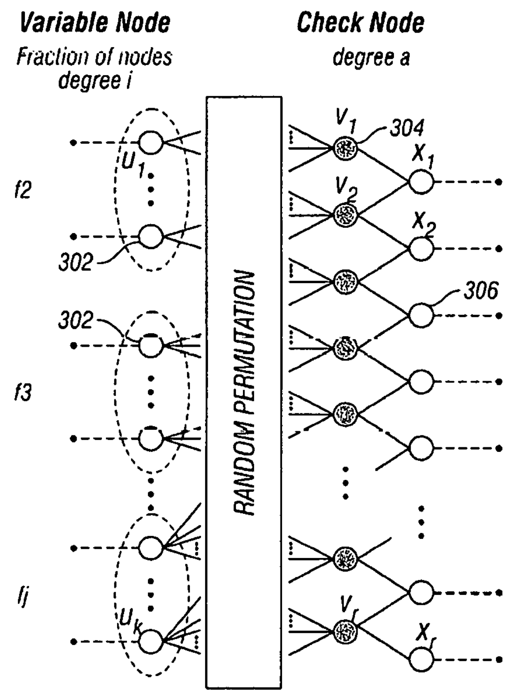

Figure 3 is described as "a Tanner graph for an irregular repeat and accumulate (IRA) coder." *Id.* at 2:20–21. The left-most column of nodes, information nodes 302 (the open circles), are variable nodes that receive information bits. The column of nodes (the filled circles) just to the right of the "RANDOM PERMUTATION" block are check nodes v indicated by reference numeral 304. An information bit node connected to two check

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nodes represents a repeat of 2. An information node connected to three check nodes represents a repeat of 3. The nodes (the open circles) in the right-most column are parity bit nodes x, referenced by 306. As shown by the edges[2] of the Tanner graph, each parity bit is a function of its previous parity bit and is also a function of information bits (edges connect through check nodes and random permutation to information bit nodes). *Id.* at 3:34–55; *see also* Ex. 1204 ¶ 110 (discussing the relationship between parity bits in the context of the claimed Tanner graph and the '032 patent's specification).

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 18 is the only independent claim. The remaining challenged claims depend directly from claim 18. Claim 18, reproduced below as originally issued and before issuance of a Certificate of Correction dated February 17, 2009, and with paragraphing added, is illustrative:

> 18. A device comprising:
>
> a message passing decoder configured to decode a received data stream that includes a collection of parity bits,
>
> the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes,
>
> wherein the message passing decoder is configured to decode the received data stream that has been encoded in accordance with the following Tanner graph:

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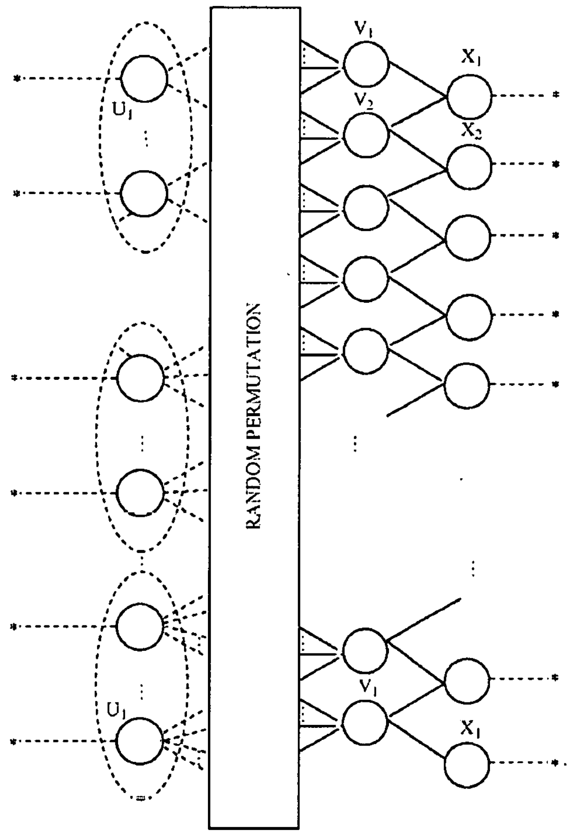
[2] We understand that "edges" are the straight lines that connect one node to another node of a Tanner graph. *See* Ex. 1201, 3:53–54.



Ex. 1201, 9:57–10:42. A Certificate of Correction for the '032 patent replaced the labels V_1, U_1, and X_1 from the lower portion of the Tanner graph in claim 18 with V_r, U_k, and X_r, respectively. *See id.* at Certificate of Correction (Feb. 17, 2009).

E. Evidence

Petitioner relies on the following art references:

Reference	**Exhibit No.**
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")	Ex. 1202

Reference	**Exhibit No.**
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")	Ex. 1203
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1208
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")	Ex. 1217

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1204), and the Declaration of Brendan Frey, Ph.D., dated February 21, 2018 (Ex. 1265) in support of its arguments. Patent Owner relies upon the Declaration of Dr. Michael Mitzenmacher, dated November 21, 2017 (Ex. 2004), and the Declaration of Dr. Dariush Divsalar, dated November 7, 2017 (Ex. 2031), in support of its arguments in the Patent Owner Response. The parties rely on other exhibits as discussed below.

F. The Asserted Ground of Unpatentability

The following ground of unpatentability remains at issue in this case (Pet. 41; Inst. Dec. 9, 22 (instituting a trial on all of the challenged claims and on the sole ground presented in the Petition)):

References	**Basis**	**Claim(s)**
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	18–23

II. ANALYSIS

A. Principles of Law

Petitioner bears the burden of proving unpatentability of the claims challenged in the Petition, and that burden never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must establish the facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) any objective evidence of non-obviousness.[3] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. The Level of Ordinary Skill in the Art

Petitioner's declarant, Dr. Davis, opines that:

> A person of ordinary skill in the art at the time of the alleged invention of the '032 patent would have had a Ph.D. in mathematics, electrical or computer engineering, or computer science with emphasis in signal processing, communications, or

[3] Although Patent Owner puts forth evidence of objective indicia of non-obviousness (PO Resp. 55–66), we need not reach this evidence based on our disposition below.

> coding, or a master's degree in the above area with at least three years of work experience in this field at the time of the alleged invention.

Ex. 1204 ¶ 98; *see* Pet. 26 (citing the same). Patent Owner's declarant, Dr. Mitzenmacher, applies the same definition offered by Dr. Davis. Ex. 2004 ¶ 66.

We determine that the definition offered by Dr. Davis comports with the qualifications a person would have needed to understand and implement the teachings of the '032 patent and the prior art of record. Accordingly, we apply Dr. Davis's definition of the level of ordinary skill in the art.

C. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Tanner Graph

For purposes of our Institution Decision, we adopted the construction for "Tanner graph" set forth in a prior Board decision concerning the '032 patent and for which Petitioner supports the application of the same construction in the present case. Inst. Dec. 10–11 (quoting IPR2015-00060, Paper 18, 12–14; citing Pet. 28–29[4]). That construction is as follows:

> [1] a graph representing an [irregular[5] repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times, and
>
> [2] check nodes, randomly connected to the repeated message bits, enforce constraints that determine the parity bits[, and] . . .
>
> [3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph.

Inst. Dec. 10.

Patent Owner does not express disagreement with the construction but contends that the term "Tanner graph" need not be construed because, *inter alia*, a person of ordinary skill in the art "would have readily understood

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[4] Petitioner contends that this construction is the broadest reasonable interpretation, yet is narrower than that adopted by the District Court in *Caltech v. Hughes Communications Inc.*, No. 2:13-cv-07245 (C.D. Cal.) because the court's construction did not include the constraint regarding parity bit determination (constraint [3]). Pet. 29 (citing Ex. 1213). Petitioner contends that the difference has no substantive effect on the issues before us. *See* Tr. 34:16–35:2.

[5] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 27–28 (advocating the adoption of that construction in this case); IPR2017-00700, Paper 32, 14 (Patent Owner, in a related case, citing Ex. 2004 ¶ 69 and asserting: "Caltech does not believe the term needs to be construed, as the plain and ordinary meaning of irregular repetition is clear. That message bits contribute in differing numbers to parity bits is made clear in the claim language.").

how to encode bits according to the Tanner graph in the claims and in view of the specification." PO Resp. 15; *see also* Ex. 2004 ¶ 73 (Dr. Mitzenmacher not disagreeing with any aspect of the construction but opining that: "[T]here is no need to 'construe' the graph. Any person of ordinary skill could readily comprehend what the graph requires in terms of an encoder or a decoder.").

Regardless as to whether the person of ordinary skill in the art—e.g., a person with a doctorate in mathematics—would understand the claim, we find a verbal description of the graph to be helpful. Accordingly, we again adopt that prior construction for purposes of analyzing Petitioner's challenges before us in this case.

On this record and for purposes of deciding the dispositive issues before us, we determine that no other claim terms require express construction.

D. The Alleged Obviousness over Ping, MacKay, Divsalar, and Luby97

Petitioner alleges that independent claim 18 and dependent claims 19–23 of the '032 patent would have been obvious over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 41–64 (addressing independent claim 18).

Petitioner asserts that Ping discloses much of the subject matter of independent claim 18, but maintains that Ping's outer coder is regular. Pet. 41–42; *see also id.* at 58. Petitioner relies on MacKay for teaching irregularity, *id.* at 41, 43, relies on Divsalar for teaching repetition "if Ping standing alone is not understood to teach, or render obvious, repeating information bits," *id.* at 46, and relies on Luby97 for teaching receiving a source data stream, *id.* at 48. Additionally, Petitioner relies on Divsalar, MacKay, and Luby97 for teaching that message passing decoders were well-known in the art. *See* Pet. 20, 51–52. Patent Owner argues, *inter alia*, that the Petition presents a flawed reason to modify Ping in light of MacKay. PO Resp. 2–3.

1. Ping (Ex. 1203)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1203, 38. In this approach, "only part of [parity check matrix] **H** is generated randomly, and the remaining part is deterministic," which "achieve[s] essentially the same performance as the standard LDPC encoding method with significantly reduced complexity." *Id.* The size of matrix **H** is $(n-k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]^t$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^\mathbf{p}, \mathbf{H}^\mathbf{d}]$." *Id.* $\mathbf{H}^\mathbf{p}$ is defined as follows:

$$\mathbf{H}^\mathbf{p} = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^\mathbf{d}$ is created such that it "has a column weight of t and a row weight of $kt/(n-k)$ (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H}^\mathbf{d} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1204 ¶ 74.[6] For each sub-block of $\mathbf{H}^{\mathbf{d}}$, there is exactly "one element 1 per column and *kt/(n-k)* 1s per row." Ex. 1203, 38. This construction "increase[s] the recurrence distance of each bit in the encoding chain" and "reduces the correlation during the decoding process." *Id.*

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{\mathrm{d}_i\}$" using the following expressions:

$$p_1 = \sum_j h_{1j}^d d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h_{ij}^d d_j \ (\text{mod } 2)$$

Ex. 1203, 38 (equation (4)).[7]

2. MacKay (Ex. 1202)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1202, 1449. According to MacKay, "[t]hc bcst known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular

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[6] This particular representation of $\mathbf{H}^{\mathbf{d}}$ is taken from Dr. Davis's testimony. Patent Owner's description of $\mathbf{H}^{\mathbf{d}}$ is found at page 8 of its Response.

[7] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or $\oplus$) logical operation, which is defined as follows: $0\oplus0=0$, $0\oplus1=1$, $1\oplus0=1$, and $1\oplus1=0$. *See* Ex. 1204 ¶ 185.

code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1217)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1204 ¶ 89 (quoting Ex. 1217, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

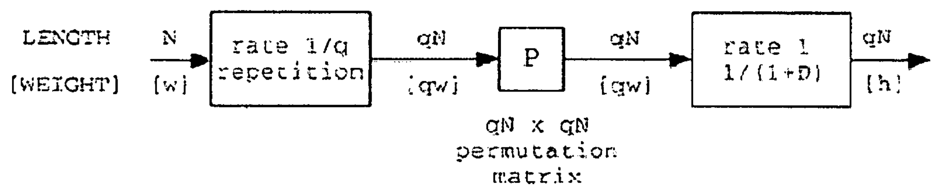

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1217, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. Luby97 (Ex. 1208)

Luby97 describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1208, 150 (Abstr.). Luby97 describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted).

5. The Alleged Obviousness of Claims 18 23

As discussed above in the context of claim construction, independent claim 18 contains a Tanner graph having at least three elements. Petitioner, in articulating its obviousness challenge of claim 18, relies on the testimony of Dr. Davis and maps the teachings of the prior art against those three elements as well as the express recitations of the claim. Pet. 50–64.

Claim 18 recites "a message passing decoder configured to decode a received data stream that includes a collection of parity bits." Petitioner maintains that Divsalar teaches an encoding device and teaches message passing decoding. *Id.* at 51. Petitioner maintains that MacKay and Luby97 also teach forms of message passing decoding. *Id.* at 51–52. Petitioner reasons that, in light of these teachings and "the fact that one of ordinary skill would understand message passing algorithms to be a standard technique for decoding linear error-correcting codes," it would have been obvious to use a message passing decoder to decode the codes of Ping. *Id.* at 52 (citing Ex. 1204 ¶ 194); *see also id.* at 20 (citing Ex. 1204 ¶ 62) (Petitioner asserting that a message passing decoder was a well-known type of decoder). Petitioner points to Luby97's teaching of receiving, in streams, data to be encoded and asserts that the sequence of blocks of symbols transmitted by the encoder of Luby97 constitutes a stream. *Id.* at 48–49. Petitioner asserts that it would have been obvious to use, for Ping's codes, a decoder that can receive encoded bits in a stream where the encoder that encoded those bits outputs them in a stream. *Id.* at 49–50, 52–53; *see* Ex. 1204 ¶¶ 195–200.

Claim 18 next recites "the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes." Relying on, *inter alia*, the testimony of Dr. Davis, Petitioner contends that such a parallel operation would have been obvious because message passing decoding works by passing messages back and forth between variable nodes and check nodes according to a Tanner graph. Pet. 23–24, 53–54; Ex. 1204 ¶¶ 68, 201–203.

As for the Tanner graph of claim 18, Petitioner addresses the three elements of our construction in an order different than that listed above in the claim construction section. For the element "[3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph," Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. Pet. at 30, 55–57; *see also id.* at 58 (maintaining that Ping's inner coder is an accumulator).

The next element of the Tanner graph addressed by Petitioner is "[1] a graph representing an [irregular repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times." Pet. 57–61. Petitioner asserts that a particular code may be represented as matrices or as a Tanner graph, with those being two ways of describing the same thing, and contends that the proposed combination would have been understood by one of ordinary skill in the art to correspond to the claimed Tanner graph. *Id.* at 59–61.

Petitioner contends that, "[i]n Ping's $\mathbf{H}^d$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^d d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 34, 35. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$

contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}^d$ has a column weight of *t* . . . .'" *Id.* at 43 (quoting Ex. 1203, 38). Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 44 (quoting Ex. 1202, 1449) (emphasis in original); *see also* Pet. Reply 3 (citing Ex. 1265 (Frey Decl.) ¶¶ 20–24) ("MacKay also teaches that codes with such parity check matrices, *i.e.*, matrices with uneven column weights, can outperform their regular counterparts.").

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." Pet. 43. Petitioner proposes modifying Ping's $\mathbf{H}^d$ matrix (or outer coder), which Petitioner characterizes as regular, and contends that one of ordinary skill in the art would have made this modification to improve the performance of Ping's code. Pet. 43; Pet. Reply 4. Petitioner maintains:

> It would have been straightforward for a person of ordinary skill to change Ping's generator $\mathbf{H}^d$ matrix such that not all columns had the same weight – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1202, p. 1451.) This change would result in some information bits contributing to more outer LDPC parity bits than others, and would have made Ping's outer LDPC code irregular. . . . Moreover, MacKay's teaching that the best performing LDPC codes are irregular would also have made this modification obvious (and desirable) to try. (Ex. 1202, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper....") (Ex. 1204, ¶116.)

Pet. 44. According to Petitioner, a person of ordinary skill would not have been motivated to modify $\mathbf{H^p}$ because "it has only a single form and because doing so would have complicated a simple encoder." Pet. Reply 8. Thus, Petitioner contends that the person of ordinary skill "who wanted to obtain the benefit of MacKay's irregularity in Ping would have had only one option—to incorporate MacKay's irregularity into $\mathbf{H^d}$." *Id.*

Petitioner further contends that, "even if Ping standing alone is not understood to teach, or render obvious, repeating information bits, doing so would have been obvious in view of Divsalar's explicit teaching of repeating bits." Pet. 46. Petitioner also argues that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references' teachings. *Id.* at 47–48.

Thus, argues Petitioner, the combination of Ping, MacKay, and Divsalar teaches an irregular repeat accumulate code where message bits are repeated and at least two different subsets of message bits are repeated a different number of times. *Id.* at 59 (citing Ex. 1204 ¶ 139).

Lastly, Petitioner contends that Ping teaches the Tanner graph requirement of "[2] check nodes, randomly connected to the repeated message bits, [which] enforce constraints that determine the parity bits." *Id.* at 61–63. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d \, d_j$$

as teaching check nodes constraining the relationship between information bits and parity bits. *Id.* at 61–63. Petitioner further maintains that Ping, using Divsalar's repetition, teaches that the check nodes are randomly connected to repeated message bits. *Id.* at 63–64.

Patent Owner disputes, *inter alia*, Petitioner's rationale for combining Ping and MacKay—which underlies the overall combination of Ping, MacKay, Divsalar, and Luby97—on a number of bases. *See* PO Resp. 15–16 (summarizing ten arguments regarding Petitioner's ground), 27–28. Patent Owner argues that Ping's parity check matrix **H** is already irregular as defined by MacKay. *See id.* at 28–33. According to Patent Owner, "Ping's parity-check matrix has three different column weights (t, 2, and 1), and two different row weights ($kt/(n-k)+1$ and $kt/(n-k)+2$)." *Id.* at 29 (citing Ex. 2033, 231:11–14); *see also* Ex. 2004 ¶ 92 (same). As such, Patent Owner argues "Ping's parity-check matrix is actually even more 'irregular' than MacKay's irregular codes," so ordinarily skilled artisans "would not have been motivated by MacKay's teachings that irregular codes are an improvement over regular codes." PO Resp. 30–31 (citing Ex. 2004 ¶¶ 94, 95, and 97–99).

Patent Owner also highlights that Petitioner's proposed modifications relate only to a portion of Ping's parity check matrix **H**, namely, sub-matrix $\mathbf{H}^d$. *See id.* at 31–32; *see also* Ex. 2004 ¶ 96. Patent Owner argues "MacKay does not even *consider* modifying submatrices, much less teach that there may be benefits to try." PO Resp. 33. According to Patent Owner, "MacKay teaches that irregular parity-check matrices <u>*as a whole*</u> may define better codes than regular parity-check matrices <u>*as a whole*</u>—it does not teach any improvement from making a submatrix within a parity-check matrix irregular, or from using any other type of irregular matrix (*e.g.*, irregular generator matrices)." *Id.* at 31. Patent Owner argues MacKay does not "suggest that *additional* irregularity should be applied to uniform portions when the overall parity-check matrix is already irregular." *Id.* at 32 (citing Ex. 2004 ¶¶ 96–99) (footnote omitted).

Patent Owner further argues that Petitioner has not established that an ordinarily skilled artisan would have reasonably expected success from the proposed modification of Ping in light of MacKay. *See* PO Resp. 46–51. Patent Owner argues "the petition does not even attempt to analyze a reasonable expectation of success, and for that reason, it is incurably deficient." *Id.* at 46. As further evidence of the lack of anticipated success, Patent Owner emphasizes that constructing error-correction codes "was a highly unpredictable endeavor" that was subject to "extensive trial-and-error and experimentation to determine whether new codes led to an improvement." *Id.* at 4 (citing Ex. 2004 ¶ 46); *see also id.* at 46 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12).

We are persuaded by Patent Owner's arguments. We agree with Patent Owner (*see* PO Resp. 31–32 & n.7) that, although Petitioner may explain how to modify Ping's $\mathbf{H}^d$ sub-matrix in light of MacKay, it does not address why such an ordinarily skilled artisan would have done this. Nor does Petitioner establish that such an artisan reasonably would have expected success from the modification. Based on the entire trial record, we determine that Petitioner has not established a persuasive rationale for modifying Ping in light of MacKay as asserted by Petitioner. Petitioner's additional reliance on Divsalar and Luby97 does not remedy this fundamental flaw in the articulated combination. *See* Pet. 46, 48–50 (relying on Divsalar for the teaching of repeating information bits and Luby97 for the teaching of receiving data to be encoded in a stream).

Petitioner's unpatentability contentions presuppose that an ordinarily skilled artisan would seek to modify a *sub-matrix* in Ping in light of MacKay. *See* Pet. Reply 7 ("Caltech's comparison of Ping's **H** matrix to MacKay's is improper. . . . The proper comparison is between Ping's $\mathbf{H}^d$ matrix . . . and MacKay's matrix."). Yet even if MacKay touts improvements from irregularity in a parity check matrix (e.g., Ping's matrix **H**), MacKay does not suggest that these improvements would have been applicable to *portions* of a parity check matrix (e.g., Ping's sub-matrix $\mathbf{H}^d$). To reach its proposed modification, Petitioner characterizes Ping's sub-matrix $\mathbf{H}^d$ as a generator matrix (or "outer coder") and Ping's sub-matrix $\mathbf{H}^p$ as merely an accumulator (or "inner coder"). Pet. 30, 44; Pet. Reply 10–13. We agree with Patent Owner (*see* PO Resp. 39), however, that Petitioner does not explain adequately why labeling sub-matrix $\mathbf{H}^d$ as a generator matrix supports the proposed modification of $\mathbf{H}^d$ based on MacKay. Indeed, this label does not explain why an ordinarily skilled artisan considering MacKay would have chosen to modify $\mathbf{H}^d$ or any other portion of parity check matrix **H**.

Petitioner's further contentions also are not persuasive. Specifically, Petitioner contends $\mathbf{H}^p$ is an accumulator with only a single, fixed form, so an ordinarily skilled artisan would not have been motivated to modify $\mathbf{H}^p$ because "doing so would have complicated a simple encoder." Pet. Reply 7–8, 13. Yet this rationalization belies the fact that Ping also specifically defines a structure for sub-matrix $\mathbf{H}^d$, which simplifies a portion of the parity check matrix. According to Dr. Mitzenmacher, "the constraints on $\mathbf{H}^d$, including its regularity, were a deliberate design decision that contributes to the improved performance of Ping's code over fully random

LDPC codes—it is a fundamental part of its code." Ex. 2004 ¶ 104. Thus, choosing to modify *any* portion of Ping's matrix would have broken constraints in Ping that were intended to simplify encoding. *See* Ex. 1203, 38 (Ping describing the disclosed approach as a "new method [that] can achieve essentially the same performance as the standard LDPC encoding method with significantly reduced complexity"). This is a strong indication that an ordinarily skilled artisan would not have been motivated to reach within Ping's parity check matrix **H** and modify a sub-matrix.

We also agree with Patent Owner that Ping's parity check matrix **H** is already "irregular," which undermines Petitioner's stated motivation for modifying Ping in view of MacKay. *See* PO Resp. 28–33. Citing Dr. Mitzenmacher, Patent Owner establishes that Ping's matrix **H** has three different column weights (t, 2, and 1). *Id.* at 28–29; Ex. 2004 ¶¶ 91–92; *see also* Ex. 2033, 231:11–14 (Dr. Davis acknowledging that Ping's parity check matrix **H** has "different weights for the columns"). We accept this as evidence of "irregularity" based on Petitioner's own acknowledgment that "irregularity" is associated with "uneven column weights." *See* Pet. Reply 12–13. Petitioner does not contest that Ping's parity check matrix **H** is irregular; rather, Petitioner contends that the appropriate comparison is between MacKay's parity check matrix and Ping's sub-matrix $\mathbf{H}^d$. *Id.* at 7. But MacKay is silent on the concept of sub-matrices, so Petitioner's association of MacKay's teaching with sub-matrix $\mathbf{H}^d$ is not apt. Instead, we agree with Patent Owner that "MacKay's teachings are only applicable to full parity check matrices." PO Resp. 15–16. Thus, the record does not establish that an ordinarily skilled artisan would have sought to add irregularity to Ping's parity check matrix **H**—or additional irregularity to a sub-matrix of **H**, such as $\mathbf{H}^d$—because **H** itself is already irregular.

Finally, we agree with Patent Owner that the Petition is silent on whether a person of ordinary skill in the art would have expected success in combining MacKay with Ping. Although Petitioner cites an alleged "straightforward modification of Ping's $\mathbf{H}^d$ matrix" at page 44 of the Petition as supporting the expectation of success (Pet. Reply 13–14), the cited passage only describes the proposed modification, rather than addressing whether an ordinarily skilled artisan would have anticipated success from the modification. *See* Pet. 44. In addition, Petitioner's argument that an ordinarily skilled artisan "would have needed no more specificity to attempt to use MacKay's irregularity in Ping" (Pet. Reply 14) only underscores the lack of evidence in the Petition regarding anticipated success.

Perhaps sensing this deficiency in the Petition, Petitioner introduces new testimony and a new simulation from Dr. Frey with its Reply in which Dr. Frey allegedly "demonstrate[s] the ease with which a [person of ordinary skill in the art] could have added MacKay's irregularity to Ping." Ex. 1265 ¶ 42. According to Petitioner, the results of the simulation "outperform Ping's original code" and "confirm that a [person of ordinary skill in the art] would have been motivated to use MacKay's uneven column weights in Ping's $\mathbf{H}^d$ matrix, and . . . would have had a reasonable expectation of success when doing so." Pet. Reply 15–16. Yet, even if we were to deem the testimony and simulation to be within the proper scope of a reply brief,[8]

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[8] We need not reach this issue, because we do not rely on this evidence in a manner adverse to Patent Owner. *See also infra* § II.E. (dismissing Patent Owner's Motion to Exclude as moot on the same basis).

they do not support a reasonable expectation of success *at the time of the invention*. We agree with Patent Owner that "[i]t is irrelevant what Dr. Frey claims he could do in the year 2018 when armed with Caltech's disclosures, [the named-inventor's] original coding work, contemporary resources (*e.g.*, Matlab), and some 18 years of post-filing date knowledge." PO Sur-Reply 7. Because this evidence is not tied to the state of the art at the time of the invention, it is not probative of anticipated success. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1367 (Fed. Cir. 2017) (quoting *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1138 (Fed. Cir. 1985)) ("Those charged with determining compliance with 35 U.S.C. § 103 are required to place themselves in the minds of those of ordinary skill in the relevant art *at the time the invention was made*, to determine whether that which is now plainly at hand would have been obvious at such earlier time." (emphasis added)).

Furthermore, as part of our obviousness analysis, we are charged to consider "the scope and content of the prior art." *See Graham*, 383 U.S. at 17–18. One important aspect of the art in this case is the relative unpredictability of developing error-correction codes. *See* PO Resp. 46 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21 257:12) ("New codes appeared from unexpected sources, and developing the precise parameters that could lead to incremental improvements often took a significant amount of time and experimentation."). In its Reply, Petitioner embraces the notion of unpredictability as supporting its combination; Petitioner contends that "rigorous mathematical analysis of codes is difficult, and, as a result, [persons of ordinary skill in the art] routinely develop codes by experimentation." Pet. Reply 14. Petitioner further contends that "running experimental tests on a version of Ping that incorporated MacKay's irregularity would have been routine[,] . . . [and] the modifications suggested by MacKay would have been straightforward and would have taken very little time to implement." *Id.*

Yet we do not agree with Petitioner that the need to run experiments in an unpredictable field, such as error-correction coding, indicates anything about whether such experiments ultimately would have been successful at the time of the invention. Importantly, "[u]npredictability of results equates more with nonobviousness rather than obviousness, whereas that which is predictable is more likely to be obvious." *Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017). In the absence of any argument rooted in the Petition directing us to evidence that substantiates a reasonable expectation of success, Petitioner's reliance on a known need for experimentation is not sufficient to support its obviousness rationale.[9] *See Arctic Cat Inc. v. Bombardier Recreational Prod. Inc.*, 876 F.3d 1350, 1360–61 (Fed. Cir. 2017) ("[W]here a party argues a skilled artisan would have been motivated to combine references, it must show the artisan would have had a reasonable expectation of success from doing so." (internal quotation omitted)).

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[9] Notably, Petitioner does not contend that its proposed combination should be analyzed under obvious-to-try case law. Tr. 15:24–16:4 (Petitioner acknowledging that it was not putting forth an obvious-to-try argument). Nor could Petitioner, because Petitioner does not develop an obvious-to-try theory. Specifically, Petitioner does not establish that the prior art directs which parameters to try and/or guides an inventor toward a particular solution. *See Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1347 (Fed. Cir. 2009).

For these reasons, we are not persuaded that an ordinarily skilled artisan would have been motivated to combine the teachings of Ping and MacKay in the manner suggested by Petitioner. Petitioner's reliance on Divsalar's and Luby97's teachings in the proposed combination does not remedy this underlying flaw. Thus, we determine Petitioner has not shown by a preponderance of the evidence that claim 18 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

Petitioner relies on the same deficient rationale for combining Ping and MacKay with respect to its analysis for dependent claims 19–23. *See* Pet. 64–73. Thus, we also determine Petitioner has not shown by a preponderance of the evidence that claims 19–23 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

E. Patent Owner's Motion to Exclude

Patent Owner moves to exclude Exhibits 1206, 1218, 1219, 1224, 1229–1249, 1257–1261, 1265, 1267, 1268, 1271, 1272, and portions of Exhibits 2038 and 2039. Paper 52, 1. Patent Owner's motion is dismissed as moot with respect to these exhibits, as we do not rely on them in a manner adverse to Patent Owner.

F. Patent Owner's Motion for Sanctions

Patent Owner requests sanctions against Petitioner for allegedly failing to stay within the proper scope of cross-examination during the deposition of Dr. Mitzenmacher and Dr. Divsalar. Paper 42, 1.[10]

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[10] Although Patent Owner cites primarily to Exhibit 1064 as the transcript of Dr. Divsalar's deposition, the pertinent exhibit in this case is Exhibit 2039. *See* Paper 42, 4.

Specifically, Patent Owner details questioning of Dr. Mitzenmacher that allegedly "ventured into various topics beyond the scope of the witness' direct testimony." *Id.* at 7–9. For example, Patent Owner cites "extensive questioning regarding Tanner graphs and figures newly created by Petitioner's lawyers, but absent from any petition materials or the witness' direct testimony." *Id.* at 8. Similarly, Patent Owner asserts that Dr. Divsalar was questioned regarding subject matter not discussed in his declaration including the Allerton Conference, Tanner graphs, and certain references. *Id.* at 3–7. As sanctions, Patent Owner asks us to: (1) strike the out-of-scope testimony elicited by Petitioner; (2) hold the direct testimony of Dr. Mitzenmacher and Dr. Divsalar to be facts established in this proceeding; and (3) impose "reasonable compensatory expenses, including attorney fees, for costs reasonably related to excessive questioning and deposition time." *Id.* at 9–10.

Petitioner contends that "each question posed by Petitioner during Dr. Mitzenmacher's deposition pertained directly to topics and opinions in his declaration." Paper 47, 5. Regarding the Tanner graphs and figures, Petitioner contends these were properly served upon Petitioner at Dr. Mitzenmacher's deposition in accordance with 37 C.F.R. § 42.53(f)(3). *Id.* at 6. According to Petitioner, Patent Owner's proposed sanctions are unwarranted, particularly because Patent Owner suffered no harm. *Id.* at 7–8.

The "Board may impose a sanction against a party for misconduct." 37 C.F.R. § 42.12(a); *see also* 35 U.S.C. § 316(a)(6) (requiring regulations prescribing sanctions). As the moving party, Patent Owner has the burden to persuade the Board that sanctions are warranted. *See* 37 C.F.R. § 42.20(c).

In general, a motion for sanctions should address three factors: (i) whether a party has performed conduct that warrants sanctions; (ii) whether the moving party has suffered harm from that conduct; and (iii) whether the sanctions requested are proportionate to the harm suffered by the moving party. *See Square, Inc. v. Think Comput. Corp.*, Case CBM2014-00159, slip op. at 2 (PTAB Nov. 27, 2015) (Paper 48) (citing *Ecclesiastes 9:10-11-12, Inc. v. LMC Holding Co.*, 497 F.3d 1135, 1143 (10th Cir. 2007)).

Having reviewed the relevant portions of Dr. Mitzenmacher's deposition, we agree with Petitioner that sanctions are not warranted. Petitioner's attempts to elicit testimony regarding the Tanner graphs and figures, while inartful, did not rise to the level of sanctionable conduct because they were reasonably related to Dr. Mitzenmacher's direct testimony.

As to Dr. Divsalar, Patent Owner characterizes his direct testimony (Ex. 2031) as merely taking the form of "a short declaration addressing only a few discrete points relating specifically to the Divsalar reference." Paper 42, 3. Patent Owner contends Petitioner's questions about the Allerton Conference, Tanner Graphs, and certain other references went beyond the "limited scope of Dr. Divsalar's 16-page declaration." *Id.* at 3–7.

Petitioner cites certain direct testimony from Dr. Divsalar regarding the perspective of a person of ordinary skill in the art, Tanner graphs, and certain "contemporaneous literature" and contends that it was permissible to question Dr. Divsalar at the deposition about the foundation and validity of his opinions on these topics. Paper 47, 3–5 (quoting Ex. 2031 ¶ 10 and citing Ex. 2031 ¶¶ 9–11, 26, 28–30, and 33–36). Petitioner further contends that "in his declaration, Dr. Divsalar discussed having submitted a paper 'in connection with the Allerton conference in 1998' [and] Petitioner thus properly asked questions about what 'in connection with the Allerton conference' means." Paper 47, 3 (citing Ex. 2031 ¶ 19).

We again agree with Petitioner that sanctions concerning the deposition of Dr. Divsalar are not warranted. In fact, Patent Owner acknowledges that Dr. Divsalar offered opinion testimony going to the heart of the dispute in this case. Paper 42, 3. In that respect, Patent Owner states:

> Dr. Divsalar expressed his view that modifying an RA [repeat-accumulate] code to include irregular repetition of information bits would not make sense on the basis that it would add unnecessary difficulty and complexity at odds with the stated objective in the paper, with no expectation of a corresponding benefit. [Ex. 2031 (Divsalar Declaration)] at ¶¶ 33-36. Dr. Divsalar was also asked to address the hypothetical modification suggested by Petitioner, which he explained was nonsensical and at odds with a key conclusion in the Divsalar paper. *Id.* at ¶ 37.

Id.; *see also* Ex. 2031 ¶ 9 (Dr. Divsalar, under the heading "Summary of Opinions," testifying: "I do not believe it would have been trivial or obvious to modify RA codes by making them 'irregular' in order to arrive at IRA codes, nor would a person of ordinary skill in the art be motivated to make such a modification."). In light of this, we are persuaded by Petitioner that its questions were reasonably related to Dr. Divsalar's direct testimony—including the opinion testimony—and were not so far afield as to warrant sanctions.

Furthermore, we agree with Petitioner that Patent Owner suffered no harm with respect to the depositions of Dr. Mitzenmacher and Dr. Divsalar, particularly in light of our disposition of the challenged claims. For these reasons, we deny Patent Owner's motion for sanctions.

III. CONCLUSION

Petitioner has *not* demonstrated by a preponderance of the evidence that claims 18–23 of the '032 patent are unpatentable as obvious over Ping, MacKay, Divsalar, and Luby97.

IV. ORDER

For the foregoing reasons, it is

ORDERED that claims 18–23 of the '032 patent have *not* been proven to be unpatentable;

FURTHER ORDERED that Patent Owner's Motion to Exclude is *dismissed as moot*;

FURTHER ORDERED that Patent Owner's Motion for Sanctions is *denied*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Paper 67
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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00701
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1101). Paper 3 ("Pet."). The Petition challenges the patentability of claims 1–10 of the '032 patent on the ground of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp."). We instituted *inter partes* review (Paper 14, "Inst. Dec.") of claims 1 and 4–10 based on Ping, MacKay, Divsalar, and Luby97. However, the instituted review did not include Petitioner's obviousness challenge of claims 2 and 3 based on those same references.

Patent Owner filed a Response to the Petition (Paper 32, "PO Resp."), and Petitioner filed a Reply (Paper 45, "Pet. Reply"). Pursuant to our authorization (Paper 43), Patent Owner filed a Sur-Reply (Paper 55, "PO Sur-Reply").

An oral hearing was held on May 8, 2018, and a transcript of the hearing is included in the record. Paper 66 ("Tr.").

As authorized in our Order of February 10, 2018 (Paper 41), Patent Owner filed a motion for sanctions related to Petitioner's cross-examination of Patent Owner's witnesses, Dr. Mitzenmacher and Dr. Divsalar (Paper 42), and Petitioner filed an opposition (Paper 47).

Additionally, Patent Owner filed a Motion to Exclude evidence (Paper 52), to which Petitioner filed an Opposition (Paper 54), and Patent Owner filed a Reply (Paper 58).

On April 24, 2018, the Supreme Court held that a decision to institute under 35 U.S.C. § 314 may not institute on fewer than all claims challenged in the petition. *SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348 (U.S. Apr. 24, 2018). On May 3, 2018, we issued an order modifying our institution decision to institute on all of the challenged claims and all of the grounds presented in the Petition. Paper 60. Subsequently, the parties filed a joint motion to limit the Petition to the claims and grounds that were originally instituted. Paper 64. We granted the motion. Paper 65. As a result, the remaining instituted claims and grounds are the same as they had been at the time of the Institution Decision. *See id.* at 3.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). After consideration of the parties' arguments and evidence, and for the reasons discussed below, we determine that Petitioner has *not* shown by a preponderance of the evidence that claims 1 and 4–10 of the '032 patent are unpatentable.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00700, and IPR2017-00728. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." Ex. 1101, [54]. The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

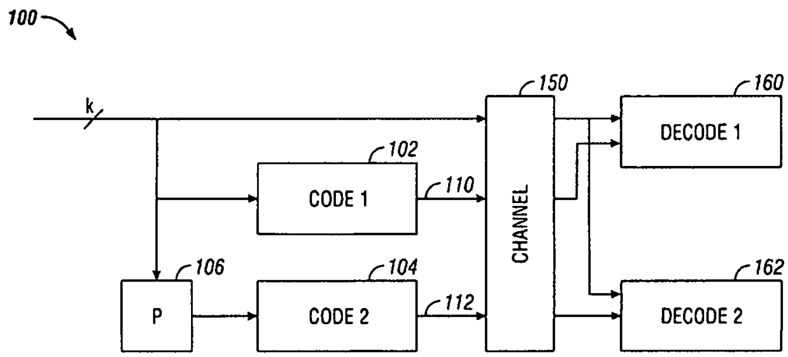

Figure 1 is a schematic diagram of a prior "turbo code" system. *Id.* at 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with reference to Figure 2, reproduced below.

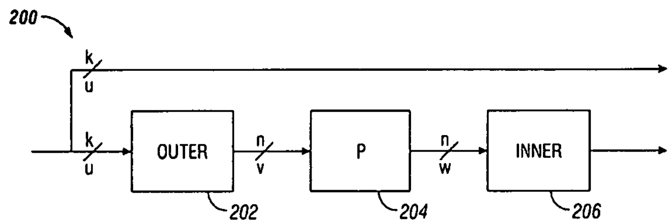

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

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[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") coder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

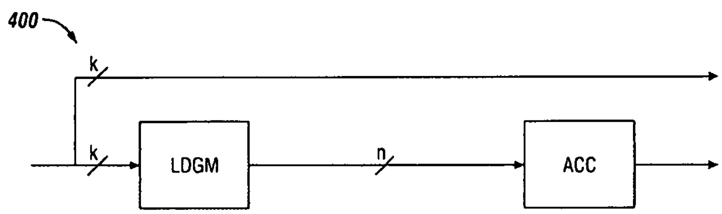

Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 1 is the only independent claim. The remaining challenged claims depend directly or indirectly from claim 1. Claim 1, reproduced below as corrected by a Certificate of Correction dated July 27, 2010, is illustrative:

> 1. A mcthod comprising:
>
> receiving a collection of message bits having a first sequence in a source data stream;
>
> generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula

$$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$

where
"x_{j-1}" is the value of a parity bit "j-1," and

$$\sum_{i=1}^{a} v_{(j-1)a+i}$$

is the value of a sum of "a" randomly chosen irregular[2] repeats of the message bits; and

making the sequence of parity bits available for transmission in a transmission data stream.

Ex. 1101, 7:63–8:20; *id.*, Certificate of Correction (July 27, 2010) (replacing the two formulas).

E. Evidence

Petitioner relies on the following art references:

Reference	**Exhibit No.**
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")	Ex. 1102

[2] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 23–24 (advocating the adoption of that construction in this case); PO Resp. 14 (citing Ex. 2004 ¶ 69 and asserting: "Caltech does not believe the term needs to be construed, as the plain and ordinary meaning of irregular repetition is clear. That message bits contribute in differing numbers to parity bits is made clear in the claim language.").

Reference	Exhibit No.
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")	Ex. 1103
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1108
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")	Ex. 1117

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1104), and the Declaration of Brendan Frey, Ph.D., dated February 21, 2018 (Ex. 1165) in support of its arguments. Patent Owner relies upon the Declaration of Dr. Michael Mitzenmacher, dated November 21, 2017 (Ex. 2004), and the Declaration of Dr. Dariush Divsalar, dated November 7, 2017 (Ex. 2031), in support of its arguments in the Patent Owner Response. The parties rely on other exhibits as discussed below.

F. Remaining Asserted Ground of Unpatentability

The following ground of unpatentability remains at issue in this case (Pet. 37; Paper 65 (granting joint motion to limit the Petition)):

References	Basis	Claims
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	1 and 4–10

II. ANALYSIS

A. Principles of Law

Petitioner bears the burden of proving unpatentability of the claims challenged in the Petition, and that burden never shifts to Patent Owner.

Dynamic Drinkware, LLC v. Nat'l Graphics, Inc., 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must establish the facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and (4) any objective evidence of non-obviousness.[3] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. The Level of Ordinary Skill in the Art

Petitioner's declarant, Dr. Davis, opines that:

> A person of ordinary skill in the art at the time of the alleged invention of the '032 patent would have had a Ph.D. in mathematics, electrical or computer engineering, or computer science with emphasis in signal processing, communications, or coding, or a master's degree in the above area with at least three years of work experience in this field at the time of the alleged invention.

[3] Although Patent Owner puts forth evidence of objective indicia of non-obviousness (PO Resp. 51–62), we need not reach this evidence based on our disposition below.

Ex. 1104 ¶ 91; *see* Pet. 21–22 (citing the same). Patent Owner's declarant, Dr. Mitzenmacher, applies the same definition offered by Dr. Davis. Ex. 2004 ¶ 66.

We determine that the definition offered by Dr. Davis comports with the qualifications a person would have needed to understand and implement the teachings of the '032 patent and the prior art of record. Accordingly, we apply Dr. Davis's definition of the level of ordinary skill in the art.

C. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

We determine that no terms require explicit construction. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy").

D. The Alleged Obviousness over Ping, MacKay, and Divsalar

Petitioner alleges that independent claim 1 and dependent claims 4–10 of the '032 patent would have been obvious over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 37–55 (addressing independent claim 1).

Petitioner asserts that Ping discloses much of the subject matter of independent claim 1, but maintains that Ping's outer coder is regular.

Pet. 39. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 37, 39, relies on Divsalar for the teaching of repetition "if Ping alone is not understood to teach, or render obvious, repeating information bits," *id.* at 42, and relies on Luby97 for the teaching of receiving a source data stream "to the extent Ping is not understood to teach encoding bits in a 'stream,'" *id.* at 44. Patent Owner argues, *inter alia*, that the Petition presents a flawed reason to modify Ping in light of MacKay. PO Resp. 2–3.

1. Ping (Ex. 1103)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1103, 38. In this approach, "only part of [parity check matrix] **H** is generated randomly, and the remaining part is deterministic," which "achieve[s] essentially the same performance as the standard LDPC encoding method with significantly reduced complexity." *Id.* The size of matrix **H** is $(n-k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]^t$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^p, \mathbf{H}^d]$." *Id.* $\mathbf{H}^p$ is defined as follows:

$$\mathbf{H}^p = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^d$ is created such that it "has a column weight of t and a row weight of $kt/(n-k)$ (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H^d} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1104 ¶ 67.[4] For each sub-block of $\mathbf{H^d}$, there is exactly "one element 1 per column and *kt/(n-k)* 1s per row." Ex. 1103, 38. This construction "increase[s] the recurrence distance of each bit in the encoding chain" and "reduces the correlation during the decoding process." *Id.*

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h^d_{1j}\, d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h^d_{ij}\, d_j \pmod 2$$

Ex. 1103, 38 (equation (4)).[5]

2. *MacKay (Ex. 1102)*

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1102, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check

[4] This particular representation of $\mathbf{H^d}$ is taken from Dr. Davis's testimony. Patent Owner's description of $\mathbf{H^d}$ is found at page 8 of its Response.
[5] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1104 ¶ 180.

matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. *Divsalar (Ex. 1117)*

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1104 ¶ 82 (quoting Ex. 1117, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

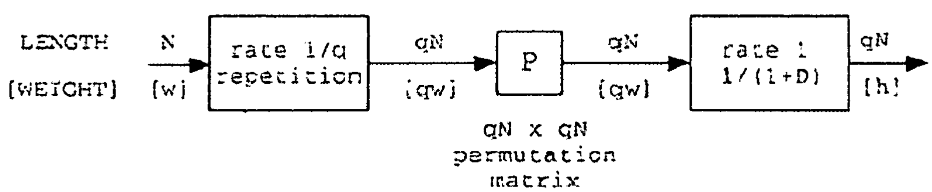

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1117, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. *Luby97 (Ex. 1108)*

Luby97 describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1108, 150 (Abstr.). Luby97 describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted).

5. The Alleged Obviousness of Claim 1

Petitioner, in articulating its obviousness challenge of claim 1, relies on the testimony of Dr. Davis and maps the teachings of the prior art against the limitations of the claim. Pet. 45–55.

Petitioner maintains that Ping, either alone or in light of Luby97, teaches a method including the step of "receiving a collection of message bits having a first sequence in a source data stream." *Id.* at 45–47 (citing Ex. 1104 ¶¶ 120–125). Specifically, Petitioner cites the information bits in Ping denoted by vector **d** for the "receiving" step. *Id.* at 46. (citing Ex. 1103, 38). Petitioner contends that Ping provides equations from which parity bits **p** can easily be calculated from information bits **d**, and that one of ordinary skill in the art would recognize that "message bits" and "information bits" are synonymous. *Id.* at 46–47. Petitioner points to Luby97's teaching of receiving data streams and asserts, "[e]ven if Ping is understood to teach only block encoding, and not encoding bits in [the claimed] 'a source data stream,' it would have been obvious to adapt Ping's coder to work with incoming data streams." *Id.* at 47; *see id.* at 44. Petitioner reasons that it would have been obvious to incorporate the stream teaching of Luby97 into Ping because coders that receive streams were common, *id.* at 44, 47, and the resulting incorporation would "make the encoder [of Ping] capable of receiving and processing 'streams' as opposed to blocks." *Id.* at 47; *see id.* at 44–45.

Petitioner next addresses the "generating" step (Pet. 48–53), which provides:

> generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula

$$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$

> where
> "x_{j-1}" is the value of a parity bit "j-1," and
> $$\sum_{i=1}^{a} v_{(j-1)a+i}$$
> is the value of a sum of "a" randomly chosen irregular repeats of the message bits.

Ex. 1101, 7:66–8:17.

Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. Pet. at 24–25, 49–50. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d d_j$$

as teaching the calculation of a parity bit as the sum of the prior parity bit and a summation of message bits. *Id.* at 49–50. Petitioner argues that Ping also teaches the "randomly chosen" aspect of the limitation, asserting:

> Ping randomly determines which values of h_{ij}^d equal "1" and which values of h_{ij}^d equal "0." Specifically, Ping teaches generating $\mathbf{H}^\mathbf{d}$ by partitioning it into "t equal sub-blocks," as shown in Equation (3), reproduced below:
>
> $$\mathbf{H}^\mathrm{d} = \begin{pmatrix} \mathbf{H}^{\mathrm{d}1} \\ \vdots \\ \mathbf{H}^{\mathrm{d}t} \end{pmatrix}$$
>
> Ex. 1103, p. 38
>
> As Ping explains, "[i]n each sub-block $\mathbf{H}^{\mathbf{d}i}$, i = 1, 2 … t, we <u>*randomly*</u> create exactly one element 1 per column and *kt/*(*n-k*) 1s per row" (Ex. 1103, p. 38, emphasis added.) The positions of the 1s in $\mathbf{H}^\mathbf{d}$ are used to determine which information bits are included in each summation $\sum_j h_{ij}^d d_j$. By placing the 1s into

> $\mathbf{H^d}$ "randomly," Ping ensures that the information bits contributing to each of the summations $\sum_j h_{ij}^d d_j$ are randomly chosen. (Ex. 1104, ¶137.)

Pet. 51.

Petitioner further contends that "it would have been obvious to one of ordinary skill to implement Ping by repeating every message bit [but] . . . , to the extent Ping does not itself teach, or render obvious, repeating every message bit, Divsalar does so explicitly." *Id.* at 52; *see id.* at 42. Petitioner also argues that the use of a repeater in an outer coder was common in the art, that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references' teachings. *Id.* at 42–43.

In addressing the "irregular repeats" aspect of claim 1, Petitioner contends that, "[i]n Ping's $\mathbf{H^d}$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^d d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 30. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H^d}$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H_d}$ has a column weight of *t* . . . .'" *Id.* at 39 (quoting Ex. 1103, 38); *see id.* at 52–53. Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 40 (quoting Ex. 1102, 1449) (emphasis in original); *see also* Pet. Reply 3 (citing Ex. 1165 (Frey Decl.)

¶¶ 20–24) ("MacKay also teaches that codes with such parity check matrices, *i.e.*, matrices with uneven column weights, can outperform their regular counterparts.").

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." Pet. 39. Petitioner proposes modifying Ping's $\mathbf{H}^{\mathbf{d}}$ matrix (or outer coder), which Petitioner characterizes as regular, and contends that one of ordinary skill in the art would have made this modification to improve the performance of Ping's code. Pet. 39; Pet. Reply 4. Specifically, Petitioner maintains:

> It would have been straightforward for one of ordinary skill to change Ping's generator $\mathbf{H}^{\mathbf{d}}$ matrix such that different columns had different weights – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1102, p. 1451.) This would result in some information bits contributing to more outer LDPC parity bits than others, making Ping's outer LDPC code irregular. This would have been an easy way for one of ordinary skill to incorporate the irregularity disclosed by MacKay into Ping. Moreover, MacKay's teaching that the best performing LDPC codes are irregular would have made this modification obvious (and desirable). (Ex. 1102, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper....") (Ex. 1104, ¶108.)

Pet. 40. According to Petitioner, a person of ordinary skill would not have been motivated to modify $\mathbf{H}^{\mathbf{p}}$ because "it has only a single form and because doing so would have complicated a simple encoder." Pet. Reply 10. Thus, Petitioner contends that the person of ordinary skill "who wanted to obtain the benefit of MacKay's irregularity in Ping would have had only one option—to incorporate MacKay's irregularity into $\mathbf{H}^{\mathbf{d}}$." *Id.* Petitioner summarizes its position on this aspect of the claim by asserting that, given the teachings of MacKay, "it would have been obvious to one of ordinary skill to incorporate the non-uniform column weight of MacKay into the LDPC-accumulate codes of Ping [and] [t]his would result in some information bits being repeated more than others, satisfying the 'irregular repeats' requirement of claim 1." Pet. 53 (citing Ex. 1104 ¶ 142).

The last step of claim 1 recites "making the sequence of parity bits available for transmission in a transmission data stream." Ex. 1101, 8:19–20. Petitioner asserts that Ping, in discussing the performance of the codes, teaches the transmission of parity bits. Pet. 54. Petitioner again points to Luby97's teaching of data streams and argues that one of ordinary skill would have understood that bits commonly are transmitted in streams and that "[i]t would also have been obvious to one of ordinary skill that an encoder receiving bits in a stream would have output bits in a stream, and that the corresponding decoder would have received encoded bits in a stream." *Id.* (citing Ex. 1108, 150; Ex. 1104, ¶ 146).

Patent Owner disputes, *inter alia*, Petitioner's rationale for combining Ping and MacKay—which underlies the overall combination of Ping, MacKay, Divsalar, and Luby97—on a number of bases. *See* PO Resp. 15–16 (summarizing eight arguments regarding Petitioner's Ground), 24. Patent Owner argues that Ping's parity check matrix **H** is already irregular as defined by MacKay. *See id.* at 24–29. According to Patent Owner, "Ping's parity-check matrix has three different column weights (t, 2, and 1), and two different row weights ($kt/(n-k)+1$ and $kt/(n-k)+2$)." *Id.* at 25 (citing Ex. 2033, 231:11–14); *see also* Ex. 2004 ¶ 92 (same). As such, Patent Owner argues "Ping's parity-check matrix is actually even more 'irregular' than MacKay's irregular codes," so ordinarily skilled artisans "would not have been motivated by MacKay's teachings that irregular codes are an improvement over regular codes." PO Resp. 26–27 (citing Ex. 2004 ¶¶ 94, 95, and 97–99).

Patent Owner also highlights that Petitioner's proposed modifications relate only to a portion of Ping's parity check matrix **H**, namely, sub-matrix $\mathbf{H}^d$. *See id.* at 27–28; *see also* Ex. 2004 ¶ 96. Patent Owner argues "MacKay does not even *consider* modifying submatrices, much less teach that there may be benefits to try." PO Resp. 29. According to Patent Owner, "MacKay teaches that irregular parity-check matrices *as a whole* may define better codes than regular parity-check matrices *as a whole*—it does not teach any improvement from making a submatrix within a parity-check matrix irregular, or from using any other type of irregular matrix (e.g., irregular generator matrices)." *Id.* at 27. Patent Owner argues MacKay does not "suggest that *additional* irregularity should be applied to individual portions when the overall parity-check matrix is already irregular." *Id.* at 28 (citing Ex. 2004 ¶¶ 96–99) (footnote omitted).

Patent Owner further argues that Petitioner has not established that an ordinarily skilled artisan would have reasonably expected success from the proposed modification of Ping in light of MacKay. *See* PO Resp. 42–47. Patent Owner argues "the petition does not even attempt to analyze a reasonable expectation of success, and for that reason, it is incurably deficient." *Id.* at 42. As further evidence of the lack of anticipated success, Patent Owner emphasizes that constructing error-correction codes "was a highly unpredictable endeavor" that was subject to "extensive trial-and-error and experimentation to determine whether new codes led to an improvement." *Id.* at 4 (citing Ex. 2004 ¶ 46); *see also id.* at 42–43 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12).

We are persuaded by Patent Owner's arguments. We agree with Patent Owner (*see* PO Resp. 27–28 & n.7) that, although Petitioner may explain how to modify Ping's $\mathbf{H}^d$ sub-matrix in light of MacKay, it does not address why such an ordinarily skilled artisan would have done this. Nor does Petitioner establish that such an artisan reasonably would have expected success from the modification. Based on the entire trial record, we determine that Petitioner has not established a persuasive rationale for modifying Ping in light of MacKay as asserted by Petitioner. Petitioner's additional reliance on Divsalar and Luby97 does not remedy this fundamental flaw in the articulated combination. *See* Pet. 42, 44–45 (relying on Divsalar for the teaching of repeating information bits and Luby97 for the teaching of encoding bits in a stream if Ping is not understood to teach these aspects).

Petitioner's unpatentability contentions presuppose that an ordinarily skilled artisan would seek to modify a *sub-matrix* in Ping in light of MacKay. *See* Pet. Reply 10 ("Caltech's comparison of Ping's **H** matrix to MacKay's is improper. . . . The proper comparison is between Ping's $\mathbf{H}^d$ matrix . . . and MacKay's matrix."). Yet even if MacKay touts improvements from irregularity in a parity check matrix (e.g., Ping's matrix **H**), MacKay does not suggest that these improvements would have been applicable to *portions* of a parity check matrix (e.g., Ping's sub-matrix $\mathbf{H}^d$). To reach its proposed modification, Petitioner characterizes Ping's sub-matrix $\mathbf{H}^d$ as a generator matrix (or "outer coder") and Ping's sub-matrix $\mathbf{H}^p$ as merely an accumulator (or "inner coder"). Pet. 24–25, 41;

Pet. Reply 7, 13–16. We agree with Patent Owner (*see* PO Resp. 35), however, that Petitioner does not explain adequately why labeling sub-matrix $\mathbf{H^d}$ as a generator matrix supports the proposed modification of $\mathbf{H^d}$ based on MacKay. Indeed, this label does not explain why an ordinarily skilled artisan considering MacKay would have chosen to modify $\mathbf{H^d}$ or any other portion of parity check matrix **H**.

Petitioner's further contentions also are not persuasive. Specifically, Petitioner contends $\mathbf{H^p}$ is an accumulator with only a single, fixed form, so an ordinarily skilled artisan would not have been motivated to modify $\mathbf{H^p}$ because "doing so would have complicated a simple encoder." Pet. Reply 10, 17. Yet this rationalization belies the fact that Ping also specifically defines a structure for sub-matrix $\mathbf{H^d}$, which simplifies a portion of the parity check matrix. According to Dr. Mitzenmacher, "the constraints on $\mathbf{H^d}$, including its regularity, were a deliberate design decision that contributes to the improved performance of Ping's code over fully random LDPC codes—it is a fundamental part of its code." Ex. 2004 ¶ 104. Thus, choosing to modify *any* portion of Ping's matrix would have broken constraints in Ping that were intended to simplify encoding. *See* Ex. 1103, 38 (Ping describing the disclosed approach as a "new method [that] can achieve essentially the same performance as the standard LDPC encoding method with significantly reduced complexity"). This is a strong indication that an ordinarily skilled artisan would not have been motivated to reach within Ping's parity check matrix **H** and modify a sub-matrix.

We also agree with Patent Owner that Ping's parity check matrix **H** is already "irregular," which undermines Petitioner's stated motivation for modifying Ping in view of MacKay. *See* PO Resp. 24–29. Citing

Dr. Mitzenmacher, Patent Owner establishes that Ping's matrix **H** has three different column weights (*t*, 2, and 1). *Id.* at 25–29; Ex. 2004 ¶¶ 91–92; *see also* Ex. 2033, 231:11–14 (Dr. Davis acknowledging that Ping's parity check matrix **H** has "different weights for the columns"). We accept this as evidence of "irregularity" based on Petitioner's own acknowledgment that "irregularity" is associated with "uneven column weights." *See* Pet. Reply 16. Petitioner does not contest that Ping's parity check matrix **H** is irregular; rather, Petitioner contends that the appropriate comparison is between MacKay's parity check matrix and Ping's sub-matrix $\mathbf{H}^d$. Pet. Reply 10. But MacKay is silent on the concept of sub-matrices, so Petitioner's association of MacKay's teaching with sub-matrix $\mathbf{H}^d$ is not apt. Instead, we agree with Patent Owner that "MacKay's teachings are only applicable to full parity check matrices." PO Resp. 15–16. Thus, the record does not establish that an ordinarily skilled artisan would have sought to add irregularity to Ping's parity check matrix **H**—or additional irregularity to a sub-matrix of **H**, such as $\mathbf{H}^d$—because **H** itself is already irregular.

Finally, we agree with Patent Owner that the Petition is silent on whether a person of ordinary skill in the art would have expected success in combining MacKay with Ping. Although Petitioner cites an alleged "straightforward modification of Ping's $\mathbf{H}^d$ matrix" at page 40 of the Petition as supporting the expectation of success (Pet. Reply 17), the cited passage only describes the proposed modification, rather than addressing whether an ordinarily skilled artisan would have anticipated success from the modification. *See* Pet. 40. In addition, Petitioner's argument that an ordinarily skilled artisan "would have needed no more specificity to attempt to use MacKay's irregularity in Ping" (Pet. Reply 17) only underscores the lack of evidence in the Petition regarding anticipated success.

Perhaps sensing this deficiency in the Petition, Petitioner introduces new testimony and a new simulation from Dr. Frey with its Reply in which Dr. Frey allegedly "demonstrate[s] the ease with which a [person of ordinary skill in the art] could have added MacKay's irregularity to Ping." Ex. 1165 ¶ 44. According to Petitioner, the results of the simulation "outperform Ping's original code" and "confirm that a [person of ordinary skill in the art] would have been motivated to use MacKay's uneven column weights in Ping's $\mathbf{H}^d$ matrix, and . . . would have had a reasonable expectation of success when doing so." Pet. Reply 19–20. Yet, even if we were to deem the testimony and simulation to be within the proper scope of a reply brief,[6] they do not support a reasonable expectation of success *at the time of the invention*. We agree with Patent Owner that "[i]t is irrelevant what Dr. Frey claims he could do in the year 2018 when armed with Caltech's disclosures, [the named-inventor's] original coding work, contemporary resources (e.g., Matlab), and some 18 years of post-filing date knowledge." PO Sur-Reply 6–7 (footnote omitted). Because this evidence is not tied to the state of the art at the time of the invention, it is not probative of anticipated success. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1367 (Fed. Cir. 2017) (quoting *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1138 (Fed. Cir. 1985)) ("Those charged with determining compliance with 35 U.S.C. § 103 are required to place themselves in the minds of those

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[6] We need not reach this issue, because we do not rely on this evidence in a manner adverse to Patent Owner. *See also infra* § II.E. (dismissing Patent Owner's Motion to Exclude as moot on the same basis).

of ordinary skill in the relevant art *at the time the invention was made*, to determine whether that which is now plainly at hand would have been obvious at such earlier time." (emphasis added)).

Furthermore, as part of our obviousness analysis, we are charged to consider "the scope and content of the prior art." *See Graham*, 383 U.S. at 17–18. One important aspect of the art in this case is the relative unpredictability of developing error-correction codes. *See* PO Resp. 42–43 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12) ("New codes appeared from unexpected sources, and developing the precise parameters that could lead to incremental improvements often took a significant amount of time and experimentation."). In its Reply, Petitioner embraces the notion of unpredictability as supporting its combination; Petitioner contends that "rigorous mathematical analysis of codes is difficult, and, as a result, [persons of ordinary skill in the art] routinely develop codes by experimentation." Pet. Reply 17–18. Petitioner further contends that "running experimental tests on a version of Ping that incorporated MacKay's irregularity would have been routine[,] . . . [and] the modifications suggested by MacKay would have been straightforward and would have taken very little time to implement." *Id.* at 18.

Yet we do not agree with Petitioner that the need to run experiments in an unpredictable field, such as error-correction coding, indicates anything about whether such experiments ultimately would have been successful at the time of the invention. Importantly, "[u]npredictability of results equates more with nonobviousness rather than obviousness, whereas that which is predictable is more likely to be obvious." *Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017). In the absence of any argument rooted in the Petition directing us to evidence that substantiates a reasonable expectation of success, Petitioner's reliance on a known need for experimentation is not sufficient to support its obviousness rationale.[7] *See Arctic Cat Inc. v. Bombardier Recreational Prod. Inc.*, 876 F.3d 1350, 1360–61 (Fed. Cir. 2017) ("[W]here a party argues a skilled artisan would have been motivated to combine references, it must show the artisan would have had a reasonable expectation of success from doing so." (internal quotation omitted)).

For these reasons, we are not persuaded that an ordinarily skilled artisan would have been motivated to combine the teachings of Ping and MacKay in the manner suggested by Petitioner. Petitioner's reliance on Divsalar's and Luby97's teachings in the proposed combination does not remedy this underlying flaw. Thus, we determine Petitioner has not shown by a preponderance of the evidence that claim 1 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

Petitioner relies on the same deficient rationale for combining Ping and MacKay with respect to its analysis for dependent claims 4–10. *See* Pet. 61–74. Thus, we also determine Petitioner has not shown by a

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[7] Notably, Petitioner does not contend that its proposed combination should be analyzed under obvious-to-try case law. Tr. 15:24–16:4 (Petitioner acknowledging that it was not putting forth an obvious-to-try argument). Nor could Petitioner, because Petitioner does not develop an obvious-to-try theory. Specifically, Petitioner does not establish that the prior art directs which parameters to try and/or guides an inventor toward a particular solution. *See Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1347 (Fed. Cir. 2009).

preponderance of the evidence that claims 4–10 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

E. Patent Owner's Motion to Exclude

Patent Owner moves to exclude Exhibits 1106, 1118, 1119, 1124, 1129-1149, 1157-1161, 1165, 1167, 1168, 1171, 1172 and portions of Exhibits 2038 and 2039. Paper 52, 1. Patent Owner's motion is dismissed as moot with respect to these exhibits, as we do not rely on them in a manner adverse to Patent Owner.

F. Patent Owner's Motion for Sanctions

Patent Owner requests sanctions against Petitioner for allegedly failing to stay within the proper scope of cross-examination during the deposition of Dr. Mitzenmacher and Dr. Divsalar. Paper 42, 1.[8] Specifically, Patent Owner details questioning of Dr. Mitzenmacher that allegedly "ventured into various topics beyond the scope of the witness' direct testimony." *Id.* at 7–9. For example, Patent Owner cites "extensive questioning regarding Tanner graphs and figures newly created by Petitioner's lawyers, but absent from any petition materials or the witness' direct testimony." *Id.* at 8. Similarly, Patent Owner asserts that Dr. Divsalar was questioned regarding subject matter not discussed in his declaration including the Allerton Conference, Tanner graphs, and certain references. *Id.* at 3–7. As sanctions, Patent Owner asks us to: (1) strike the out-of-scope testimony elicited by Petitioner; (2) hold the direct testimony of

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[8] Although Patent Owner cites primarily to Exhibit 1064 as the transcript of Dr. Divsalar's deposition, the pertinent exhibit in this case is Exhibit 2039. *See* Paper 42, 4.

Dr. Mitzenmacher and Dr. Divsalar to be facts established in this proceeding; and (3) impose "reasonable compensatory expenses, including attorney fees, for costs reasonably related to excessive questioning and deposition time." *Id.* at 9–10.

Petitioner contends that "each question posed by Petitioner during Dr. Mitzenmacher's deposition pertained directly to topics and opinions in his declaration." Paper 47, 5. Regarding the Tanner graphs and figures, Petitioner contends these were properly served upon Petitioner at Dr. Mitzenmacher's deposition in accordance with 37 C.F.R. § 42.53(f)(3). *Id.* at 6. According to Petitioner, Patent Owner's proposed sanctions are unwarranted, particularly because Patent Owner suffered no harm. *Id.* at 7–8.

The "Board may impose a sanction against a party for misconduct." 37 C.F.R. § 42.12(a); *see also* 35 U.S.C. § 316(a)(6) (requiring regulations prescribing sanctions). As the moving party, Patent Owner has the burden to persuade the Board that sanctions are warranted. *See* 37 C.F.R. § 42.20(c). In general, a motion for sanctions should address three factors: (i) whether a party has performed conduct that warrants sanctions; (ii) whether the moving party has suffered harm from that conduct; and (iii) whether the sanctions requested are proportionate to the harm suffered by the moving party. *See Square, Inc. v. Think Comput. Corp.*, Case CBM2014-00159, slip op. at 2 (PTAB Nov. 27, 2015) (Paper 48) (citing *Ecclesiastes 9:10-11-12, Inc. v. LMC Holding Co.*, 497 F.3d 1135, 1143 (10th Cir. 2007)).

Having reviewed the relevant portions of Dr. Mitzenmacher's deposition, we agree with Petitioner that sanctions are not warranted. Petitioner's attempts to elicit testimony regarding the Tanner graphs and figures, while inartful, did not rise to the level of sanctionable conduct because they were reasonably related to Dr. Mitzenmacher's direct testimony.

As to Dr. Divsalar, Patent Owner characterizes his direct testimony (Ex. 2031) as merely taking the form of "a short declaration addressing only a few discrete points relating specifically to the Divsalar reference." Paper 42, 3. Patent Owner contends Petitioner's questions about the Allerton Conference, Tanner Graphs, and certain other references went beyond the "limited scope of Dr. Divsalar's 16-page declaration." *Id.* at 3–7.

Petitioner cites certain direct testimony from Dr. Divsalar regarding the perspective of a person of ordinary skill in the art, Tanner graphs, and certain "contemporaneous literature" and contends that it was permissible to question Dr. Divsalar at the deposition about the foundation and validity of his opinions on these topics. Paper 47, 3–4 (quoting Ex. 2031 ¶ 10 and citing Ex. 2031 ¶¶ 9–11, 26, 28–30, and 33–36). Petitioner further contends that "in his declaration, Dr. Divsalar discussed having submitted a paper 'in connection with the Allerton conference in 1998' [and] Petitioner thus properly asked questions about what 'in connection with the Allerton conference' means." Paper 47, 3 (citing Ex. 2031 ¶ 19).

We again agree with Petitioner that sanctions concerning the deposition of Dr. Divsalar are not warranted. In fact, Patent Owner acknowledges that Dr. Divsalar offered opinion testimony going to the heart of the dispute in this case. Paper 42, 3. In that respect, Patent Owner states:

> Dr. Divsalar expressed his view that modifying an RA [repeat-accumulate] code to include irregular repetition of information bits would not make sense on the basis that it would add

> unnecessary difficulty and complexity at odds with the stated objective in the paper, with no expectation of a corresponding benefit. [Ex. 2031 (Divsalar Declaration)] at ¶¶ 33-36. Dr. Divsalar was also asked to address the hypothetical modification suggested by Petitioner, which he explained was nonsensical and at odds with a key conclusion in the Divsalar paper. *Id.* at ¶ 37.

Id.; *see also* Ex. 2031 ¶ 9 (Dr. Divsalar, under the heading "Summary of Opinions," testifying: "I do not believe it would have been trivial or obvious to modify RA codes by making them 'irregular' in order to arrive at IRA codes, nor would a person of ordinary skill in the art be motivated to make such a modification."). In light of this, we are persuaded by Petitioner that its questions were reasonably related to Dr. Divsalar's direct testimony—including the opinion testimony—and were not so far afield as to warrant sanctions.

Furthermore, we agree with Petitioner that Patent Owner suffered no harm with respect to the depositions of Dr. Mitzenmacher and Dr. Divsalar, particularly in light of our disposition of the challenged claims. For these reasons, we deny Patent Owner's motion for sanctions.

III. CONCLUSION

Petitioner has *not* demonstrated by a preponderance of the evidence that claims 1 and 4–10 of the '032 patent are unpatentable as obvious over Ping, MacKay, Divsalar, and Luby97.

IV. ORDER

For the foregoing reasons, it is

ORDERED that claims 1 and 4–10 of the '032 patent have *not* been proven to be unpatentable;

FURTHER ORDERED that Patent Owner's Motion to Exclude is *dismissed as moot*;

FURTHER ORDERED that Patent Owner's Motion for Sanctions is *denied*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Paper 67
Entered: August 2, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00700
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318(a) and 37 C.F.R. § 42.73

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1001). Paper 5 ("Pet."). The Petition challenges the patentability of claims 11–17 of the '032 patent on various grounds of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp."). We instituted *inter partes* review (Paper 14, "Inst. Dec.") of claims 11, 12, and 14–16 based on Ping, MacKay, and Divsalar, and of claim 13 based on Ping, MacKay, Divsalar, and Luby97. However, the instituted review did not include Petitioner's obviousness challenge of claim 17 based on Ping, MacKay, Divsalar, and Pfister Slides.

Patent Owner filed a Response to the Petition (Paper 32, "PO Resp."), and Petitioner filed a Reply (Paper 45, "Pet. Reply"). Pursuant to our authorization (Paper 43), Patent Owner filed a Sur-Reply (Paper 55, "PO Sur-Reply").

An oral hearing was held on May 8, 2018, and a transcript of the hearing is included in the record. Paper 66 ("Tr.").

As authorized in our Order of February 10, 2018 (Paper 41), Patent Owner filed a motion for sanctions related to Petitioner's cross-examination of Patent Owner's witnesses, Dr. Mitzenmacher and Dr. Divsalar (Paper 42), and Petitioner filed an opposition (Paper 47).

Additionally, Patent Owner filed a Motion to Exclude evidence (Paper 52), to which Petitioner filed an Opposition (Paper 54), and Patent Owner filed a Reply (Paper 58).

On April 24, 2018, the Supreme Court held that a decision to institute under 35 U.S.C. § 314 may not institute on fewer than all claims challenged in the petition. *SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348 (U.S. Apr. 24, 2018). On May 3, 2018, we issued an order modifying our institution decision to institute on all of the challenged claims and all of the grounds presented in the Petition. Paper 60. Subsequently, the parties filed a joint motion to limit the Petition to the claims and grounds that were originally instituted. Paper 64. We granted the motion. Paper 65. As a result, the remaining instituted claims and grounds are the same as they had been at the time of the Institution Decision. *See id.* at 3.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). After consideration of the parties' arguments and evidence, and for the reasons discussed below, we determine that Petitioner has *not* shown by a preponderance of the evidence that claims 11–16 of the '032 patent are unpatentable.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00701, and IPR2017-00728. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." Ex. 1001, [54]. The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

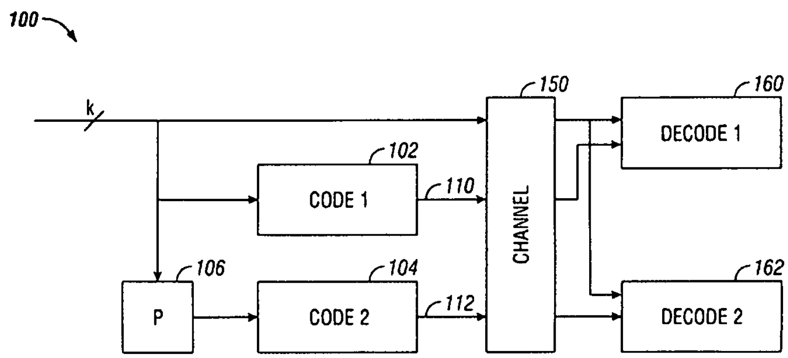

Figure 1 is a schematic diagram of a prior "turbo code" system. *Id.* at 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with reference to Figure 2, reproduced below.

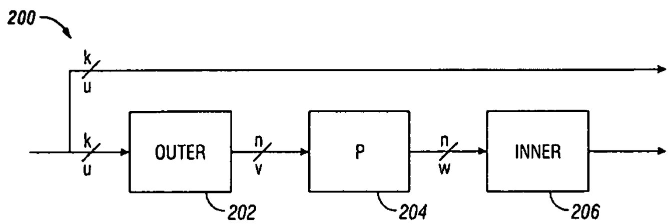

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that rcpcats thc k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remaindcr of bits may bc rcpcatcd four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can bc writtcn as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

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[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") coder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

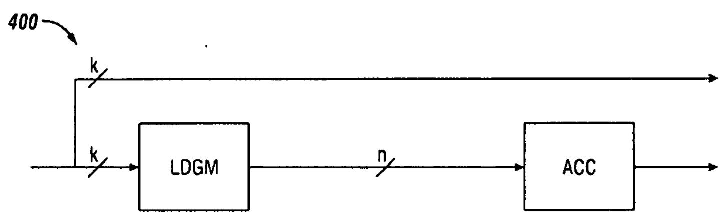


Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

"The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code." *Id.* at 3:33–35. Figure 3, shown below, depicts such a Tanner graph.

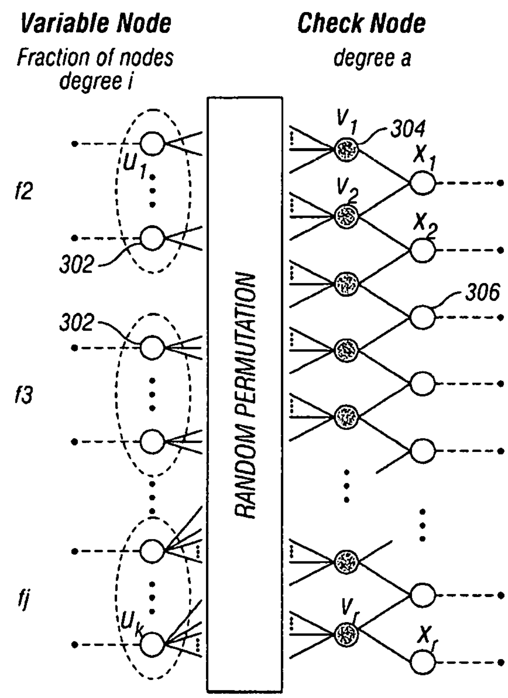


Figure 3 is described as a "Tanner graph for an irregular repeat and accumulate (IRA) coder." *Id.* at 2:20–21. The left-most column of nodes, information nodes 302 (the open circles), are variable nodes that receive information bits. The column of nodes (the filled circles) just to the right of the "RANDOM PERMUTATION" block are check nodes v indicated by reference numeral 304. An information bit node connected to two check nodes represents a repeat of 2. An information node connected to three check nodes represents a repeat of 3. The nodes (the open circles) in the right-most column are parity bit nodes x, referenced by 306. As shown by the edges[2] of the Tanner graph, each parity bit is a function of its previous parity bit and is also a function of information bits (edges connect through

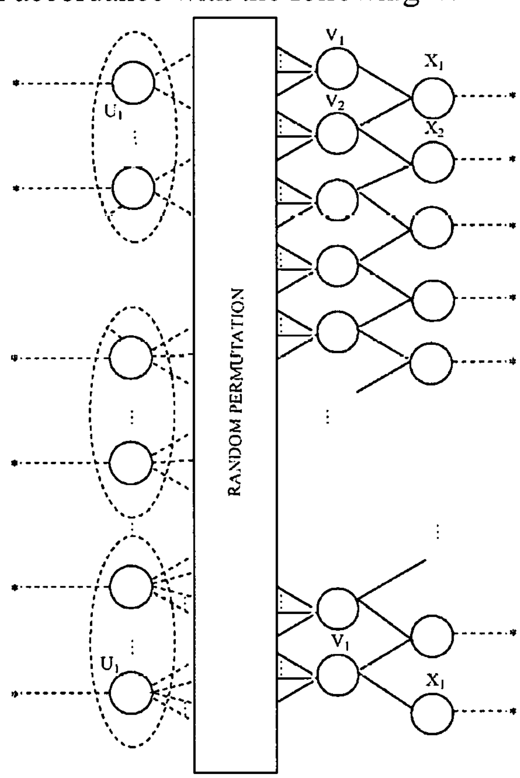
[2] We understand that "edges" are the straight lines that connect one node to another node of a Tanner graph. *See* Ex. 1001, 3:53–54.

check nodes and random permutation to information bit nodes). *Id.* at 3:34–55; *see also* Ex. 1004 ¶ 110 (discussing the relationship between parity bits in the context of the claimed Tanner graph and the '032 patent's specification).

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 11 is the only independent claim. The remaining challenged claims depend directly or indirectly from claim 11. Claim 11, reproduced below as originally issued and before issuance of a Certificate of Correction dated February 17, 2009, is illustrative:

> 11. A device comprising:
> an encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits in accordance with the following Tanner graph:



Ex. 1001, 8:63–9:34. A Certificate of Correction for the '032 patent replaced the labels V_1, U_1, and X_1 from the lower portion of the Tanner graph in claim 11 with V_r, U_k, and X_r, respectively. *See id.* at Certificate of Correction (Feb. 17, 2009).

E. Evidence

Petitioner relies on the following art references:

Reference	**Exhibit No.**
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")	Ex. 1002
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")	Ex. 1003
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1008
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")	Ex. 1017

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1004), and the Declaration of Brendan Frey, Ph.D., dated February 21, 2018 (Ex. 1065) in support of its arguments. Patent Owner relies upon the Declaration of Dr. Michael Mitzenmacher, dated November 21, 2017 (Ex. 2004), and the Declaration of Dr. Dariush Divsalar, dated November 7, 2017 (Ex. 2031), in support of its arguments in the Patent Owner Response. The parties rely on other exhibits as discussed below.

F. Remaining Asserted Grounds of Unpatentability

The following grounds of unpatentability remain at issue in this case (Pet. 39, 64, 71; Paper 65 (granting joint motion to limit the Petition)):

References	**Basis**	**Claim(s)**
Ping, MacKay, and Divsalar	§ 103(a)	11, 12, and 14–16
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	13

II. ANALYSIS

A. Principles of Law

Petitioner bears the burden of proving unpatentability of the claims challenged in the Petition, and that burden never shifts to Patent Owner. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015). To prevail, Petitioner must establish the facts supporting its challenge by a preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

A patent claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3)

the level of skill in the art; and (4) any objective evidence of non-obviousness.[3] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

B. The Level of Ordinary Skill in the Art

Petitioner's declarant, Dr. Davis, opines that:

> A person of ordinary skill in the art at the time of the alleged invention of the '032 patent would have had a Ph.D. in mathematics, electrical or computer engineering, or computer science with emphasis in signal processing, communications, or coding, or a master's degree in the above area with at least three years of work experience in this field at the time of the alleged invention.

Ex. 1004 ¶ 98; *see* Pet. 23 (citing the same). Patent Owner's declarant, Dr. Mitzenmacher, applies the same definition offered by Dr. Davis. Ex. 2004 ¶ 66.

We determine that the definition offered by Dr. Davis comports with the qualifications a person would have needed to understand and implement the teachings of the '032 patent and the prior art of record. Accordingly, we apply Dr. Davis's definition of the level of ordinary skill in the art.

C. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary

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[3] Although Patent Owner puts forth evidence of objective indicia of non-obviousness (PO Resp. 54–66), we need not reach this evidence based on our disposition below.

skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Tanner Graph

For purposes of our Institution Decision, we adopted the construction for "Tanner graph" set forth in a prior Board decision concerning the '032 patent and for which Petitioner supports the application of the same construction in the present case. Inst. Dec. 9–10 (quoting IPR2015-00060, Paper 18, 12–14; citing Pet. 26[4]). The prior construction was specifically addressing the Tanner graph of claim 18, but is equally applicable to claim 11, at issue in this case, because the Tanner graph is the same in both claims. *See* Ex. 1004 ¶ 99 (Dr. Davis); Ex. 2001 ¶ 20 (Dr. Tanner); Tr. 49:18–21, 62:10–13. That construction is as follows:

> [1] a graph representing an [irregular[5] repeat accumulate] IRA code as a set of parity checks where every message bit is

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[4] Petitioner contends that this construction is the broadest reasonable interpretation, yet is narrower than that adopted by the District Court in *Caltech v. Hughes Communications Inc.*, No. 2:13-cv-07245 (C.D. Cal.) because the court's construction did not include the constraint regarding parity bit determination (constraint [3]). Pet. 26 (citing Ex. 1013). Petitioner contends that the difference has no substantive effect on the issues before us. *See* Tr. 34:16–35:2.

[5] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 24 (advocating the adoption of that construction in this case); PO Resp. 14 (citing Ex. 2004 ¶ 69 and asserting: "Caltech does not believe the term needs to be construed, as the plain and ordinary meaning of irregular repetition is clear. That message bits contribute in differing numbers to parity bits is made clear in the claim language.").

> repeated, at least two different subsets of message bits are repeated a different number of times, and
>
> [2] check nodes, randomly connected to the repeated message bits, enforce constraints that determine the parity bits[, and] . . .
>
> [3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph.

Inst. Dec. 9–10.

Patent Owner does not express disagreement with the construction but contends that the term "Tanner graph" need not be construed because, *inter alia*, a person of ordinary skill in the art "would have readily understood how to encode bits according to the Tanner graph in the claims and in view of the specification." PO Resp. 16; *see also* Ex. 2004 ¶ 73 (Dr. Mitzenmacher not disagreeing with any aspect of the construction but opining that: "[T]here is no need to 'construe' the graph. Any person of ordinary skill could readily comprehend what the graph requires in terms of an encoder or a decoder.").

Regardless as to whether the person of ordinary skill in the art—e.g., a person with a doctorate in mathematics—would understand the claim, we find a verbal description of the graph to be helpful. Accordingly, we again adopt that prior construction for purposes of analyzing Petitioner's challenges before us in this case.

On this record and for purposes of deciding the dispositive issues before us, we determine that no other claim terms require express construction.

D. The Alleged Obviousness over Ping, MacKay, and Divsalar

Petitioner alleges that independent claim 11 and dependent claims 12, and 14–16 of the '032 patent would have been obvious over Ping, MacKay, and Divsalar. *See* Pet. 39–57 (addressing independent claim 11).

Petitioner asserts that Ping discloses much of the subject matter of independent claim 11, but maintains that Ping's outer coder is regular. Pet. 41; *see also id.* at 51. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 39, 41, and relies on Divsalar for the teaching of repetition "if Ping standing alone is not understood to teach, or render obvious, repeating information bits," *id.* at 44. Patent Owner argues, *inter alia*, that the Petition presents a flawed reason to modify Ping in light of MacKay. PO Resp. 2–3.

1. Ping (Ex. 1003)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1003, 38. In this approach, "only part of [parity check matrix] **H** is generated randomly, and the remaining part is deterministic," which "achieve[s] essentially the same performance as the standard LDPC encoding method with significantly reduced complexity." *Id.* The size of matrix **H** is $(n–k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]'$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^{\mathbf{p}}, \mathbf{H}^{\mathbf{d}}]$." *Id.* $\mathbf{H}^{\mathbf{p}}$ is defined as follows:

$$\mathbf{H^p} = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H^d}$ is created such that it "has a column weight of *t* and a row weight of *kt*/(*n*–*k*) (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H^d} = \begin{bmatrix} h_{1,1}^d & h_{1,2}^d & h_{1,3}^d & \cdots & h_{1,k}^d \\ h_{2,1}^d & h_{2,2}^d & h_{2,3}^d & \cdots & h_{2,k}^d \\ h_{3,1}^d & h_{3,2}^d & h_{3,3}^d & \cdots & h_{3,k}^d \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h_{n-k,1}^d & h_{n-k,2}^d & h_{n-k,3}^d & \cdots & h_{n-k,k}^d \end{bmatrix}$$

Ex. 1004 ¶ 74.[6] For each sub-block of $\mathbf{H^d}$, there is exactly "one element 1 per column and *kt/(n-k)* 1s per row." Ex. 1003, 38. This construction "increase[s] the recurrence distance of each bit in the encoding chain" and "reduces the correlation during the decoding process." *Id.*

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h_{1j}^d d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h_{ij}^d d_j \pmod 2$$

Ex. 1003, 38 (equation (4)).[7]

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[6] This particular representation of $\mathbf{H^d}$ is taken from Dr. Davis's testimony. Patent Owner's description of $\mathbf{H^d}$ is found at page 8 of its Response.
[7] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is

2. MacKay (Ex. 1002)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1002, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1017)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1004 ¶ 89 (quoting Ex. 1017, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

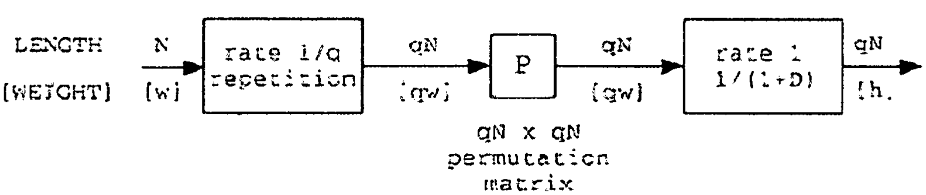

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1017, 5. The numbers above the input-output lines

defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1004 ¶ 185.

indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. The Alleged Obviousness of Claim 11

As discussed above in the context of claim construction, independent claim 11 contains a Tanner graph having at least three elements. Petitioner, in articulating its obviousness challenge of claim 11, relies on the testimony of Dr. Davis and maps the teachings of the prior art against those three elements as well as the express recitations of the claim. Pet. 46–57.

Petitioner maintains that Ping teaches the recited "encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits." *Id.* at 46–47 (citing Ex. 1004 ¶¶ 127–128). Specifically, Petitioner contends that Ping provides equations from which parity bits **p** can easily be calculated from information bits **d**, and that one of ordinary skill in the art would recognize that "message bits" and "information bits" are synonymous. *Id.*

As for the Tanner graph, Petitioner addresses the three elements but in an order different than that listed above in the claim construction section. For the element "[3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph," Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. *Id.* at 27, 48–50; *see also id.* at 51–52 (maintaining that Ping's inner coder is an accumulator).

The next element of the Tanner graph addressed by Petitioner is "[1] a graph representing an [irregular repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times." Pet. 50–54. Petitioner asserts that a particular code may be represented as matrices or as a Tanner graph, with those being two ways of describing the same thing, and contends that the proposed combination would have been understood by one of ordinary skill in the art to correspond to the claimed Tanner graph. *Id.* at 52–54.

Petitioner contends that, "[i]n Ping's $\mathbf{H^d}$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^d\, d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 31, 32. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H^d}$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H_d}$ has a column weight of *t* . . . .'" *Id.* at 41 (quoting Ex. 1003, 38). Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 41 (quoting Ex. 1102, 1449) (emphasis in original); *see also* Pet. Reply 3 (citing Ex. 1065 (Frey Decl.) ¶¶ 20–24) ("MacKay also teaches that codes with such parity check matrices, *i.e.*, matrices with uneven column weights, can outperform their regular counterparts.").

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." Pet. at 41. Petitioner proposes modifying Ping's $\mathbf{H^d}$ matrix (or outer coder), which Petitioner characterizes as regular, and contends that one of ordinary skill in the art would have made this modification to improve the performance of Ping's code. Pet. 41; Pet. Reply 4. Specifically, Petitioner maintains:

> It would have been straightforward for a person of ordinary skill to change Ping's generator $\mathbf{H}^d$ matrix such that not all columns had the same weight – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1002, p. 1451.) This change would result in some information bits contributing to more outer LDPC parity bits than others, and would have made Ping's outer LDPC code irregular. . . . Moreover, MacKay's teaching that the best performing LDPC codes are irregular would also have made this modification obvious (and desirable) to try. (Ex. 1002, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper….") (Ex. 1004, ¶116.)

Pet. 42. According to Petitioner, a person of ordinary skill would not have been motivated to modify $\mathbf{H}^p$ because "it has only a single form and because doing so would have complicated a simple encoder." Pet. Reply 8. Thus, Petitioner contends that the person of ordinary skill "who wanted to obtain the benefit of MacKay's irregularity in Ping would have had only one option—to incorporate MacKay's irregularity into $\mathbf{H}^d$." *Id.*

Petitioner further contends that, "even if Ping standing alone is not understood to teach, or render obvious, repeating information bits, doing so would have been obvious in view of Divsalar's explicit teaching of repeating bits." Pet. 44. Petitioner also argues that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references teachings. *Id.* at 44–45.

Thus, argues Petitioner, the combination of Ping, MacKay, and Divsalar teaches an irregular repeat accumulate code where message bits are repeated and at least two different subsets of message bits are repeated a different number of times. *Id.* at 52 (citing Ex. 1004 ¶ 139).

Lastly, Petitioner contends that Ping teaches the Tanner graph requirement of "[2] check nodes, randomly connected to the repeated message bits, [which] enforce constraints that determine the parity bits." *Id.* at 54–57. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d \, d_j$$

as teaching check nodes constraining the relationship between information bits and parity bits. *Id.* at 54–56. Petitioner further maintains that Ping, using Divsalar's repetition, teaches that the check nodes are randomly connected to repeated message bits. *Id.* at 56–57.

Patent Owner disputes, *inter alia*, Petitioner's rationale for combining Ping and MacKay—which underlies the overall combination of Ping, MacKay, and Divsalar—on a number of bases. *See* PO Resp. 17–18 (summarizing eight arguments regarding Petitioner's Ground 1), 26. Patent Owner argues that Ping's parity check matrix **H** is already irregular as defined by MacKay. *See id.* at 26–30. According to Patent Owner, "Ping's parity-check matrix has three different column weights (t, 2, and 1), and two different row weights ($kt/(n\text{-}k)$+1 and $kt/(n\text{-}k)$+2)." *Id.* at 28 (citing Ex. 2033, 231:11–14); *see also* Ex. 2004 ¶ 92 (same). As such, Patent Owner argues "Ping's parity-check matrix is actually even more 'irregular' than MacKay's irregular codes," so ordinarily skilled artisans "would not have been motivated by MacKay's teachings that irregular codes are an improvement over regular codes." PO Resp. 28–29 (citing Ex. 2004 ¶¶ 94, 95, and 97–99).

Patent Owner also highlights that Petitioner's proposed modifications relate only to a portion of Ping's parity check matrix **H**, namely, sub-matrix $\mathbf{H^d}$. *See id.* at 29–30; *see also* Ex. 2004 ¶ 96. Patent Owner argues "MacKay does not even *consider* modifying submatrices, much less teach that there may be benefits to try." PO Resp. 31. According to Patent Owner, "MacKay teaches that irregular parity-check matrices *as a whole* may define better codes than regular parity-check matrices *as a whole*—it does not teach any improvement from making a submatrix within a parity-check matrix irregular, or from using any other type of irregular matrix (e.g., irregular generator matrices)." *Id.* at 30. Patent Owner argues MacKay does not "suggest that *additional* irregularity should be applied to individual portions when the overall parity-check matrix is already irregular." *Id.* (citing Ex. 2004 ¶¶ 96–99) (footnote omitted).

Patent Owner further argues that Petitioner has not established that an ordinarily skilled artisan would have reasonably expected success from the proposed modification of Ping in light of MacKay. *See* PO Resp. 44–49. Patent Owner argues "the petition does not even attempt to analyze a reasonable expectation of success, and for that reason, it is incurably deficient." *Id.* at 44. As further evidence of the lack of anticipated success, Patent Owner emphasizes that constructing error-correction codes "was a highly unpredictable endeavor" that was subject to "extensive trial-and-error and experimentation to determine whether new codes led to an improvement." *Id.* at 4 (citing Ex. 2004 ¶ 46); *see also id.* at 45 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12).

We are persuaded by Patent Owner's arguments. We agree with Patent Owner (*see* PO Resp. 30–31 & n.7) that, although Petitioner may explain how to modify Ping's $\mathbf{H}^d$ sub-matrix in light of MacKay, it does not address why such an ordinarily skilled artisan would have done this. Nor does Petitioner establish that such an artisan reasonably would have expected success from the modification. Based on the entire trial record, we determine that Petitioner has not established a persuasive rationale for modifying Ping in light of MacKay as asserted by Petitioner. Petitioner's additional reliance on Divsalar does not remedy this fundamental flaw in the articulated combination. *See* Pet. 44 (relying on Divsalar for the teaching of repeating information bits if Ping is not understood to teach this aspect).

Petitioner's unpatentability contentions presuppose that an ordinarily skilled artisan would seek to modify a *sub-matrix* in Ping in light of MacKay. *See* Pet. Reply 7 ("Caltech's comparison of Ping's **H** matrix to MacKay's is improper. . . . The proper comparison is between Ping's $\mathbf{H}^d$ matrix . . . and MacKay's matrix."). Yet even if MacKay touts improvements from irregularity in a parity check matrix (e.g., Ping's matrix **H**), MacKay does not suggest that these improvements would have been applicable to *portions* of a parity check matrix (e.g., Ping's sub-matrix $\mathbf{H}^d$). To reach its proposed modification, Petitioner characterizes Ping's sub-matrix $\mathbf{H}^d$ as a generator matrix (or "outer coder") and Ping's sub-matrix $\mathbf{H}^p$ as merely an accumulator (or "inner coder"). Pet. 27, 42; Pet. Reply 10–13. We agree with Patent Owner (*see* PO Resp. 37), however, that Petitioner does not explain adequately why labeling sub-matrix $\mathbf{H}^d$ as a generator matrix supports the proposed modification of $\mathbf{H}^d$ based on MacKay. Indeed, this label does not explain why an ordinarily skilled artisan considering

MacKay would have chosen to modify $\mathbf{H}^d$ or any other portion of parity check matrix **H**.

Petitioner's further contentions also are not persuasive. Specifically, Petitioner contends $\mathbf{H}^p$ is an accumulator with only a single, fixed form, so an ordinarily skilled artisan would not have been motivated to modify $\mathbf{H}^p$ because "doing so would have complicated a simple encoder." Pet. Reply 7–8, 14. Yet this rationalization belies the fact that Ping also specifically defines a structure for sub-matrix $\mathbf{H}^d$, which simplifies a portion of the parity check matrix. According to Dr. Mitzenmacher, "the constraints on $\mathbf{H}^d$, including its regularity, were a deliberate design decision that contributes to the improved performance of Ping's code over fully random LDPC codes—it is a fundamental part of its code." Ex. 2004 ¶ 104. Thus, choosing to modify *any* portion of Ping's matrix would have broken constraints in Ping that were intended to simplify encoding. *See* Ex. 1003, 38 (Ping describing the disclosed approach as a "new method [that] can achieve essentially the same performance as the standard LDPC encoding method with significantly reduced complexity"). This is a strong indication that an ordinarily skilled artisan would not have been motivated to reach within Ping's parity check matrix **H** and modify a sub-matrix.

We also agree with Patent Owner that Ping's parity check matrix **H** is already "irregular," which undermines Petitioner's stated motivation for modifying Ping in view of MacKay. *See* PO Resp. 26–31. Citing Dr. Mitzenmacher, Patent Owner establishes that Ping's matrix **H** has three different column weights (t, 2, and 1). *Id.* at 27–28; Ex. 2004 ¶¶ 91–92; *see also* Ex. 2033, 231:11–14 (Dr. Davis acknowledging that Ping's parity check matrix **H** has "different weights for the columns"). We accept this as evidence of "irregularity" based on Petitioner's own acknowledgment that "irregularity" is associated with "uneven column weights." *See* Pet. Reply 13. Petitioner does not contest that Ping's parity check matrix **H** is irregular; rather, Petitioner contends that the appropriate comparison is between MacKay's parity check matrix and Ping's sub-matrix $\mathbf{H}^d$. Pet. Reply 7. But MacKay is silent on the concept of sub-matrices, so Petitioner's association of MacKay's teaching with sub-matrix $\mathbf{H}^d$ is not apt. Instead, we agree with Patent Owner that "MacKay's teachings are only applicable to full parity check matrices." PO Resp. 17. Thus, the record does not establish that an ordinarily skilled artisan would have sought to add irregularity to Ping's parity check matrix **H**—or additional irregularity to a sub-matrix of **H**, such as $\mathbf{H}^d$—because **H** itself is already irregular.

Finally, we agree with Patent Owner that the Petition is silent on whether a person of ordinary skill in the art would have expected success in combining MacKay with Ping. Although Petitioner cites an alleged "straightforward modification of Ping's $\mathbf{H}^d$ matrix" at page 42 of the Petition as supporting the expectation of success (Pet. Reply 14), the cited passage only describes the proposed modification, rather than addressing whether an ordinarily skilled artisan would have anticipated success from the modification. *See* Pet. 42. In addition, Petitioner's argument that an ordinarily skilled artisan "would have needed no more specificity to attempt to use MacKay's irregularity in Ping" (Pet. Reply 14) only underscores the lack of evidence in the Petition regarding anticipated success.

Perhaps sensing this deficiency in the Petition, Petitioner introduces new testimony and a new simulation from Dr. Frey with its Reply in which Dr. Frey allegedly "demonstrate[s] the ease with which a [person of ordinary skill in the art] could have added MacKay's irregularity to Ping." Ex. 1065 ¶ 42. According to Petitioner, the results of the simulation "outperform Ping's original code" and "confirm that a [person of ordinary skill in the art] would have been motivated to use MacKay's uneven column weights in Ping's $\mathbf{H}^d$ matrix, and . . . would have had a reasonable expectation of success when doing so." Pet. Reply 16–17. Yet, even if we were to deem the testimony and simulation to be within the proper scope of a reply brief,[8] they do not support a reasonable expectation of success *at the time of the invention*. We agree with Patent Owner that "[i]t is irrelevant what Dr. Frey claims he could do in the year 2018 when armed with Caltech's disclosures, [the named-inventor's] original coding work, contemporary resources (e.g., Matlab), and some 18 years of post-filing date knowledge." PO Sur-Reply 7. Because this evidence is not tied to the state of the art at the time of the invention, it is not probative of anticipated success. *See Millennium Pharm., Inc. v. Sandoz Inc.*, 862 F.3d 1356, 1367 (Fed. Cir. 2017) (quoting *Interconnect Planning Corp. v. Feil*, 774 F.2d 1132, 1138 (Fed. Cir. 1985)) ("Those charged with determining compliance with 35 U.S.C. § 103 are required to place themselves in the minds of those of ordinary skill in the relevant art *at the time the invention was made*, to determine whether that which is now plainly at hand would have been obvious at such earlier time." (emphasis added)).

Furthermore, as part of our obviousness analysis, we are charged to consider "the scope and content of the prior art." *See Graham*, 383 U.S.

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[8] We need not reach this issue, because we do not rely on this evidence in a manner adverse to Patent Owner. *See also infra* § II.F. (dismissing Patent Owner's Motion to Exclude as moot on the same basis).

at 17–18. One important aspect of the art in this case is the relative unpredictability of developing error-correction codes. *See* PO Resp. 45 (citing Ex. 2004 ¶¶ 126–128; Ex. 2033, 256:21–257:12) ("New codes appeared from unexpected sources, and developing the precise parameters that could lead to incremental improvements often took a significant amount of time and experimentation."). In its Reply, Petitioner embraces the notion of unpredictability as supporting its combination; Petitioner contends that "rigorous mathematical analysis of codes is difficult, and, as a result, [persons of ordinary skill in the art] routinely develop codes by experimentation." Pet. Reply 14. Petitioner further contends that "running experimental tests on a version of Ping that incorporated MacKay's irregularity would have been routine[,] . . . [and] the modifications suggested by MacKay would have been straightforward and would have taken very little time to implement." *Id.*

Yet we do not agree with Petitioner that the need to run experiments in an unpredictable field, such as error-correction coding, indicates anything about whether such experiments ultimately would have been successful at the time of the invention. Importantly, "[u]npredictability of results equates more with nonobviousness rather than obviousness, whereas that which is predictable is more likely to be obvious." *Honeywell Int'l Inc. v. Mexichem Amanco Holding S.A.*, 865 F.3d 1348, 1356 (Fed. Cir. 2017). In the absence of any argument rooted in the Petition directing us to evidence that substantiates a reasonable expectation of success, Petitioner's reliance on a known need for experimentation is not sufficient to support its obviousness rationale.[9] *See Arctic Cat Inc. v. Bombardier Recreational Prod. Inc.*, 876 F.3d 1350, 1360–61 (Fed. Cir. 2017) ("[W]here a party argues a skilled artisan would have been motivated to combine references, it must show the artisan would have had a reasonable expectation of success from doing so." (internal quotation omitted)).

For these reasons, we are not persuaded that an ordinarily skilled artisan would have been motivated to combine the teachings of Ping and MacKay in the manner suggested by Petitioner. Petitioner's reliance on Divsalar's teachings in the proposed combination does not remedy this underlying flaw. Thus, we determine Petitioner has not shown by a preponderance of the evidence that claim 11 would have been obvious over the combination of Ping, MacKay, and Divsalar.

Petitioner relies on the same deficient rationale for combining Ping and MacKay with respect to its analysis for dependent claims 12 and 14–16. *See, e.g.*, Pet. 60–61, 63–64. Thus, we also determine Petitioner has not shown by a preponderance of the evidence that claims 12 and 14–16 would have been obvious over the combination of Ping, MacKay, and Divsalar.

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[9] Notably, Petitioner does not contend that its proposed combination should be analyzed under obvious-to-try case law. Tr. 15:24–16:4 (Petitioner acknowledging that it was not putting forth an obvious-to-try argument). Nor could Petitioner, because Petitioner does not develop an obvious-to-try theory. Specifically, Petitioner does not establish that the prior art directs which parameters to try and/or guides an inventor toward a particular solution. *See Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1347 (Fed. Cir. 2009).

E. The Alleged Obviousness of Claim 13 over Ping, MacKay, Divsalar, and Luby97

Dependent claim 13 specifies that the encoder comprises a low density generator matrix (LDGM) coder and an accumulator. Ex. 1001, 9:38–45. The LDGM coder is "configured to perform an irregular repeat on message bits having a first sequence in a source data stream." *Id.* at 9:39–41. Luby97 (Ex. 1008) describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1008, 150 (Abstr.). Luby97 also describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted). Petitioner relies on Luby97 for the teachings of receiving message bits in a stream (Pet. 66, 69), but does not rely on Luby97 in a manner that cures the defects of the Ping-MacKay-Divsalar combination discussed above (*see* Pet. 65 ("As explained above for Ground 1, one of ordinary skill would have been motivated to use MacKay's irregularity and Divsalar's repetition in Ping."); *id.* at 67 ("As explained above, the combination of Ping in view of MacKay and Divsalar discloses every claim limitation of claim 11.").

Accordingly, we determine Petitioner has not shown by a preponderance of the evidence that claim 13 would have been obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

F. Patent Owner's Motion to Exclude

Patent Owner moves to exclude Exhibits 1006, 1018, 1019, 1024, 1029–1049, 1057–1061, 1065, 1067, 1068, 1071, 1072 and portions of Exhibits 2038 and 2039. Paper 52, 1. Patent Owner's motion is dismissed as moot with respect to these exhibits, as we do not rely on them in a manner adverse to Patent Owner.

G. Patent Owner's Motion for Sanctions

Patent Owner requests sanctions against Petitioner for allegedly failing to stay within the proper scope of cross-examination during the deposition of Dr. Mitzenmacher and Dr. Divsalar. Paper 42, 1.[10] Specifically, Patent Owner details questioning of Dr. Mitzenmacher that allegedly "ventured into various topics beyond the scope of the witness' direct testimony." *Id.* at 7–9. For example, Patent Owner cites "extensive questioning regarding Tanner graphs and figures newly created by Petitioner's lawyers, but absent from any petition materials or the witness' direct testimony." *Id.* at 8. Similarly, Patent Owner asserts that Dr. Divsalar was questioned regarding subject matter not discussed in his declaration including the Allerton Conference, Tanner graphs, and certain references. *Id.* at 3–7. As sanctions, Patent Owner asks us to: (1) strike the out-of-scope testimony elicited by Petitioner; (2) hold the direct testimony of Dr. Mitzenmacher and Dr. Divsalar to be facts established in this proceeding; and (3) impose "reasonable compensatory expenses, including attorney fees, for costs reasonably related to excessive questioning and deposition time." *Id.* at 9–10.

Petitioner contends that "each question posed by Petitioner during Dr. Mitzenmacher's deposition pertained directly to topics and opinions in his declaration." Paper 47, 5. Regarding the Tanner graphs and figures,

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[10] Although Patent Owner cites primarily to Exhibit 1064 as the transcript of Dr. Divsalar's deposition, the pertinent exhibit in this case is Exhibit 2039. *See* Paper 42, 4.

Petitioner contends these were properly served upon Petitioner at Dr. Mitzenmacher's deposition in accordance with 37 C.F.R. § 42.53(f)(3). *Id.* at 6. According to Petitioner, Patent Owner's proposed sanctions are unwarranted, particularly because Patent Owner suffered no harm. *Id.* at 7–8.

The "Board may impose a sanction against a party for misconduct." 37 C.F.R. § 42.12(a); *see also* 35 U.S.C. § 316(a)(6) (requiring regulations prescribing sanctions). As the moving party, Patent Owner has the burden to persuade the Board that sanctions are warranted. *See* 37 C.F.R. § 42.20(c). In general, a motion for sanctions should address three factors: (i) whether a party has performed conduct that warrants sanctions; (ii) whether the moving party has suffered harm from that conduct; and (iii) whether the sanctions requested are proportionate to the harm suffered by the moving party. *See Square, Inc. v. Think Comput. Corp.*, Case CBM2014-00159, slip op. at 2 (PTAB Nov. 27, 2015) (Paper 48) (citing *Ecclesiastes 9:10-11-12, Inc. v. LMC Holding Co.*, 497 F.3d 1135, 1143 (10th Cir. 2007)).

Having reviewed the relevant portions of Dr. Mitzenmacher's deposition, we agree with Petitioner that sanctions are not warranted. Petitioner's attempts to elicit testimony regarding the Tanner graphs and figures, while inartful, did not rise to the level of sanctionable conduct because they were reasonably related to Dr. Mitzenmacher's direct testimony.

As to Dr. Divsalar, Patent Owner characterizes his direct testimony (Ex. 2031) as merely taking the form of "a short declaration addressing only a few discrete points relating specifically to the Divsalar reference." Paper 42, 3. Patent Owner contends Petitioner's questions about the

Allerton Conference, Tanner Graphs, and certain other references went beyond the "limited scope of Dr. Divsalar's 16-page declaration." *Id.* at 3–7.

Petitioner cites certain direct testimony from Dr. Divsalar regarding the perspective of a person of ordinary skill in the art, Tanner graphs, and certain "contemporaneous literature" and contends that it was permissible to question Dr. Divsalar at the deposition about the foundation and validity of his opinions on these topics. Paper 47, 3–4 (quoting Ex. 2031 ¶ 10 and citing Ex. 2031 ¶¶ 9–11, 26, 28–30, and 33–36). Petitioner further contends that "in his declaration, Dr. Divsalar discussed having submitted a paper 'in connection with the Allerton conference in 1998' [and] Petitioner thus properly asked questions about what 'in connection with the Allerton conference' means." Paper 47, 3 (citing Ex. 2031 ¶ 19).

We again agree with Petitioner that sanctions concerning the deposition of Dr. Divsalar are not warranted. In fact, Patent Owner acknowledges that Dr. Divsalar offered opinion testimony going to the heart of the dispute in this case. Paper 42, 3. In that respect, Patent Owner states:

> Dr. Divsalar expressed his view that modifying an RA [repeat-accumulate] code to include irregular repetition of information bits would not make sense on the basis that it would add unnecessary difficulty and complexity at odds with the stated objective in the paper, with no expectation of a corresponding benefit. [Ex. 2031 (Divsalar Declaration)] at ¶¶ 33-36. Dr. Divsalar was also asked to address the hypothetical modification suggested by Petitioner, which he explained was nonsensical and at odds with a key conclusion in the Divsalar paper. *Id.* at ¶ 37.

Id.; *see also* Ex. 2031 ¶ 9 (Dr. Divsalar, under the heading "Summary of Opinions," testifying: "I do not believe it would have been trivial or obvious to modify RA codes by making them 'irregular' in order to arrive at IRA codes, nor would a person of ordinary skill in the art be motivated to make such a modification."). In light of this, we are persuaded by Petitioner that its questions were reasonably related to Dr. Divsalar's direct testimony—including the opinion testimony—and were not so far afield as to warrant sanctions.

Furthermore, we agree with Petitioner that Patent Owner suffered no harm with respect to the depositions of Dr. Mitzenmacher and Dr. Divsalar, particularly in light of our disposition of the challenged claims. For these reasons, we deny Patent Owner's motion for sanctions.

III. CONCLUSION

Petitioner has *not* demonstrated by a preponderance of the evidence that claims 11, 12, and 14–16 of the '032 patent are unpatentable as obvious over Ping, MacKay, and Divsalar, and has *not* demonstrated by a preponderance of the evidence that claim 13 is unpatentable as obvious over the combination of Ping, MacKay, Divsalar, and Luby97.

IV. ORDER

For the foregoing reasons, it is

ORDERED that claims 11–16 of the '032 patent have *not* been proven to be unpatentable;

FURTHER ORDERED that Patent Owner's Motion to Exclude is *dismissed as moot*;

FURTHER ORDERED that Patent Owner's Motion for Sanctions is *denied*; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Paper 14
Entered: August 21, 2017

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00728
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1201). Paper 5 ("Pet."). The Petition challenges the patentability of claims 18–23 of the '032 patent on the ground of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp.").

An *inter partes* review may not be instituted "unless . . . the information presented in the petition . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a). Having considered the arguments and evidence presented by Petitioner and Patent Owner, we determine that Petitioner has demonstrated a reasonable likelihood that it would prevail in establishing the unpatentability of challenged claims 18–23 of the '032 patent.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211, IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00700, and IPR2017-00701. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

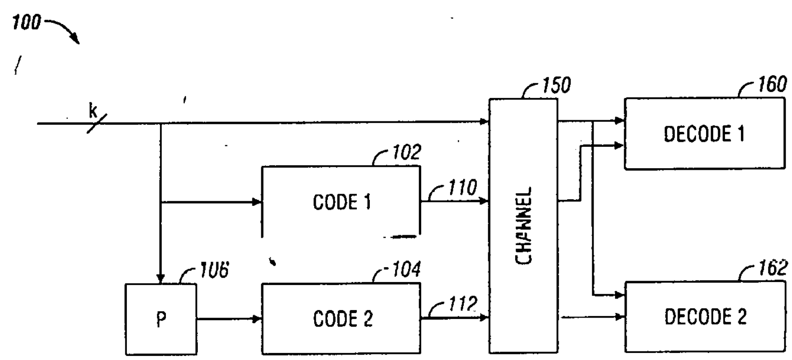

Figure 1 is a schematic diagram of a prior "turbo code" system. Ex. 1201, 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with respect to Figure 2, reproduced below.

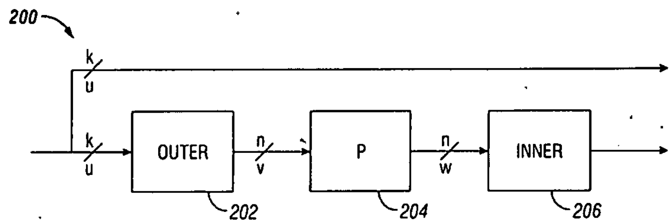

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

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[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

Id. at 2:36–65. In an embodiment, the second ("inner") encoder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

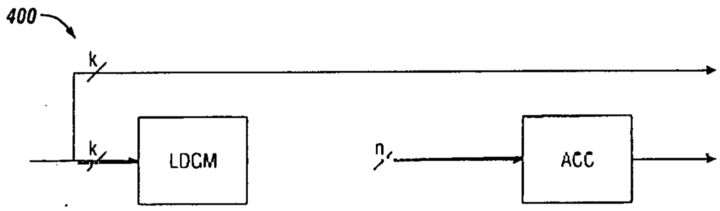


Figure 4 shows an alternative embodiment in which the outer encoder is a low-density gencrator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

"The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code." *Id.* at 3:33–35. Figure 3, shown below, depicts such a Tanner graph.

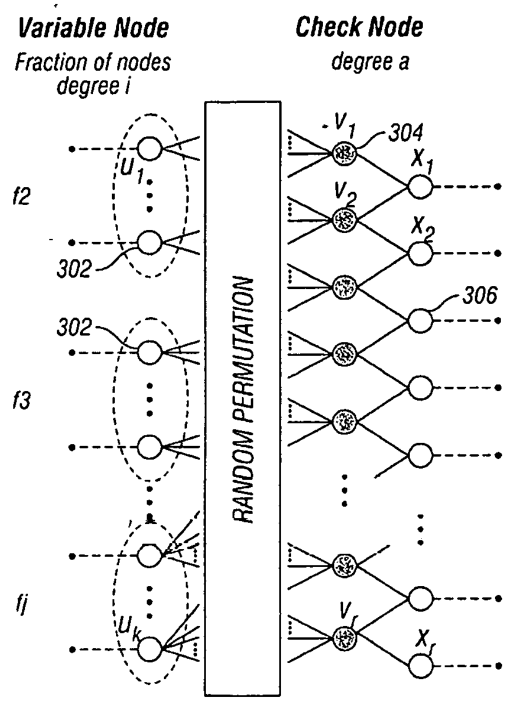


Figure 3 is described as a Tanner graph for an irregular repeat and accumulate (IRA) coder. *Id.* at 2:20–21. The left-most column of nodes, information nodes 302 (the open circles), are variable nodes that receive information bits. The column of nodes (the filled circles) just to the right of the "RANDOM PERMUTATION" block are check nodes v indicated by reference numeral 304. An information bit node connected to two check nodes represents a repeat of 2. An information node connected to three check nodes represents a repeat of 3. The nodes (the open circles) in the right-most column are parity bit nodes x, referenced by 306. As shown by the edges[2] of the Tanner graph, each parity bit is a function of its previous parity bit and is also a function of information bits (edges connect through

[2] We understand that "edges" are the straight lines that connect one node to another node of a Tanner graph. *See* Ex. 1201, 3:53–54.

check nodes and random permutation to information bit nodes). Ex. 1201, 3:34–55; *see also* Ex. 1204 ¶ 110 (discussing the relationship between parity bits in the context of the claimed Tanner graph and the '032 patent's specification).

D. Illustrative Claim

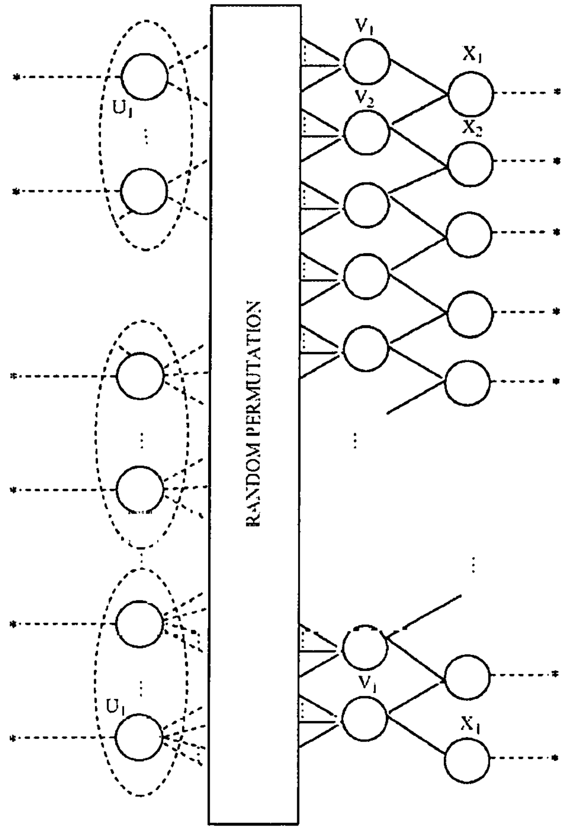
Of the challenged claims of the '032 patent, claim 18 is the only independent claim. The remaining challenged claims depend directly from claim 18. Claim 18, reproduced below as originally issued and before issuance of the Certificate of Correction and with paragraphing added, is illustrative.

18. A devicc comprising:

a message passing decoder configured to decode a received data stream that includes a collection of parity bits,

the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes,

wherein the message passing decoder is configured to decode the received data stream that has been encoded in accordance with the following Tanner graph:



Ex. 1201, 9:57–10:42. A Certificate of Correction for the ’032 patent replaced the labels V_1, U_1, and X_1 from the lower portion of the Tanner graph in claim 18 with V_r, U_k, and X_r, respectively. *See id.* at Certificate of Correction.

E. Applied References

Reference	Exhibit No.
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 (“MacKay”)	Ex. 1202
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 (“Ping”)	Ex. 1203

Reference	**Exhibit No.**
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")	Ex. 1208
D. Divsalar et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar").	Ex. 1217

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1204), in support of its arguments. Patent Owner relies upon the Declaration of Dr. R. Michael Tanner, dated May 8, 2017 (Ex. 2001), in support of its arguments.

F. Asserted Ground of Unpatentability

Petitioner asserts the following ground of unpatentability:

References	**Basis**	**Claims**
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	18–23

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary

skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Tanner graph

In a prior decision regarding the '032 patent, the Board construed the Tanner graph of claim 18 as follows:

> [1] a graph representing an [irregular[3] repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times, and
>
> [2] check nodes, randomly connected to the repeated message bits, enforce constraints that determine the parity bits[, and] . . .
>
> [3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph.

IPR2015-00060, Paper 18, 12–14 (numbering and paragraphing added for clarity).

Petitioner supports the application of the same construction here. Pet. 28–29. Patent Owner contends "no construction is necessary beyond observing that in the above Tanner graph, different subsets of message bits are repeated a different number of times." Prelim. Resp. 5. Patent Owner's position corresponds to only the first of the three requirements in the

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[3] The Board, in the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 27–28 (advocating the adoption of that construction in this case); Prelim. Resp. 5–6 (asserting that the "irregularity" of the Tanner graph of claim 18 means "different subsets of message bits are repeated a different number of times").

Board's prior construction. Patent Owner's proposed construction does not go far enough as it does not address the other limitations apparent from the Tanner Graph.

We adopt our prior construction for purposes of this decision.

B. The Alleged Obviousness of Claims 18–23 Over Ping, MacKay, Divsalar, and Luby97

Petitioner alleges that claims 18–23 of the '032 patent would have been obvious over Ping, MacKay, Divsalar, and Luby97. Pet. 41–73. Patent Owner opposes. Prelim. Resp. 6–21.

Petitioner asserts that Ping discloses much of the subject matter of independent claim 18, but maintains that Ping's outer coder is regular. *See* Pet. 41–42; *see also id.* at 58. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 41, 43, relies on Divsalar for the teaching of repetition "if Ping standing alone is not understood to teach, or render obvious, repeating information bits," *id.* at 46, and relies on Luby97 for the teaching of receiving a source data stream, *id.* at 48. Additionally, Petitioner relies on Divsalar, MacKay, and Luby97 for the teaching that message passing decoders were well-known in the art. *See* Pet. 20, 51–52.

1. Ping (Ex. 1203)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1203, 38. In this approach, "[a]n LDPC code is defined from a randomly generated parity check matrix **H**." *Id.* The size of matrix **H** is $(n-k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]^t$, where **p** and **d** contain the parity and information bits, respectively." *Id.*

Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^\mathbf{p}, \mathbf{H}^\mathbf{d}]$." *Id.* $\mathbf{H}^\mathbf{p}$ is defined as follows:

$$\mathbf{H}^\mathbf{p} = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^\mathbf{d}$ is created such that it "has a column weight of t and a row weight of $kt/(n-k)$ (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H}^\mathbf{d} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1204 ¶ 74.

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h^d_{1j}\, d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h^d_{ij}\, d_j \pmod 2$$

Ex. 1203, 38 (equation (4)).[4]

[4] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1204 ¶ 185.

2. MacKay (Ex. 1202)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1202, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1217)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1204 ¶ 89 (quoting Ex. 1217, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

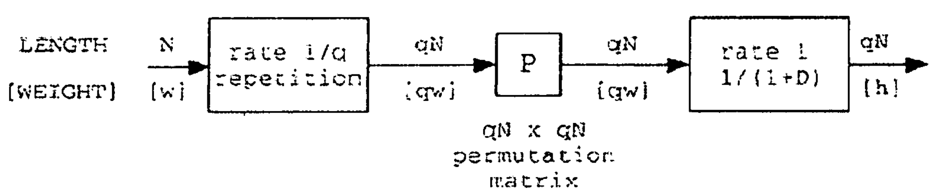

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1217, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. Luby97 (Ex. 1208)

Luby97 describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1208, 150 (Abstr.). Luby97 describes receiving data to be encoded in a stream of data symbols, such as bits, where the "*stream of data symbols* [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted).

5. The Alleged Obviousness of Independent Claim 18

For reasons discussed below, Petitioner has shown a reasonable likelihood that it would prevail in establishing unpatentability of independent claim 18 as obvious over Ping, MacKay, Divsalar, and Luby97.

As discussed above in the context of claim construction, independent claim 18 contains a Tanner graph having at least three elements. Petitioner, in articulating its obviousness challenge of claim 18, relies on the testimony of Dr. Davis and maps the teachings of the prior art against those three elements as well as the express recitations of the claim. Pet. 50–64.

Claim 18 recites "a message passing decoder configured to decode a received data stream that includes a collection of parity bits." Petitioner maintains that Divsalar teaches an encoding device and teaches message passing decoding. *Id.* at 51. Petitioner maintains that MacKay and Luby97 also teach forms of message passing decoding. *Id.* at 51–52. Petitioner reasons that, in light of these teachings and "the fact that one of ordinary skill would understand message passing algorithms to be a standard technique for decoding linear error-correcting codes," it would have been obvious to use a message passing decoder to decode the codes of Ping. *Id.* at 52 (citing Ex. 1204 ¶ 194); *see also id.* at 20 (citing Ex. 1204 ¶ 62)

(Petitioner asserting that a message passing decoder was a well-known type of decoder). Petitioner points to Luby97's teaching of receiving, in streams, data to be encoded and asserts that the sequence of blocks of symbols transmitted by the encoder of Luby97 constitutes a stream. *Id.* at 48–49. Petitioner asserts that it would have been obvious to use, for Ping's codes, a decoder that can receive encoded bits in a stream where the encoder that encoded those bits outputs them in a stream. *Id.* at 49–50, 52–53; *see* Ex. 1204 ¶¶ 195–200.

Claim 18 next recites "the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes." Relying, *inter alia*, on the testimony of Dr. Davis, Petitioner contends that such a parallel operation would have been obvious because message passing decoding works by passing messages back and forth between variable nodes and check nodes according to a Tanner graph. Pet. 23–24, 53–54; Ex. 1204 ¶¶ 68, 201–203.

As for the Tanner graph of claim 18, Petitioner addresses the three elements but in an order different than that listed above in the claim construction section. For the element "[3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph," Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. Pet. at 30, 55–57; *see also id.* at 58 (maintaining that Ping's inner coder is an accumulator).

The next element of the Tanner graph addressed by Petitioner is "[1] a graph representing an [irregular repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times." Pet. 57–61. Petitioner asserts that a particular code may be represented as matrices or as a Tanner graph, with those being two ways of describing the same thing, and contends that the proposed combination would have been understood by one of ordinary skill in the art to correspond to the claimed Tanner graph. *Id.* at 59–61.

Petitioner contends that, "[i]n Ping's $\mathbf{H}^d$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\Sigma_j h_{ij}^d d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 34, 35. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$ contains the same number of 1s – exactly 't' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}^d$ has a column weight of t . . . .'" *Id.* at 43 (quoting Ex. 1203, 38). Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 44 (quoting Ex. 1202, 1449) (emphasis in original).

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." *Id.* at 43. Petitioner maintains:

> It would have been straightforward for a person of ordinary skill to change Ping's generator $\mathbf{H}^d$ matrix such that not all columns had the same weight – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1202, p. 1451.) This change would result in some information bits contributing to more outer LDPC parity bits than others, and would have made Ping's outer LDPC code irregular. . . . Moreover, MacKay's teaching that the best performing LDPC codes are irregular would also have made this modification obvious (and desirable) to try. (Ex. 1202, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper....") (Ex. 1204, ¶116.)

Pet. 44. Petitioner notes that Ping credits a reference written by the author of MacKay as having creating "revived interest in the low density parity check (LDPC) codes originally introduced in 1962 by Gallager." *Id.* at 42 (quoting Ex. 1203, 38).

Petitioner further contends that, "even if Ping standing alone is not understood to teach, or render obvious, repeating information bits, doing so would have been obvious in view of Divsalar's explicit teaching of repeating bits." *Id.* at 46. Petitioner also argues that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references teachings. *Id.* at 47–48.

Thus, argues Petitioner, the combination of Ping, MacKay, and Divsalar teaches an irregular repeat accumulate code where message bits are repeated and at least two different subsets of message bits are repeated a different number of times. *Id.* at 59 (citing Ex. 1204 ¶ 139).

Lastly, Petitioner contends that Ping teaches the Tanner graph requirement of "[2] check nodes, randomly connected to the repeated message bits, [which] enforce constraints that determine the parity bits." *Id.* at 61–63. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d d_j$$

as teaching check nodes constraining the relationship between information bits and parity bits. *Id.* at 61–63. Petitioner further maintains that Ping, using Divsalar's repetition, teaches that the check nodes are randomly connected to repeated message bits. *Id.* at 63–64.

We now turn to Patent Owner's arguments. Patent Owner first argues that MacKay fails to disclose the irregularity of claim 18, namely irregularity in the number of message (information) bits repeated in a coding operation. *See* Prelim. Resp. 7–8. Specifically, Patent Owner asserts that Petitioner fails to identify any "instance of nonuniform weight per column among information bits." *Id.* at 8. Petitioner's articulated ground, however, is based at least on the application of MacKay's irregularity into Ping's generator $\mathbf{H}^{\mathbf{d}}$ matrix making the outer LDPC code irregular. Pet. 43–44 (citing, *inter alia*, Ex. 1204 ¶¶ 114–116); *see also id.* at 37 (Petitioner arguing "MacKay's nonuniform weight per column ensures that some information bits contribute to more parity bits than others."). Patent Owner's argument that MacKay standing alone lacks the irregularity of claim 18 does not persuade us that Petitioner incorrectly asserts that the combination of references would result in that subject matter.

Patent Owner also argues "the petition incorrectly addresses only a portion of Ping's parity check matrix $\mathbf{H}^{\mathbf{d}}$, rather than the parity check matrix **H**." Prelim. Resp. 9. Accordingly, Patent Owner argues "Ping's parity check matrix **H** already includes nonuniform weight per column—*i.e.*, the 'irregularity' of MacKay." *Id.* Based on Patent Owner's interpretation of the structure of parity check matrix **H** as being [$\mathbf{H}^p$, $\mathbf{H}^d$], and Patent Owner's allegation regarding $\mathbf{H}^d$ that "[t]he only value of t disclosed by Ping is 4" (Prelim. Resp. 9–10), Patent Owner contends that matrix **H** has column weights as shown in a diagram from page 11 of the Preliminary Response, which is reproduced below.

$$H = \begin{array}{c} \left(\begin{array}{cccc|c} 1 & & & 0 & \\ 1 & 1 & & & \\ & \ddots & \ddots & & H^d \\ 0 & & 1 & 1 & \end{array}\right) \\ \begin{array}{ccc} \underbrace{\qquad\qquad}_{\substack{(n\text{-}k\text{-}1) \\ \text{Weight 2}}} & \underbrace{\quad}_{\substack{(1) \\ \text{Weight 1}}} & \underbrace{\qquad\qquad}_{\substack{(k) \\ \text{Weight 4}}} \end{array} \end{array}$$

Id. at 11, 14. Patent Owner concludes "Ping discloses a parity check matrix with different numbers of ones per column—*i.e.*, different column weights [weight 2, weight 1, and weight $t = 4$]." *Id.* at 11. Thus, Patent Owner argues that there would be no reason to modify Ping to include "irregularity" when Ping "already incorporates the irregularity of MacKay." *Id.* at 15.

Patent Owner's argument does not address directly Petitioner's articulation of the ground. Petitioner does not utilize Ping's entire parity check matrix **H** in its analysis; rather, Petitioner notes that the $\mathbf{H}^d$ matrix is part of Ping's "parity check" matrix **H**. Pet. 45. Petitioner maintains that, "[b]ecause Ping's Equation (4) uses the $\mathbf{H}^d$ matrix to produce parity bits from information bits, it is a 'generator matrix.'" *Id.* (citing Ex. 1203, 38). Petitioner asserts that "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}_d$ has a column weight of *t* . . . .'" *Id.* at 43 (quoting Ex. 1203, 38). As such, we do not agree that matrix $\mathbf{H}^d$ from Ping, as cited by Petitioner and as forming the basis of the articulated ground, already includes "irregularity" in the manner suggested by Patent Owner. We understand Petitioner's combination as relating to the specific application of MacKay's "non-uniform column weight" to Ping's matrix $\mathbf{H}^d$ (*see* Pet. 44–46), not a generic application of "irregularity" to Ping's teachings as a whole. Accordingly, Patent Owner's arguments do not undermine Petitioner's stated reason to combine MacKay with Ping.

Patent Owner additionally argues "nothing in the reference [MacKay] teaches such a specific modification" of only Ping's "submatrix $\mathbf{H}^d$" and that "MacKay says nothing about modifying a specific portion of a parity check matrix to provide a subset of columns with nonuniform column weights, let alone doing so for a portion specifically corresponding to information bits." Prelim. Resp. 11; *see also id.* 14–15. Nevertheless, Petitioner shows persuasively, on this record, that MacKay "teaches how to make LDPC matrices 'irregular' by implementing a '*nonuniform* weight per column.'" Pet. 44 (quoting Ex. 1202, 1449). Petitioner cites a specific example in MacKay where a matrix "has columns of weight 9 and of weight 3." *Id.* at 43–44 (quoting Ex. 1202, 1451 and citing Ex. 1204 ¶ 115). In light of this evidence, we agree that an ordinarily skilled artisan would have known how to add nonuniform column weights from MacKay to the uniform column weights in Ping's matrix $\mathbf{H}^d$.

Having considered Petitioner's and Patent Owner's arguments and evidence, we determine Petitioner has established sufficiently at this stage that Ping, MacKay, Divsalar, and Luby97 teach every limitation of claim 18. Petitioner also has provided, on the current record, a sufficient rationale for its proposed combination. Thus, for the foregoing reasons, Petitioner demonstrates a reasonable likelihood of prevailing in showing that claim 18 would have been obvious over Ping, MacKay, Divsalar, and Luby97.

6. The Alleged Obviousness of Dependent Claims 19–23 Over Ping, MacKay, Divsalar, and Luby97

The remaining claims subject to Petitioner's ground, claims 19–23, each depend directly from independent claim 18.

Patent Owner specifically addresses dependent claim 20, Prelim. Resp. 18–21, which recites "the message passing decoder is configured to decode the received data stream as if a number of inputs into nodes v_i was not constant," Ex. 1201, 10:46–48. Petitioner relies on MacKay for the teaching of this limitation, equating nonuniform row weight with the "not constant" aspect of the claim. Pet. 66–70. Petitioner's analysis, including the reasoning to combine the references' teachings, is similar to that regarding claim 18 and the application of MacKay's teaching of "nonuniform column weight" in the combination of Ping, MacKay, and Divsalar and specifically to make Ping's matrix $\mathbf{H}^{d}$ nonuniform. *See id.* at 68. Patent Owner again argues that Petitioner's reference to only Ping's matrix $\mathbf{H}^{d}$, rather than **H**, is flawed. Prelim. Resp. 20 ("Petitioner's attempt to apply MacKay's 'nonuniform row weights' to $\mathbf{H}^{d}$ (*see* Pet. at 68-70) repeats the errors discussed above in Section III.A.2, and so should be disregarded for similar reasons."). Patent Owner also argues that Petitioner fails to provide a reason to modify the references with regard to this claim but Patent Owner does not address adequately Petitioner's statements on pages 68–69 of the Petition. Prelim. Resp. 21. We again do not find Patent Owner's arguments persuasive, and determine, on the record before us, that

Petitioner has demonstrated a reasonable likelihood of prevailing in showing that claim 20 would have been obvious over Ping, MacKay, Divsalar, and Luby97.

Patent Owner does not address separately Petitioner's explanations and supporting evidence regarding claims 19 and 21–23. *See* Prelim. Resp. 21. Based on the record before us, Petitioner has demonstrated a reasonable likelihood that it would prevail on its assertion that claims 19 and 21–23 would have been unpatentable over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 64–65, 70–73.

III. CONCLUSION

Petitioner has demonstrated that there is a reasonable likelihood of establishing the unpatentability of claims 18–23 of the '032 patent.

IV. ORDER

For the foregoing reasons, it is

ORDERED that, pursuant to 35 U.S.C. § 314, *inter partes* review is instituted as to claims 18–23 of the '032 patent on the following ground of unpatentability:

Claims 18–23 as obvious over Ping, MacKay, Divsalar, and Luby97 pursuant to 35 U.S.C. § 103(a);

FURTHER ORDERED that *inter partes* review is commenced on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial; and

FURTHER ORDERED that the trial is limited to the grounds of unpatentability listed above, and no other grounds of unpatentability are authorized for *inter partes* review.

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Paper: 14
Entered: August 8, 2017

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00701
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1101). Paper 3 ("Pet."). The Petition challenges the patentability of claims 1–10 of the '032 patent on the ground of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp.").

An *inter partes* review may not be instituted "unless . . . the information presented in the petition . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a). Having considered the arguments and evidence presented by Petitioner and Patent Owner, we determine that Petitioner has demonstrated a reasonable likelihood that it would prevail in establishing the unpatentability of challenged claims 1 and 4–10 of the '032 patent, and that Petitioner has not demonstrated a reasonable likelihood that it would prevail in establishing the unpatentability of claims 2 and 3 of the '032 patent.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211,

IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00700, and IPR2017-00728. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

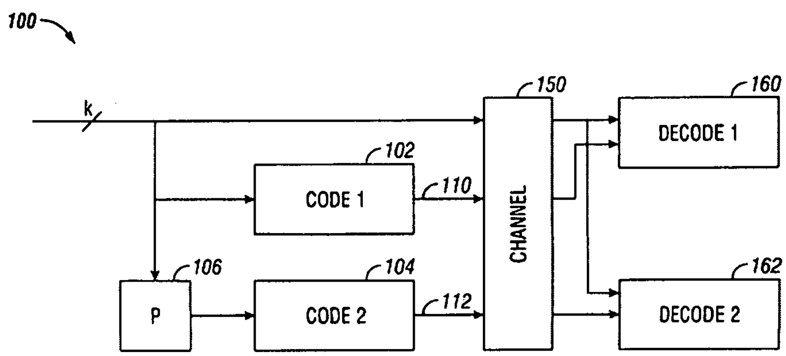

Figure 1 is a schematic diagram of a prior "turbo code" system. Ex. 1101, 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with respect to Figure 2, reproduced below.

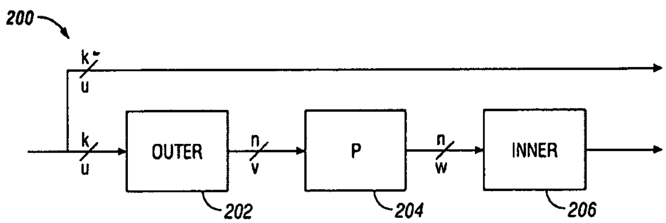

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[[1]] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1 % of 1.

Id. at 2:36–60. In an embodiment, the second ("inner") encoder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

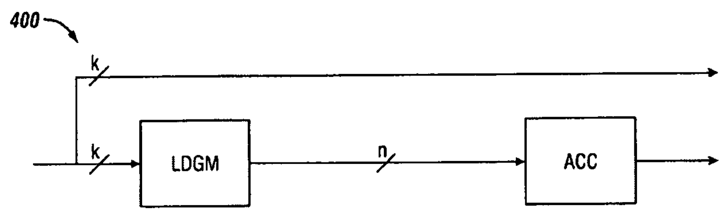

Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 1 is the only independent claim. The remaining challenged claims depend directly or indirectly from claim 1. Claim 1, reproduced below as corrected by a Certificate of Correction, is illustrative:

> 1. A method comprising:
> receiving a collection of message bits having a first sequence in a source data stream;

> generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula
>
> $$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$
>
> where
> "x_{j-1}" is the value of a parity bit "j-1," and
>
> $$\sum_{i=1}^{a} v_{(j-1)a+i}$$
>
> is the value of a sum of "a" randomly chosen irregular[2] repeats of the message bits; and
>
> making the sequence of parity bits available for transmission in a transmission data stream.

Ex. 1101, 7:63–8:20; *id.*, Certificate of Correction (dated July 27, 2010; replacing the two formulae).

E. Applied References

Reference	**Dates**	**Exhibit No.**
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 ("MacKay")		Ex. 1102

[2] The Board, in a prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 23–24 (advocating the adoption of that construction in this case); Prelim. Resp. 6 (referring to "the "irregularity" claimed ('irregular repeats of the message bits')").

Reference	Dates	Exhibit No.
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 ("Ping")		Ex. 1103
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 ("Luby97")		Ex. 1108
Dariush Divsalar, et al., *Coding Theorems for "Turbo-Like" Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 ("Divsalar")		Ex. 1117

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1104), in support of its arguments.

F. Asserted Ground of Unpatentability

Petitioner asserts the following ground of unpatentability:

References	Basis	Claims
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	1–10

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Based on the current record, we determine that no terms require explicit construction at this time. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy").

B. The Alleged Obviousness of Claims 1–10 Over Ping, MacKay, Divsalar, and Luby97

Petitioner alleges that claims 1–10 of the '032 patent would have been obvious over Ping, MacKay, Divsalar, and Luby97. Pet. 37–74. Patent Owner opposes. Prelim. Resp. 4–24.

Petitioner asserts that Ping discloses much of the subject matter of claim 1, but maintains that Ping's outer coder is regular. *See* Pet. 38; *see also id.* at 52–53. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 37, relies on Divsalar for the teaching of repetition "if Ping alone is not understood to teach, or render obvious, repeating information bits," *id.* at 42, and relies on Luby97 for the teaching of receiving a source data stream, *id.* at 44.

1. Ping (Ex. 1103)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1103, 38. In this approach, "[a]n LDPC code is defined from a randomly generated parity check matrix **H**." *Id.* The size of matrix **H** is $(n-k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]^t$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^p, \mathbf{H}^d]$." *Id.* $\mathbf{H}^p$ is defined as follows:

$$\mathbf{H}^{p} = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^{\mathrm{d}}$ is created such that it "has a column weight of *t* and a row weight of *kt*/(*n*–*k*) (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H}^{\mathrm{d}} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1104 ¶ 67.

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given $\mathbf{d} = \{d_i\}$" using the following expressions:

$$p_1 = \sum_j h^d_{1j}\, d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h^d_{ij}\, d_j \ (\text{mod } 2)$$

Ex. 1103, 38 (equation (4)).[3]

2. MacKay (Ex. 1102)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1102, 1449. According to MacKay,

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[3] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1104 ¶ 180.

"[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1117)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1104 ¶ 82 (quoting Ex. 1117, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

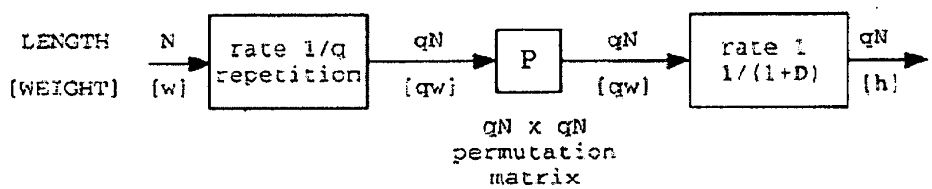

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1117, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. Luby97 (Ex. 1108)

Luby97 describes "randomized constructions of linear-time encodable and decodable codes that can transmit over lossy channels at rates extremely close to capacity." Ex. 1108, 150 (Abstr.). Luby97 describes receiving data to be encoded in a stream of data symbols, such as bits, where the "stream of data symbols [] is partitioned and transmitted in logical units of blocks." *Id.* (emphasis added, footnote omitted).

5. The Alleged Obviousness of Independent Claim 1

For reasons discussed below, Petitioner has shown a reasonable likelihood that it would prevail in establishing unpatentability of independent claim 1 as obvious over Ping, MacKay, Divsalar, and Luby97.

Petitioner, in articulating its obviousness challenge of claim 1, relies on the testimony of Dr. Davis and maps the teachings of the prior art against the limitations of the claim. Pet. 45–55.

Petitioner maintains that Ping, either alone or in light of Luby97, teaches a method including the step of "receiving a collection of message bits having a first sequence in a source data stream." *Id.* at 45–47 (citing Ex. 1104 ¶¶ 120–125). Specifically, Petitioner cites the information bits in Ping denoted by vector **d** for the "receiving" step. *Id.* at 46. (citing Ex. 1103, 38). Petitioner contends that Ping provides equations from which parity bits **p** can easily be calculated from information bits **d**, and that one of ordinary skill in the art would recognize that "message bits" and "information bits" are synonymous. *Id.* at 46–47. Petitioner points to Luby97's teaching of receiving data streams and asserts, "[e]ven if Ping is understood to teach only block encoding, and not encoding bits in [the claimed] 'a source data stream,' it would have been obvious to adapt Ping's coder to work with incoming data streams." *Id.* at 47; *see id.* at 44. Petitioner reasons that it would have been obvious to incorporate the stream teaching of Luby97 into Ping because coders that receive streams were common, *id.* at 44, 47, and the resulting incorporation would "make the encoder [of Ping] capable of receiving and processing 'streams' as opposed to blocks." *Id.* at 47; *see id.* at 44–45.

Petitioner next addresses the "generating" step (Pet. 48–53), which provides:

> generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula
>
> $$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$
>
> where
> "x_{j-1}" is the value of a parity bit "j-1," and
>
> $$\sum_{i=1}^{a} v_{(j-1)a+i}$$
>
> is the value of a sum of "a" randomly chosen irregular repeats of the message bits.

Ex. 1101, 7:66–8:17.

Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. Pet. at 24–25, 49–50. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h_{ij}^d d_j$$

as teaching the calculation of a parity bit as the sum of the prior parity bit and a summation of message bits. *Id.* at 49–50. Petitioner argues that Ping also teaches the "randomly chosen" aspect of the limitation, asserting:

> Ping randomly determines which values of h_{ij}^d equal "1" and which values of h_{ij}^d equal "0." Specifically, Ping teaches generating $\mathbf{H}^d$ by partitioning it into "t equal sub-blocks," as shown in Equation (3), reproduced below:

$$\mathbf{H}^{\mathbf{d}} = \begin{pmatrix} \mathbf{H}^{\mathbf{d1}} \\ \vdots \\ \mathbf{H}^{\mathbf{dt}} \end{pmatrix}$$

Ex. 1103, p. 38

> As Ping explains, "[i]n each sub-block $\mathbf{H}^{\mathbf{d}i}$, i = 1, 2 … t, we *randomly* create exactly one element 1 per column and *kt/*(*n-k*) 1s per row" (Ex. 1103, p. 38, emphasis added.) The positions of the 1s in $\mathbf{H}^{\mathbf{d}}$ are used to determine which information bits are included in each summation $\sum_j h_{ij}^d d_j$. By placing the 1s into $\mathbf{H}^{\mathbf{d}}$ "randomly," Ping ensures that the information bits contributing to each of the summations $\sum_j h_{ij}^d d_j$ are randomly chosen. (Ex. 1104, ¶137.)

Pet. 51.

Petitioner further contends that "it would have been obvious to one of ordinary skill to implement Ping by repeating every message bit [but] . . . , to the extent Ping does not itself teach, or render obvious, repeating every message bit, Divsalar does so explicitly." *Id.* at 52; *see id.* at 42. Petitioner also argues that the use of a repeater in an outer coder was common in the art, that [o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references teachings. *Id.* at 42–43.

In addressing the "irregular repeats" aspect of claim 1, Petitioner contends that, "[i]n Ping's $\mathbf{H}^{\mathbf{d}}$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\sum_j h_{ij}^d d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 30. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}_d$ has a column weight of t . . . .'" *Id.* at 39 (quoting Ex. 1103, 38); *see id.* at 52–53. Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 40 (quoting Ex. 1102, 1449) (emphasis in original).

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." *Id.* at 39. Petitioner maintains:

> It would have been straightforward for one of ordinary skill to change Ping's generator $\mathbf{H}^d$ matrix such that different columns had different weights – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1102, p. 1451.) This would result in some information bits contributing to more outer LDPC parity bits than others, making Ping's outer LDPC code irregular. This would have been an easy way for one of ordinary skill to incorporate the irregularity disclosed by MacKay into Ping. Moreover, MacKay's teaching that the best performing LDPC codes are irregular would have made this modification obvious (and desirable). (Ex. 1102, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper….") (Ex. 1104, ¶108.)

Pet. 40. Petitioner notes that Ping credits a reference written by the author of MacKay as having creating "revived interest in the low density parity check (LDPC) codes originally introduced in 1962 by Gallager." *Id.* at 38 (quoting Ex. 1103, 38). Thus, argues Petitioner, "it would have been obvious to one of ordinary skill to incorporate the non-uniform column weight of MacKay into the LDPC-accumulate codes of Ping [and] [t]his would result in some information bits being repeated more than others, satisfying the 'irregular repeats' requirement of claim 1." *Id.* at 53 (citing Ex. 1104 ¶ 142).

The last step of claim 1 recites "making the sequence of parity bits available for transmission in a transmission data stream." Ex. 1101, 8:19–20. Petitioner asserts that Ping, in discussing the performance of the codes, teaches the transmission of parity bits. Pet. 54. Petitioner again points to Luby97's teaching of data streams and argues that one of ordinary skill would have understood that bits commonly are transmitted in streams and that "[i]t would also have been obvious to one of ordinary skill that an encoder receiving bits in a stream would have output bits in a stream, and that the corresponding decoder would have received encoded bits in a stream." *Id.* (citing Ex. 1108, 150; Ex. 1104, ¶ 146).

We now turn to Patent Owner's arguments. Patent Owner first argues that MacKay fails to disclose the irregularity of claim 1, namely irregular repeats of the message bits. *See* Prelim. Resp. 6. Specifically, Patent Owner asserts that Petitioner fails to identify any "instance of nonuniform weight per column among information bits." *Id.* at 6–7. Petitioner's articulated ground, however, is based at least on the application of MacKay's irregularity into Ping's generator $\mathbf{H}^d$ matrix making the outer LDPC code irregular. Pet. 39–40 (citing, *inter alia*, Ex. 1104 ¶¶ 106–108); *see also* Pet. 32 (Petitioner arguing "MacKay's nonuniform weight per column ensures that some information bits contribute to more parity bits than others."). Patent Owner's argument that MacKay standing alone lacks the irregular repetition of claim 1 does not persuade us that Petitioner incorrectly asserts that the combination of references would result in that subject matter.

Patent Owner also argues "the petition incorrectly addresses only a portion of Ping's parity check matrix $\mathbf{H^d}$, rather than the parity check matrix **H**." Prelim. Resp. 7. Accordingly, Patent Owner argues "Ping's parity check matrix **H** already includes nonuniform weight per column—*i.e.*, the 'irregularity' of MacKay." *Id.* at 7–8. Based on Patent Owner's interpretation of the structure of parity check matrix **H** as being [$\mathbf{H^p}$, $\mathbf{H^d}$], and Patent Owner's allegation regarding $\mathbf{H^d}$ that "[t]he only value of t disclosed by Ping is 4" (Prelim. Resp. 8), Patent Owner contends that matrix **H** has column weights as shown in a diagram from page 9 of the Preliminary Response, which is reproduced below.

$$H = \left(\underbrace{\begin{matrix} 1 & & \\ 1 & 1 & \\ & \ddots & \ddots \\ 0 & & 1 \end{matrix}}_{\substack{(n-k-1)\\ \text{Weight 2}}} \;\; \underbrace{\begin{matrix} 0 \\ \\ \\ 1 \end{matrix}}_{\substack{(1)\\ \text{Weight 1}}} \;\middle|\;\; \underbrace{\begin{matrix} \\ H^d \\ \\ \\ \end{matrix}}_{\substack{(k)\\ \text{Weight 4}}} \right)$$

Id. at 9, 13. Patent Owner concludes "Ping discloses a parity check matrix with different numbers of ones per column—*i.e.*, different column weights [weight 2, weight 1, and weight $t = 4$]." *Id.* at 9. Thus, Patent Owner argues that there would be no motivation to modify Ping to include "irregularity" when Ping already includes the aspects identified in MacKay. *Id.* at 12–13.

Patent Owner's argument does not address directly Petitioner's articulation of the ground. Petitioner does not utilize Ping's entire parity check matrix **H** in its analysis; rather, Petitioner notes that the $\mathbf{H^d}$ matrix is part of Ping's "parity check" matrix **H**. Pet. 41. Petitioner maintains that, "[b]ecause Ping's Equation (4) uses the $\mathbf{H^d}$ matrix to produce parity bits from information bits, it is a 'generator matrix.'" *Id.* (citing Ex. 1103, 38).

Petitioner asserts that "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}^d$ has a column weight of *t* . . . .'" *Id.* at 39 (quoting Ex. 1103, 38). As such, we do not agree that matrix $\mathbf{H}^d$ from Ping, as cited by Petitioner and as forming the basis of the articulated ground, already includes "irregularity" in the manner suggested by Patent Owner. We understand Petitioner's combination as relating to the specific application of MacKay's "non-uniform column weight" to Ping's matrix $\mathbf{H}^d$ (*see* Pet. 40, 53), not a generic application of "irregularity" to Ping's teachings as a whole. Accordingly, Patent Owner's arguments do not undermine Petitioner's stated motivation to combine MacKay with Ping.

Patent Owner additionally argues "nothing in the references teach such a specific modification" of only Ping's "submatrix $\mathbf{H}^d$" and that "MacKay says nothing about modifying a specific portion of a parity check matrix to provide a subset of columns with nonuniform column weights, let alone doing so for a portion specifically corresponding to information bits." Prelim. Resp. 10; *see also id.* 13–14. Nevertheless, Petitioner shows persuasively, on this record, that MacKay "teaches how to make LDPC matrices 'irregular' with '*nonuniform* weight per column.'" Pet. 40 (quoting Ex. 1102, 1449). Petitioner cites a specific example in MacKay where a matrix "has columns of weight 9 and of weight 3." *Id.* (quoting Ex. 1102, 1451 and citing Ex. 1104 ¶ 107). In light of this evidence, we agree that an ordinarily skilled artisan would have known how to add nonuniform column weights from MacKay to the uniform column weights in Ping's matrix $\mathbf{H}^d$.

Having considered Petitioner's and Patent Owner's arguments and evidence, we determine Petitioner has established sufficiently at this stage that Ping, MacKay, Divsalar, and Luby97 teach every limitation of claim 1. Petitioner also has provided, on the current record, a sufficient rationale for its proposed combination. Thus, for the foregoing reasons, Petitioner demonstrates a reasonable likelihood of prevailing in showing that claim 1 would have been obvious over Ping, MacKay, Divsalar, and Luby97.

6. *The Alleged Obviousness of Dependent Claims 2–10 Over Ping, MacKay, Divsalar, and Luby97*

The remaining claims subject to Petitioner's challenge, claims 2–10, each depend directly or indirectly from independent claim 1.

a) *Claim 2*

Dependent claim 2 recites that "the sequence of parity bits is generated is [sic] in accordance with 'a' being constant." Ex. 1101, 8:21–22. The "a" of claim 1, from which claim 2 depends, refers to the number of randomly chosen irregular repeats of the message bits. *See id.* at 8:16–17 (the preceding equation "is the value of a sum of 'a' randomly chosen irregular repeats of the message bits.").

Petitioner cites Ping for teaching that the "$\mathbf{H}^d$ matrix has '*kt*/(*n*-*k*) 1s per row.'" Pet. 56 (quoting Ex. 1103, 38). Petitioner argues "[c]onsequently, the number of message bits chosen for each summation $\sum_j h_{ij}^d d_j$ (i.e., the number of message bits summed to produce each outer LDPC coder parity bit) is also constant – each of Ping's outer coder LDPC parity bits is a sum of *kt*/(*n*-*k*) message bits." *Id.* (citing Ex. 1104 ¶ 149); *see id.* at 58 ("[T]he variable 'a', as it appears in the claims, corresponds to the weight of a row in the parity check matrix. Claim 2 deals with constant row weight, as taught by Ping.").

Patent Owner notes that Petitioner's analysis for independent claim 1 depends on Ping's matrix $\mathbf{H}^d$ as modified by MacKay's nonuniform column weights. *See* Prelim. Resp. 17. Patent Owner argues that Petitioner, applying an inconsistent and incompatible theory, relies on an unmodified version of Ping's $\mathbf{H}^d$ for teaching the "'a' being constant" limitation in claim 2. *Id.* at 17–18. Patent Owner provides an example of how a matrix having constant row weights (like $\mathbf{H}^d$) would no longer have constant weights after modification of the column weights to introduce non-uniformity. *Id.* at 17–18.

We are persuaded by Patent Owner's arguments. Petitioner's analysis for claim 2 is inconsistent with its analysis for claim 1, which relies on a version of Ping's $\mathbf{H}^d$ that has been modified according to the teachings of MacKay. *See* Pet. 39–40. Petitioner has not shown persuasively that this modified version of $\mathbf{H}^d$ still would have the constant "a" of claim 2. Indeed, Petitioner's analysis for claim 2 makes no mention of MacKay or its teachings. Accordingly, Petitioner has not shown a reasonable likelihood that it would prevail with respect to claim 2 as obvious over Ping, MacKay, Divsalar, and Luby97.

b) Claim 3

Claim 3 depends from independent claim 1 and recites "the sequence of parity bits is generated is [sic] in accordance with "a" varying for different parity bits." Ex. 1101, 8:23–25.

Petitioner relies on MacKay for the teaching of this limitation, equating nonuniform row weight with the "'a' varying for different parity bits" aspect of the claim. Pet. 57–59. Petitioner argues that it would have been obvious to modify Ping's $\mathbf{H}^d$ matrix to have MacKay's teaching of nonuniform row weights, and contends that this would have been obvious for the same reasons given earlier, in the context of claim 1, as to why one would consider MacKay's teachings of nonuniform column weight when modifying Ping's $\mathbf{H}^d$ matrix. *Id.* at 59. However, Petitioner's specific reasoning for modifying the references is that "one of ordinary skill would have been motivated to implement MacKay's uneven row weight in Ping's matrix to determine whether this improved the code's bit error rate (BER) as MacKay suggests (when reporting on the teachings of Luby *et al.*)." *Id.* (citing Ex. 1102, 1449; Ex. 1104 ¶ 159); *see also* Ex. 1104 ¶ 159 (Petitioner's expert making the same or similar statement).

Patent Owner persuasively argues that Petitioner has failed to establish a reason as to why one would have modified Ping as proposed. Prelim. Resp. 21–22. Patent Owner quotes a portion of the cited page of MacKay that does not suggest what Petitioner proposed but rather implies the opposite. *Id.* at 21. That portion of MacKay, as quoted in the Preliminary Response, is as follows:

> The irregular codes of [Luby *et al.*] have parity check matrices with nonuniform weights per row and nonuniform weights per column. It has not yet been established whether both of these nonuniformities are desirable. In our experience with codes for noisy channels, performance is more sensitive to the distribution of column weights. In this paper, we concentrate on irregular codes with the weight per row as uniform as possible.

Prelim. Resp. 21 (quoting Ex. 1102, 1449). Without more explanation from Petitioner, we are not persuaded that the cited page of MacKay would have suggested to one of ordinary skill in the art the proposed modification of Ping's $\mathbf{H}^d$ matrix to have nonuniform row weights.

Petitioner has not demonstrated a reasonable likelihood of prevailing in showing that claim 3 would have been obvious over Ping, MacKay, Divsalar, and Luby97.

c) Claims 5 and 6

Claim 5 depends directly from independent claim 1 and recites additional requirements for the "generating" step. Patent Owner does not address separately Petitioner's explanations and supporting evidence regarding claim 5. Based on the record before us, Petitioner has demonstrated a reasonable likelihood that it would prevail on its assertion that claim 5 would have been unpatentable over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 63–67.

Claim 6 depends from claim 5 and calls for "generating the random sequence of bits comprises coding the collection of message bits using a low-density generator matrix (LDGM) coder." Ex. 1101, 8:42–44.

Petitioner provides citations to the prior art and declaration testimony to support the contention that Ping, MacKay, Divsalar, and Luby97 teach the limitations of claim 6 (including those of claims from which it depends, claim 5 and independent claim 1) and would have rendered obvious the subject matter of the claim. *See id.* at 63–68 (citing Ex. 1104 ¶¶ 171–185) (addressing claims 5 and 6). For example, Petitioner provides testimony that Ping's matrix $\mathbf{H}^d$ is a low-density generator matrix as recited in dependent claim 6. *Id.* at 67–68; Ex. 1104 ¶¶ 185. Although Patent Owner argues that this evidence is not sufficient as "Ping never identifies $\mathbf{H}^d$ as a *generator* matrix," Prelim. Resp. 22, at issue is whether Petitioner likely is to prevail in showing that the references teach the limitation to a person of ordinary skill in the art, and not whether the reference expressly uses the term low-density generator matrix or identifies matrix $\mathbf{H}^d$ as such.

Having considered Patent Owner's further argument that "petition's own discussion of generator matrices adds confusion as it contradicts Petitioner's identification of $\mathbf{H}^d$ as a generator matrix," *id.* at 23, we determine, on the record before us, that Petitioner has presented sufficient argument and evidence to support the finding that it will prevail in showing that Ping teaches the low-density generator matrix limitation of claim 6, and that Petitioner has met its burden of demonstrating a likelihood of success in showing that claim 6 would have been obvious in view of Ping, MacKay, Divsalar, and Luby97.

d) Claims 4 and 7–10

Patent Owner does not address separately Petitioner's explanations and supporting evidence regarding claims 4 and 7–10. Based on the record before us, Petitioner has demonstrated a reasonable likelihood that it would prevail on its assertion that claims 4 and 7–10 would have been unpatentable over Ping, MacKay, Divsalar, and Luby97. *See* Pet. 61–62, 68–74.

III. CONCLUSION

Petitioner has demonstrated that there is a reasonable likelihood of establishing the unpatentability of claims 1 and 4–10 of the '032 patent. Petitioner has not demonstrated that there is a reasonable likelihood of establishing the unpatentability of claims 2 and 3 of the '032 patent.

IV. ORDER

For the foregoing reasons, it is

ORDERED that, pursuant to 35 U.S.C. § 314, *inter partes* review is instituted as to claims 1 and 4–10 of the '032 patent on the following ground of unpatentability:

Claims 1 and 4–10 as obvious over Ping, MacKay, Divsalar, and Luby97 pursuant to 35 U.S.C. § 103(a);

FURTHER ORDERED that *inter partes* review is commenced on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial; and

FURTHER ORDERED that the trial is limited to the grounds of unpatentability listed above, and no other grounds of unpatentability are authorized for *inter partes* review.

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

CALIFORNIA INSTITUTE OF TECHNOLOGY,
Patent Owner.

Case IPR2017-00700
Patent 7,421,032 B2

Before KEN B. BARRETT, TREVOR M. JEFFERSON, and JOHN A. HUDALLA, *Administrative Patent Judges*.

BARRETT, *Administrative Patent Judge*.

DECISION
Institution of *Inter Partes* Review
37 C.F.R. § 42.108

I. INTRODUCTION

A. Background and Summary

Apple Inc. ("Petitioner") filed a Petition requesting *inter partes* review of U.S. Patent No. 7,421,032 B2, issued September 2, 2008 ("the '032 patent," Ex. 1001). Paper 5 ("Pet."). The Petition challenges the patentability of claims 11–17 of the '032 patent on various grounds of obviousness under 35 U.S.C. § 103. California Institute of Technology ("Patent Owner") filed a Preliminary Response to the Petition. Paper 13 ("Prelim. Resp.").

An *inter partes* review may not be instituted "unless . . . the information presented in the petition . . . shows that there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a). Having considered the arguments and evidence presented by Petitioner and Patent Owner, we determine that Petitioner has demonstrated a reasonable likelihood that it would prevail in establishing the unpatentability of challenged claims 11–16 of the '032 patent, and that Petitioner has not demonstrated a reasonable likelihood that it would prevail in establishing the unpatentability of claim 17 of the '032 patent.

B. Related Proceedings

One or both parties identify, as matters involving or related to the '032 patent, *Cal. Inst. of Tech. v. Broadcom Ltd.*, No. 2:16-cv-03714 (C.D. Cal. filed May 26, 2016) and *Cal. Inst. of Tech. v. Hughes Commc'ns, Inc.*, 2:13-cv-07245 (C.D. Cal. filed Oct. 1, 2013), and Patent Trial and Appeal Board cases IPR2015-00059, IPR2015-00060, IPR2015-00061, IPR 2015-00067, IPR2015-00068, IPR2015-00081, IPR2017-00210, IPR2017-00211,

IPR2017-00219, IPR2017-00297, IPR2017-00423, IPR2017-00701, and IPR2017-00728. Pet. 3, Paper 7.

C. The '032 Patent

The '032 patent is titled "Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes." The '032 patent explains some of the prior art with reference to its Figure 1, reproduced below.

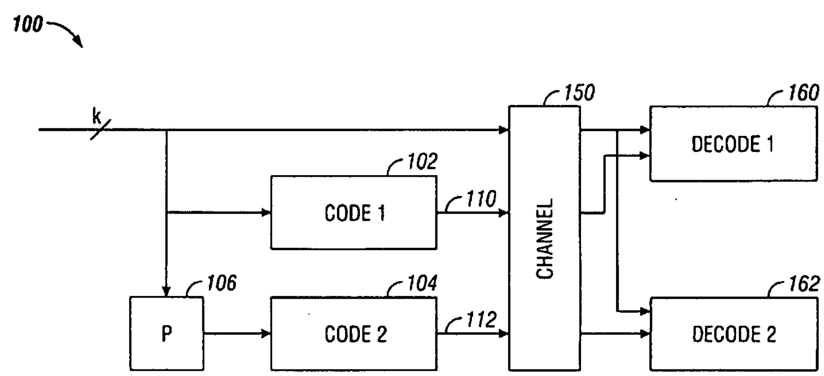

Figure 1 is a schematic diagram of a prior "turbo code" system. Ex. 1001, 2:16–17. The '032 patent specification describes Figure 1 as follows:

> A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.
>
> Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

Id. at 1:41–56.

A coder 200, according to a first embodiment of the invention, is described with respect to Figure 2, reproduced below.

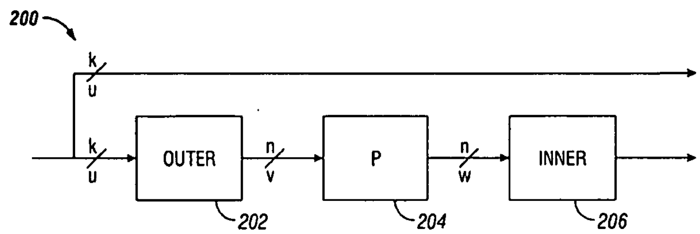

Figure 2 of the '032 patent is a schematic diagram of coder 200.

> The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. . . . The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where n>k. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n×k matrix, and the rate[1] of the coder is k/n.
>
> The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where n=qk. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.
>
> The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_Iw$, where T_I is a nonsingular n×n matrix. The inner coder 210 can

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[1] We understand that the "rate" of an encoder refers to the ratio of the number of input bits to the number of resulting encoded output bits related to those input bits.

> have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1 % of 1.

Id. at 2:36–60. In an embodiment, the second ("inner") encoder 206 is an accumulator. *Id.* at 2:66–67. "The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code." *Id.* at 3:30–32.

Figure 4 of the '032 patent is reproduced below.

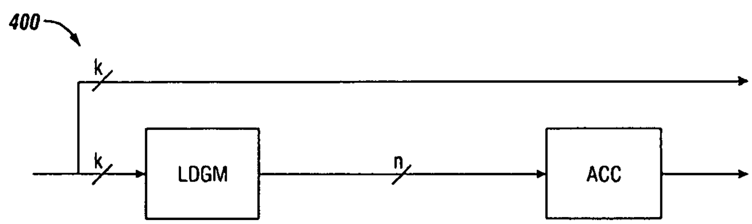


Figure 4 shows an alternative embodiment in which the outer encoder is a low-density generator matrix (LDGM). *Id.* at 3:56–59. LDGM codes have a "sparse" generator matrix. *Id.* at 3:59–60. The IRA code produced is a serial concatenation of the LDGM code and the accumulator code. *Id.* at 3:60–62. No interleaver (as in the Figure 2 embodiment) is required in the Figure 4 arrangement because the LDGM provides scrambling otherwise provided by the interleaver in the Figure 2 embodiment. *Id.* at 3:62–64.

"The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code." *Id.* at 3:33–35. Figure 3, shown below, depicts such a Tanner graph.

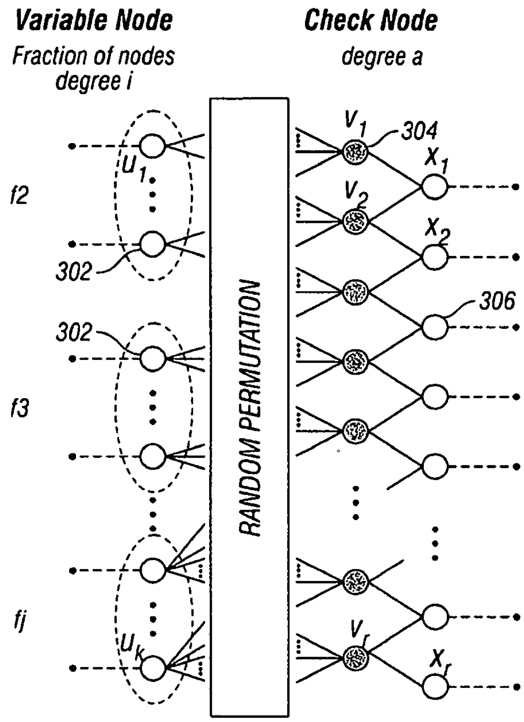


Figure 3 is described as a Tanner graph for an irregular repeat and accumulate (IRA) coder. *Id.* at 2: 20–21. The left-most column of nodes, information nodes 302 (the open circles), are variable nodes that receive information bits. The column of nodes (the filled circles) just to the right of the "RANDOM PERMUTATION" block are check nodes v indicated by reference numeral 304. An information bit node connected to two check nodes represents a repeat of 2. An information node connected to three check nodes represents a repeat of 3. The nodes (the open circles) in the right-most column are parity bit nodes x, referenced by 306. As shown by the edges[2] of the Tanner graph, each parity bit is a function of its previous parity bit and is also a function of information bits (edges connect through

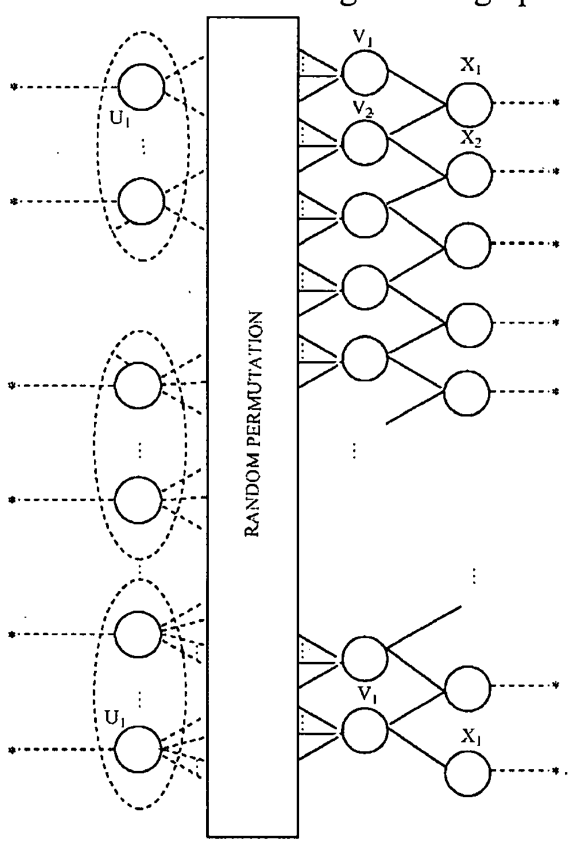
[2] We understand that "edges" are the straight lines that connect one node to another node of a Tanner graph. *See* Ex. 1001, 3:53–54.

check nodes and random permutation to information bit nodes). Ex. 1001, 3:34–55; *see also* Ex. 1004 ¶ 110 (discussing the relationship between parity bits in the context of the claimed Tanner graph and the '032 patent's specification).

D. Illustrative Claim

Of the challenged claims of the '032 patent, claim 11 is the only independent claim. The remaining challenged claims depend directly or indirectly from claim 11. Claim 11, reproduced below as originally issued and before issuance of the Certificate of Correction, is illustrative:

> 11. A device comprising:
> an encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits in accordance with the following Tanner graph:



Ex. 1001, 8:63–9:34. A Certificate of Correction for the ’032 patent replaced the labels V_1, U_1, and X_1 from the lower portion of the Tanner graph in claim 11 with V_r, U_k, and X_r, respectively. *See id.* at Certificate of Correction.

E. Applied References

Reference	**Dates**	**Exhibit No.**
D. J. C. MacKay et al., *Comparison of Constructions of Irregular Gallager Codes*, IEEE TRANSACTIONS ON COMMUNICATIONS, Vol. 47, No. 10, pp. 1449–54, October 1999 (“MacKay”)		Ex. 1002
L. Ping et al., *Low Density Parity Check Codes with Semi-Random Parity Check Matrix*, IEE ELECTRONICS LETTERS, Vol. 35, No. 1, pp. 38–39, Jan. 7, 1999 (“Ping”)		Ex. 1003
M. Luby et al., *Practical Loss-Resilient Codes*, PROCEEDINGS OF THE TWENTY-NINTH ANNUAL ACM SYMPOSIUM ON THEORY OF COMPUTING, May 4–6, 1997, at 150–159 (“Luby97”)		Ex. 1008
Dariush Divsalar, et al., *Coding Theorems for “Turbo-Like” Codes*, PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL ALLERTON CONFERENCE ON COMMUNICATION, CONTROL, AND COMPUTING, Sept. 23–25, 1998, at 201–209 (“Divsalar”).		Ex. 1017
H. Pfister and P Siegel, *The Serial Concatenation of Rate-1 Codes Through Uniform Random Interleavers*, Presentation at Allerton Conference, Sept. 22–24, 1999 (“Pfister Slides”).		Ex. 1022

Petitioner also relies on the Declaration of Dr. James A. Davis, dated January 19, 2017 (Ex. 1004), in support of its arguments. Patent Owner relies upon the Declaration of Dr. R. Michael Tanner, dated May 8, 2017 (Ex. 2001), in support of its arguments.

F. Asserted Grounds of Unpatentability

Petitioner asserts the following grounds of unpatentability:

References	**Basis**	**Claim(s)**
Ping, MacKay, and Divsalar	§ 103(a)	11, 12, and 14–16
Ping, MacKay, Divsalar, and Luby97	§ 103(a)	13
Ping, MacKay, Divsalar, and Pfister Slides	§ 103(a)	17

II. ANALYSIS

A. Claim Construction

In an *inter partes* review, claim terms in an unexpired patent are given their broadest reasonable construction in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b); *see also Cuozzo Speed Techs. LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable construction standard, claim terms are given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

Tanner graph

In a prior decision regarding the '032 patent, the Board construed the Tanner graph of claim 18 (not challenged here) as follows:

> [1] a graph representing an [irregular[3] repeat accumulate] IRA code as a set of parity checks where every message bit is

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[3] The Board, the prior decision regarding the '032 patent, adopted a construction where, "[i]n the context of the '032 patent specification, . . . 'irregular' refers to the notion that different message bits or groups of message bits contribute to different numbers of parity bits." IPR2015-00060, Paper 18, 12 (Decision denying institution); *see also* Pet. 24 (advocating the adoption of that construction in this case); Prelim.

> repeated, at least two different subsets of message bits are repeated a different number of times, and
>
> [2] check nodes, randomly connected to the repeated message bits, enforce constraints that determine the parity bits[, and] . . .
>
> [3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph.

IPR2015-00060, Paper 18, 12–14 (numbering and paragraphing added for clarity). The Tanner graph of claim 18 is the same as that of claim 11. *See* Ex. 1004 ¶ 99 (Dr. Davis); Ex. 2001 ¶ 20 (Dr. Tanner).

Petitioner supports the application of the same construction here. Pet. 26. Patent Owner contends "no construction is necessary beyond observing that in the above Tanner graph, different subsets of message bits are repeated a different number of times." Prelim. Resp. 6. Patent Owner's position corresponds to only the first of the three requirements in the Board's prior construction. Patent Owner's proposed construction does not go far enough as it does not address the other limitations apparent from the Tanner Graph.

We adopt our prior construction for purposes of this decision.

B. The Alleged Obviousness of Claims 11, 12, and 14–16 Over Ping, MacKay, and Divsalar

Petitioner alleges that claims 11, 12, and 14–16 of the '032 patent would have been obvious over Ping, MacKay, and Divsalar. Pet. 39–64. Patent Owner opposes. Prelim. Resp. 7–21.

Resp. 6 (asserting that the "irregularity" of the Tanner graph of claim 11 means "different subsets of message bits are repeated a different number of times").

Petitioner asserts that Ping discloses much of the subject matter of claim 11, but maintains that Ping's outer coder is regular. Pet. 41; *see also id.* at 51. Petitioner relies on MacKay for the teaching of irregularity, *id.* at 39, 41, and relies on Divsalar for the teaching of repetition "if Ping standing alone is not understood to teach, or render obvious, repeating information bits," *id.* at 44.

1. Ping (Ex. 1003)

Ping is an article directed to "[a] semi-random approach to low density parity check [LDPC] code design." Ex. 1103, 38. In this approach, "[a]n LDPC code is defined from a randomly generated parity check matrix **H**." *Id.* The size of matrix **H** is $(n–k) \times n$ where k is the information length and n is the coded length. *Id.* A codeword c is decomposed "as $\mathbf{c} = [\mathbf{p}, \mathbf{d}]$, where **p** and **d** contain the parity and information bits, respectively." *Id.* Parity check matrix **H** can be decomposed into two parts corresponding to **p** and **d** as "$\mathbf{H} = [\mathbf{H}^p, \mathbf{H}^d]$." *Id.* $\mathbf{H}^p$ is defined as follows:

$$\mathbf{H}^p = \begin{pmatrix} 1 & & & 0 \\ 1 & 1 & & \\ & \ddots & \ddots & \\ 0 & & 1 & 1 \end{pmatrix}$$

Id. $\mathbf{H}^d$ is created such that it "has a column weight of t and a row weight of $kt/(n–k)$ (the weight of a vector is the number of 1s among its elements)," *id.*, such that

$$\mathbf{H^d} = \begin{bmatrix} h^d_{1,1} & h^d_{1,2} & h^d_{1,3} & \cdots & h^d_{1,k} \\ h^d_{2,1} & h^d_{2,2} & h^d_{2,3} & \cdots & h^d_{2,k} \\ h^d_{3,1} & h^d_{3,2} & h^d_{3,3} & \cdots & h^d_{3,k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ h^d_{n-k,1} & h^d_{n-k,2} & h^d_{n-k,3} & \cdots & h^d_{n-k,k} \end{bmatrix}$$

Ex. 1104 ¶ 74.

Parity bits "$\mathbf{p} = \{p_i\}$ can easily be calculated from a given d = {di}" using the following expressions:

$$p_1 = \sum_j h^d_{1j}\, d_j \quad \text{and} \quad p_i = p_{i-1} + \sum_j h^d_{ij}\, d_j \ (\text{mod } 2)$$

Ex. 1103, 38 (equation (4)).[4]

2. MacKay (Ex. 1002)

MacKay is a paper related to Gallager codes based on irregular graphs, which are "low-density parity check codes whose performance is closest to the Shannon limit." Ex. 1002, 1449. According to MacKay, "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* A parity check matrix that "can be viewed as defining a bipartite graph with 'bit' vertices corresponding to the columns and 'check' vertices corresponding to the rows" where "[e]ach nonzero entry in the matrix corresponds to an edge connecting a bit to a check." *Id.* at 1450. As an example of an irregular

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[4] The reference to "mod 2" refers to modulo-2 addition. Modulo-2 addition corresponds to the exclusive-OR (XOR or ⊕) logical operation, which is defined as follows: 0⊕0=0, 0⊕1=1, 1⊕0=1, and 1⊕1=0. *See* Ex. 1004 ¶ 185.

code in a parity check matrix, MacKay describes a matrix that "has columns of weight 9 and of weight 3 [and] all rows hav[ing] weight 7." *Id.* at 1451.

3. Divsalar (Ex. 1017)

Divsalar teaches "repeat and accumulate" codes, described as "a simple class of rate $1/q$ serially concatenated codes where the outer code is a q-fold repetition code and the inner code is a rate 1 convolutional code with transfer function 1/(1 + D)." Ex. 1004 ¶ 89 (quoting Ex. 1017, 1 (Abstr.)). Petitioner relies on Divsalar's Figure 3, reproduced below.

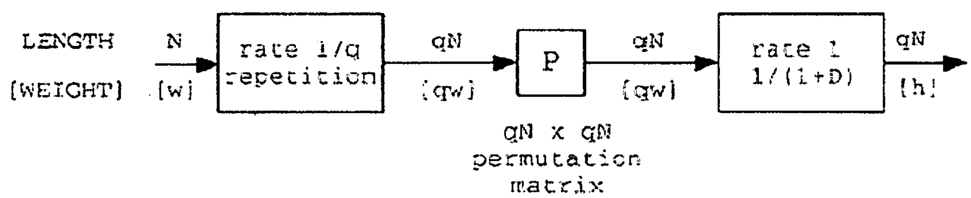

Figure 3 of Divsalar describes an encoder for a (qN, N) repeat and accumulate code. Ex. 1017, 5. The numbers above the input-output lines indicate the length of the corresponding block, and those below the lines indicate the weight of the block. *Id.*

4. The Alleged Obviousness of Independent Claim 11

For reasons discussed below, Petitioner has shown a reasonable likelihood that it would prevail in establishing unpatentability of independent claim 11 as obvious over Ping, MacKay, and Divsalar.

As discussed above in the context of claim construction, independent claim 11 contains a Tanner graph having at least three elements. Petitioner, in articulating its obviousness challenge of claim 11, relies on the testimony of Dr. Davis and maps the teachings of the prior art against those three elements as well as the express recitations of the claim. Pet. 46–57.

Petitioner maintains that Ping teaches the recited "encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits." *Id.* at 46–47 (citing Ex. 1004 ¶¶ 127–128). Specifically, Petitioner contends that Ping provides equations from which parity bits **p** can easily be calculated from information bits **d**, and that one of ordinary skill in the art would recognize that "message bits" and "information bits" are synonymous. *Id.*

As for the Tanner graph, Petitioner addresses the three elements but in an order different than that listed above in the claim construction section. For the element "[3] a parity bit is determined as a function of both information bits and other parity bits as shown by the configuration of nodes and edges of the Tanner graph," Petitioner asserts that Ping teaches a two-stage, low-density parity-check (LDPC)-accumulate code where the value of one parity bit is used in the calculation of the next parity bit. *Id.* at 27, 48–50; *see also id.* at 51–52 (maintaining that Ping's inner coder is an accumulator).

The next element of the Tanner graph addressed by Petitioner is "[1] a graph representing an [irregular repeat accumulate] IRA code as a set of parity checks where every message bit is repeated, at least two different subsets of message bits are repeated a different number of times." Pet. 50–54. Petitioner asserts that a particular code may be represented as matrices or as a Tanner graph, with those being two ways of describing the same thing, and contends that the proposed combination would have been understood by one of ordinary skill in the art to correspond to the claimed Tanner graph. *Id.* at 52–54.

Petitioner contends that, "[i]n Ping's $\mathbf{H}^d$ matrix, every column corresponds to an information bit (d_i) and every row corresponds to a summation ($\Sigma_j h^d_{ij} d_j$)" and that one of ordinary skill in the art would have understood that the summations are computed as the first stage of computing the parity bits in Ping. *Id.* at 31, 32. According to Petitioner, "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H}^d$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H}_d$ has a column weight of t . . . .'" *Id.* at 41 (quoting Ex. 1003, 38). Petitioner cites MacKay for teaching that "[t]he best known binary Gallager codes are *irregular* codes whose parity check matrices have *nonuniform* weight per column." *Id.* at 41 (quoting Ex. 1102, 1449) (emphasis in original).

Petitioner reasons that, "[b]ecause MacKay teaches that irregular codes perform better than regular codes, one of ordinary skill would have been motivated to incorporate irregularity into Ping." *Id.* at 41. Petitioner maintains:

> It would have been straightforward for a person of ordinary skill to change Ping's generator $\mathbf{H}_d$ matrix such that not all columns had the same weight – *e.g.*, setting some columns to weight 9 and others to weight 3, as taught by MacKay. (Ex. 1002, p. 1451.) This change would result in some information bits contributing to more outer LDPC parity bits than others, and would have made Ping's outer LDPC code irregular. . . . Moreover, MacKay's teaching that the best performing LDPC codes are irregular would also have made this modification obvious (and desirable) to try. (Ex. 1002, pp. 1449, 1454, "The excellent performance of irregular Gallager codes is the motivation for this paper….") (Ex. 1004, ¶116.)

Pet. 42. Petitioner notes that Ping credits a reference written by the author of MacKay as having creating "revived interest in the low density parity check (LDPC) codes originally introduced in 1962 by Gallager." *Id.* at 39 (quoting Ex. 1003, 38).

Petitioner further contends that, "even if Ping standing alone is not understood to teach, or render obvious, repeating information bits, doing so would have been obvious in view of Divsalar's explicit teaching of repeating bits." *Id.* at 44. Petitioner also argues that "[o]ne of ordinary skill would have been further motivated to implement Ping using the repeater of Divsalar because this implementation would be both cost-effective and easy to build," and that the similarities between Ping and Divsalar provide additional motivation to combine the references teachings. *Id.* at 44–45.

Thus, argues Petitioner, the combination of Ping, MacKay, and Divsalar teaches an irregular repeat accumulate code where message bits are repeated and at least two different subsets of message bits are repeated a different number of times. *Id.* at 52 (citing Ex. 1004 ¶ 139).

Lastly, Petitioner contends that Ping teaches the Tanner graph requirement of "[2] check nodes, randomly connected to the repeated message bits, [which] enforce constraints that determine the parity bits." *Id.* at 54–57. Petitioner points to Ping's Equation (4)

$$p_i = p_{i-1} + \sum_j h^d_{ij} d_j$$

as teaching check nodes constraining the relationship between information bits and parity bits. *Id.* at 54–56. Petitioner further maintains that Ping, using Divsalar's repetition, teaches that the check nodes are randomly connected to repeated message bits. *Id.* at 56–57.

We now turn to Patent Owner's arguments. Patent Owner first argues that MacKay fails to disclose the irregularity of claim 11, namely irregularity in the number of message (information) bits repeated in a coding operation. *See* Prelim. Resp. 8–9. Specifically, Patent Owner asserts that Petitioner fails to identify any "instance of nonuniform weight per column among information bits." *Id.* Petitioner's articulated ground, however, is based at least on the application of MacKay's irregularity into Ping's generator $\mathbf{H^d}$ matrix making the outer LDPC code irregular. Pet. 41–42 (citing, *inter alia*, Ex. 1004 ¶¶ 114–116); *see also* Pet. 34 (Petitioner arguing "MacKay's nonuniform weight per column ensures that some information bits contribute to more parity bits than others."). Patent Owner's argument that MacKay standing alone lacks the irregularity of claim 11 does not persuade us that Petitioner incorrectly asserts that the combination of references would result in that subject matter.

Patent Owner also argues "the petition incorrectly addresses only a portion of Ping's parity check matrix $\mathbf{H^d}$, rather than the parity check matrix **H**." Prelim. Resp. 9. Accordingly, Patent Owner argues "Ping's parity check matrix **H** already includes nonuniform weight per column—*i.e.*, the 'irregularity' of MacKay." *Id.* Based on Patent Owner's interpretation of the structure of parity check matrix **H** as being $[\mathbf{H^p}, \mathbf{H^d}]$, and Patent Owner's allegation regarding $\mathbf{H^d}$ that "[t]he only value of t disclosed by Ping is 4" (Prelim. Resp. 10–11), Patent Owner contends that matrix **H** has column weights as shown in a diagram from page 11 of the Preliminary Response, which is reproduced below.

$$H = \left(\begin{array}{cccc|c} 1 & & & 0 & \\ 1 & 1 & & & H^d \\ & \ddots & \ddots & & \\ 0 & & 1 & 1 & \end{array}\right)$$

(n-k-1) Weight 2 (1) Weight 1 (k) Weight 4

Id. at 11, 14. Patent Owner concludes "Ping discloses a parity check matrix with different numbers of ones per column—*i.e.*, different column weights [weight 2, weight 1, and weight $t = 4$]." *Id.* at 11. Thus, Patent Owner argues that there would be no motivation to modify Ping to include "irregularity" when Ping "already includes the aspects identified in MacKay." *Id.* at 14–15.

Patent Owner's argument does not address directly Petitioner's articulation of the ground. Petitioner does not utilize Ping's entire parity check matrix **H** in its analysis; rather, Petitioner notes that the $\mathbf{H^d}$ matrix is part of Ping's "parity check" matrix **H**. Pet. 42. Petitioner maintains that, "[b]ecause Ping's Equation (4) uses the $\mathbf{H^d}$ matrix to produce parity bits from information bits, it is a 'generator matrix.'" *Id.* (citing Ex. 1003, 38). Petitioner asserts that "Ping's outer LDPC code is regular because each column in Ping's generator matrix $\mathbf{H^d}$ contains the same number of 1s – exactly '*t*' 1s," and notes that "Ping thus states that matrix '$\mathbf{H_d}$ has a column weight of t . . . .'" *Id.* at 41 (quoting Ex. 1003, 38). As such, we do not agree that matrix $\mathbf{H^d}$ from Ping, as cited by Petitioner and as forming the basis of the articulated ground, already includes "irregularity" in the manner suggested by Patent Owner. We understand Petitioner's combination as relating to the specific application of MacKay's "non-uniform column weight" to Ping's matrix $\mathbf{H^d}$ (*see* Pet. 42–43), not a generic application of "irregularity" to Ping's teachings as a whole. Accordingly, Patent Owner's arguments do not undermine Petitioner's stated motivation to combine MacKay with Ping.

Patent Owner additionally argues "nothing in the references teach such a specific modification" of only Ping's "submatrix $\mathbf{H}^d$" and that "MacKay says nothing about modifying a specific portion of a parity check matrix to provide a subset of columns with nonuniform column weights, let alone doing so for a portion specifically corresponding to information bits." Prelim. Resp. 12; *see also id.* 15–16. Nevertheless, Petitioner shows persuasively, on this record, that MacKay "teaches how to make LDPC matrices 'irregular' by implementing a '*nonuniform* weight per column.'" Pet. 41 (quoting Ex. 1102, 1449). Petitioner cites a specific example in MacKay where a matrix "has columns of weight 9 and of weight 3." *Id.* at 41–42 (quoting Ex. 1102, 1451 and citing Ex. 1004 ¶ 115). In light of this evidence, we agree that an ordinarily skilled artisan would have known how to add nonuniform column weights from MacKay to the uniform column weights in Ping's matrix $\mathbf{H}^d$.

Having considered Petitioner's and Patent Owner's arguments and evidence, we determine Petitioner has established sufficiently at this stage that Ping, MacKay, and Divsalar teach every limitation of claim 11. Petitioner also has provided, on the current record, a sufficient rationale for its proposed combination. Thus, for the foregoing reasons, Petitioner demonstrates a reasonable likelihood of prevailing in showing that claim 11 would have been obvious over Ping, MacKay, and Divsalar.

5. *The Alleged Obviousness of Claims 12 and 14–16 Over Ping, MacKay, and Divsalar*

The remaining claims subject to Petitioner's first ground, claims 12 and 14–16, each depend directly or indirectly from independent claim 11.

Dependent claim 12 recites that "the encoder [of claim 11] is configured to generate the collection of parity bits as if a number of inputs into nodes v_i was not constant." Ex. 1001, 9:35–37. Petitioner relies on MacKay for the teaching of this limitation, equating nonuniform column weight with the "not constant" aspect of the claim. Pet. 58–62. Petitioner's analysis, including the reasoning to combine the references' teachings, is the same or similar to that regarding claim 11 and the application of MacKay's teaching of "nonuniform column weight" in the combination of Ping, MacKay, and Divsalar and specifically to make Ping's matrix $\mathbf{H^d}$ nonuniform. *Id.* at 60. Patent Owner again argues that Petitioner's reference to only Ping's matrix $\mathbf{H^d}$, rather than $\mathbf{H}$, is flawed. Prelim. Resp. 21 ("Petitioner's attempt to apply MacKay's 'nonuniform row weights' to $\mathbf{H^d}$ (*see* Pet. at 61-62) repeats the errors discussed above in Section III.A.2, and so should be disregarded for similar reasons."). Patent Owner also argues that Petitioner fails to provide a reason to modify the references with regard to this claim but does not acknowledge Petitioner's statements on pages 60–61 of the petition. We again do not find Patent Owner's arguments persuasive, and determine, on the record before us, that Petitioner has demonstrated a reasonable likelihood of prevailing in showing that claim 12 would have been obvious over Ping, MacKay, and Divsalar.

Patent Owner does not address separately Petitioner's explanations and supporting evidence regarding claims 14–16. *See* Prelim. Resp. 21–22.

Based on the record before us, Petitioner has demonstrated a reasonable likelihood that it would prevail on its assertion that claims 14–16 would have been unpatentable over Ping, MacKay, and Divsalar. *See* Pet. 62–64.

C. The Alleged Obviousness of Claim 13 Over Ping, MacKay, Divsalar, and Luby97

Dependent claim 13 specifies that the encoder comprises a low-density generator matrix (LDGM) coder and an accumulator. Ex. 1001, 9:38–45. Petitioner, relying on Luby97 for the teachings of receiving message bits in a stream (Pet. 69), provides citations to the prior art and declaration testimony to support the contention that Ping, MacKay, Divsalar, and Luby97 teach the limitations of claim 13 and would have rendered obvious the subject matter of the claim. *Id.* at 64–71 (citing Ex. 1004 ¶¶ 172–187). For example, Petitioner provides testimony that Ping's matrix $\mathbf{H}^d$ is a low-density generator matrix as recited in dependent claim 13. *Id.* at 67–68; Ex. 1004 ¶¶ 179–181. Although Patent Owner argues that this evidence is not sufficient as "Ping never identifes [sic] $\mathbf{H}^d$ as a *generator* matrix," Prelim. Resp. 22, at issue is whether Petitioner likely is to prevail in showing that the references teach the limitation to a person of ordinary skill in the art, and not whether the reference expressly uses the term low-density generator matrix or identifies matrix $\mathbf{H}^d$ as such.

We determine, on the record before us, that Petitioner has presented sufficient argument and evidence to support the finding that it will prevail in showing that Ping teaches the low-density generator matrix limitation of claim 13, and that Petitioner has met its burden of demonstrating a likelihood of success in showing that claim 13 would have been obvious in view of Ping, MacKay, Divsalar, and Luby97.

D. The Alleged Obviousness of Claim 17 Over Ping, MacKay, Divsalar, and the Pfister Slides

Petitioner's argument for dependent claim 17, which adds the requirement of a second accumulator, relies on the Pfister Slides (Ex. 1022) to teach the additional limitation. Pet. 71–72. Patent Owner argues that Petitioner has failed to establish that the Pfister Slides qualify as prior art. Prelim. Resp. 24–27.

Petitioner contends that Paul Siegel presented the Pfister Slides at the Allerton Conference in September 1999. Pet. 37–38 (citing Declaration of Paul Siegel, Ex. 1023, 3). Patent Owner correctly argues that the Petition is devoid of any explanation or argument as to why or how the Pfister Slides qualify as prior art. Prelim. Resp. 24–25. Indeed, the Petition makes no attempt to show how the Pfister Slides qualify as a "printed publication" under 35 U.S.C. § 311(b), which limits *inter partes* reviews to challenges based on patents and printed publications.

We look to the underlying facts to make a legal determination as to whether a reference is a printed publication. *Suffolk Techs., LLC v. AOL Inc.*, 752 F.3d 1358, 1364 (Fed. Cir. 2014). The determination of whether a given reference qualifies as a prior art "printed publication" involves a case-by-case inquiry into the facts and circumstances surrounding its disclosure to members of the public. *In re Klopfenstein*, 380 F.3d 1345, 1350 (Fed. Cir. 2004). The key inquiry is whether the reference was made "sufficiently accessible to the public interested in the art" before the critical date. *In re Cronyn*, 890 F.2d 1158, 1160 (Fed. Cir. 1989); *see In re Wyer*, 655 F.2d 221, 226 (CCPA 1981). "A given reference is 'publicly accessible' upon a satisfactory showing that such document has been disseminated or otherwise made available to the extent that persons interested and ordinarily skilled in the subject matter or art exercising reasonable diligence, can locate it." *Bruckelmyer v. Ground Heaters, Inc.*, 445 F.3d 1374, 1378 (Fed. Cir. 2006) (citation omitted).

With respect to slide presentations, Federal Circuit case law and a prior opinion from our Board have found that the mere presentation of slides at a professional conference is not *per se* a prior art printed publication. *Klopfenstein*, 380 F.3d at 1349 n.4; *Temporal Power Ltd. v. Beacon Power, LLC*, Case IPR2015-00146, slip op. at 8–11 (PTAB April 27, 2015) (Paper 10).

In the present case, Petitioner cites to a specific page of Mr. Siegel's declaration that does not support a conclusion that the Pfister Slides qualify as a printed publication. Pet. 37–38 (citing Ex. 1023, 3). Mr. Siegel's declaration in its entirety does not address the factors cited in *In re Klopfenstein* as to whether the slides in question qualify as a printed publication. *See* Ex. 1023. The Petition and Mr. Siegel's declaration merely support the assertion that a presentation took place, but fail to provide sufficient evidence or argument regarding whether the Pfister Slides were published or how the Pfister Slides were made accessible to the relevant public, among other issues raised by slide presentations. *See, e.g., Klopfenstein*, 380 F.3d at 1350; *Temporal Power Ltd.*, IPR2015-00146, Paper 10 at 8–11.

With respect to the Pfister Slides, Petitioner fails to meet the burden imposed under § 314(a) to establish in its Petition a reasonable likelihood of success, which includes, among other things, making a threshold showing that the Pfister Slides qualify as a prior art printed publication. Accordingly, we determine that Petitioner has not demonstrated a likelihood of showing that claim 17 would have been obvious over Ping, MacKay, Divsalar, and the Pfister Slides.

III. CONCLUSION

Petitioner has demonstrated that there is a reasonable likelihood of establishing the unpatentability of claims 11–16 of the '032 patent. Petitioner has not demonstrated that there is a reasonable likelihood of establishing the unpatentability of claim 17 of the '032 patent.

IV. ORDER

For the foregoing reasons, it is

ORDERED that, pursuant to 35 U.S.C. § 314, *inter partes* review is instituted as to claims 11–16 of the '032 patent on the following grounds of unpatentability:

Claims 11, 12, and 14–16 as obvious over Ping, MacKay, and Divsalar pursuant to 35 U.S.C. § 103(a);

Claim 13 as obvious over Ping, MacKay, Divsalar, and Luby97 pursuant to 35 U.S.C. § 103(a);

FURTHER ORDERED that *inter partes* review is commenced on the entry date of this Order, and pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial; and

FURTHER ORDERED that the trial is limited to the grounds of unpatentability listed above, and no other grounds of unpatentability are authorized for *inter partes* review.

For PETITIONER:

Richard Goldenberg
Brian Seeve
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brian.seeve@wilmerhale.com

For PATENT OWNER:

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Matthew Argenti
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rtorczon@wsgr.com

ORIGINAL

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following ☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
CV13-07245	10/01/2013	Central District of California

PLAINTIFF	DEFENDANT
The California Institute of Technology	Hughes Communications, Inc., Hughes Network Systems, LLC, DISH Network Corporation, DISH Network L.L.C., dishNET Satellite Broadband L.L.C.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,116,710	10/3/2006	California Institute of Technology
2 7,421,032	9/2/2008	California Institute of Technology
3 7,916,781	3/29/2011	California Institute of Technology
4 8,284,833	10/9/2012	California Institute of Technology
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
see attached Order of Dismissal

FILED
2013 OCT -1 AM 10: 21
CLERK U.S. DISTRICT COURT
CENTRAL DIST. OF CALIF.
LOS ANGELES
BY

CLERK	(BY) DEPUTY CLERK	DATE
KIRY K. GRAY		5/31/16

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Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

JS-6

FILED
CLERK, U.S. DISTRICT COURT
MAY 31, 2016
CENTRAL DISTRICT OF CALIFORNIA
BY: BH DEPUTY

UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY, a California corporation,

Plaintiff,

vs.

HUGHES COMMUNICATIONS, INC., a Delaware corporation, HUGHES NETWORK SYSTEMS, LLC, a Delaware limited liability company, DISH NETWORK CORPORATION, a Nevada corporation, DISH NETWORK L.L.C., a Colorado limited liability company, and DISHNET SATELLITE BROADBAND L.L.C., a Colorado limited liability company,

Defendants.

CASE NO. 2:13-CV-7245 MRP-JEM

[~~PROPOSED~~] ORDER OF DISMISSAL

CAME ON THIS DAY for consideration of the Joint Stipulated Motion for Dismissal with Prejudice of all claims, defenses, and counterclaims asserted between Caltech and Defendants, and the Court being of the opinion that said motion should be GRANTED, it is hereby ORDERED, ADJUDGED AND DECREED that all claims, defenses, and counterclaims in this action asserted in this suit between Caltech and Defendants are hereby dismissed with prejudice.

It is further ORDERED that all attorneys' fees and costs are to be borne by the party that incurred them. .

IT IS SO ORDERED.

DATED: May 27, 2016

Honorable George H. King
Chief United States District Court Judge

AO 120 (Rev. 08/10)

TO: **Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 2:15-cv-01108	DATE FILED 2/17/2015	U.S. DISTRICT COURT Central District of California
PLAINTIFF The California Institute of Technology		DEFENDANT Hughes Communications, Inc., Hughes Network Systems, LLC, DISH Network Corporation, DISH Network L.L.C., and dishNET Satellite Broadband, L.L.C.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,116,710	10/3/2006	California Institute of Technology
2 7,421,032	9/2/2008	California Institute of Technology
3 7,916,781	3/29/2011	California Institute of Technology
4 8,284,833	10/9/2012	California Institute of Technology
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT
see attached Order of Dismissal

CLERK	(BY) DEPUTY CLERK	DATE
KIRY K. GRAY		5/31/16

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

JS-6

FILED
CLERK, U.S. DISTRICT COURT
MAY 31, 2016
CENTRAL DISTRICT OF CALIFORNIA
BY: BH DEPUTY

UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY, a California corporation,

Plaintiff,

vs.

HUGHES COMMUNICATIONS, INC., a Delaware corporation, HUGHES NETWORK SYSTEMS, LLC, a Delaware limited liability company, DISH NETWORK CORPORATION, a Nevada corporation, DISH NETWORK L.L.C., a Colorado limited liability company, and DISHNET SATELLITE BROADBAND L.L.C., a Colorado limited liability company,

Defendants.

CASE NO. 2:15-CV-01108-MRP-JEM

[~~PROPOSED~~] ORDER OF DISMISSAL

CAME ON THIS DAY for consideration of the Joint Stipulated Motion for Dismissal with Prejudice of all claims, defenses, and counterclaims asserted between Caltech and Defendants, and the Court being of the opinion that said motion should be GRANTED, it is hereby ORDERED, ADJUDGED AND DECREED that all claims, defenses, and counterclaims in this action asserted in this suit between Caltech and Defendants are hereby dismissed with prejudice.

It is further ORDERED that all attorneys' fees and costs are to be borne by the party that incurred them.

IT IS SO ORDERED.

DATED: May 27, 2016

Honorable George H. King
Chief United States District Court Judge

AO 120 (Rev. 08/10)

TO: **Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 2:16-cv-3714	DATE FILED 5/26/2016	U.S. DISTRICT COURT Central District of California
PLAINTIFF California Institute of Technology		DEFENDANT Broadcom Limited, Broadcom Corporation, Avago Technologies Limited, Apple Inc.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,116,710	10/3/2006	California Institute of Technology
2 7,421,032	9/2/2008	California Institute of Technology
3 7,916,781	3/29/2011	California Institute of Technology
4 8,284,833	10/9/2012	California Institute of Technology
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

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AO 120 (Rev. 08/10)

TO: **Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

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☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:15-cv-01108	2/17/2015	Central District of California

PLAINTIFF	DEFENDANT
The California Institute of Technology	Hughes Communications, Inc., Hughes Network Systems, LLC, DISH Network Corporation, DISH Network L.L.C., and dishNET Satellite Broadband, L.L.C.

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In the above—entitled case, the following patent(s)/ trademark(s) have been included:

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DECISION/JUDGEMENT

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AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Central District of California on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. CV13-07245	DATE FILED 10/01/2013	U.S. DISTRICT COURT Central District of California
PLAINTIFF The California Institute of Technology		DEFENDANT Hughes Communications, Inc., Hughes Network Systems, LLC, DISH Network Corporation, DISH Network L.L.C., dishNET Satellite Broadband L.L.C.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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2 7,421,032	9/2/2008	California Institute of Technology
3 7,916,781	3/29/2011	California Institute of Technology
4 8,284,833	10/9/2012	California Institute of Technology
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

FILED

2013 OCT -1 AM 10:21

CLERK U.S. DISTRICT COURT
CENTRAL DIST. OF CALIF.
LOS ANGELES

BY

CLERK	(BY) DEPUTY CLERK	DATE

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Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C

CONFIRMATION NO. 6431

POWER OF ATTORNEY NOTICE

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

OC000000049381139

Date Mailed: 08/18/2011

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/10/2011.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

/snguyen/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	CIT 3220-C

CONFIRMATION NO. 6431

POA ACCEPTANCE LETTER

OC000000049381190

29690
CALIFORNIA INSTITUTE OF TECHNOLOGY
1200 E.CALIFORNIA BLVD.
M/C 201-85
PASADENA, CA 91125

Date Mailed: 08/18/2011

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/10/2011.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/snguyen/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

POWER OF ATTORNEY OR REVOCATION OF POWER OF ATTORNEY WITH A NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS

Application Number	11/542,950
Filing Date	October 3, 2006
First Named Inventor	Robert J. McEliece
Title	Serial Concatenation of Interleaved...
Art Unit	
Examiner Name	
Attorney Docket Number	CIT 3220-C

I hereby revoke all previous powers of attorney given in the above-identified application.

☐ A Power of Attorney is submitted herewith.

OR

☒ I hereby appoint Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith: **29690**

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

Practitioner(s) Name	Registration Number

Please recognize or change the correspondence address for the above-identified application to:

☒ The address associated with the above-mentioned Customer Number.

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☐ Applicant/Inventor.

OR

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) (Form PTO/SB/96) submitted herewith or filed on ______________________.

SIGNATURE of Applicant or Assignee of Record

Signature	/Fred Farina/	Date	June 1, 2011
Name	Fred Farina	Telephone	(626) 395-3058
Title and Company	Chief Innovation Officer, California Institute of Technology		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☒ *Total of 1 forms are submitted.

PTO/SB/96 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Robert J. McEliece, Hui Jin, Aamod Khandekar

Application No./Patent No.: 11/542,950 Filed/Issue Date: 10/03/2006

Titled: Serial Concatenation of Interleaved Convolutional Codes Forming Turbo-Like Codes

California Institute of Technology, a University
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. ☐ the assignee of the entire right, title, and interest in;

2. ☐ an assignee of less than the entire right, title, and interest in
(The extent (by percentage) of its ownership interest is ______ %); or

3. ☒ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 018470, Frame 0321, or for which a copy therefore is attached.

OR

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: ______ To: ______
The document was recorded in the United States Patent and Trademark Office at
Reel ______, Frame ______, or for which a copy thereof is attached.

2. From: ______ To: ______
The document was recorded in the United States Patent and Trademark Office at
Reel ______, Frame ______, or for which a copy thereof is attached.

3. From: ______ To: ______
The document was recorded in the United States Patent and Trademark Office at
Reel ______, Frame ______, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Fred Farina/	7/21/2011
Signature	Date
Fred Farina	Chief Innovation Officer, OTT
Printed or Typed Name	Title

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	10708586
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	Case Kyn Cortese/Kim Bowman
Filer Authorized By:	Case Kyn Cortese
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	10-AUG-2011
Filing Date:	03-OCT-2006
Time Stamp:	16:50:00
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	CIT-3220-C-POA.pdf	32411 4c1bcf23a7916b1f11323cea337ca9658269f2bf	no	1

Warnings:

Information:

2	Oath or Declaration filed	CIT-3220-C-Cert.pdf	432476 544d8c0f0ad96aef39ec5462ab1e8912a0754d04	no	2

Warnings:

Information:

Total Files Size (in bytes):	464887

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<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C

CONFIRMATION NO. 6431

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

MISCELLANEOUS NOTICE

OC000000048314768

Date Mailed: 06/22/2011

A communication which cannot be delivered in electronic form has been mailed to the applicant.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C

CONFIRMATION NO. 6431

OC000000048314768

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Cc: CALIFORNIA INSTITUTE OF TECHNOLOGY
1200 E.CALIFORNIA BLVD.
M/C 201-85
PASADENA, CA 91125

Date Mailed: 06/21/11

DENIAL OF REQUEST FOR POWER OF ATTORNEY

The request for Power of Attorney filed 06/14/11 is acknowledged. However, the request cannot be granted at this time for the reason stated below.

- ☐ The Power of Attorney you provided did not comply with the new Power of Attorney rules that became effective on June 25, 2004. See 37 CFR 1.32.
- ☐ The revocation is not signed by the applicant, the assignee of the entire interest, or one particular principal attorney having the authority to revoke.
- ☑ The Power of Attorney is from an assignee and the Certificate required by 37 CFR 3.73(b) has not been received.
- ☐ The person signing for the assignee has omitted their empowerment to sign on behalf of the assignee.
- ☐ The inventor(s) is without authority to appoint attorneys since the assignee has intervened as provided by 37 CFR 3.71.
- ☐ The signature(s) of ____________________, a co-inventor in this application, has been omitted. The Power of Attorney will be entered upon receipt of confirmation signed by said co-inventor(s).
- ☐ The person(s) appointed in the Power of Attorney is not registered to practice before the U.S. Patent and Trademark Office.

Questions relating to this Notice should be directed to the Application Assistance Unit.

H-S

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/81 (01-09)
Approved for use through 11/30/2011. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY OR REVOCATION OF POWER OF ATTORNEY WITH A NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS

Application Number	11/542,950
Filing Date	October 3, 2006
First Named Inventor	Robert J. McEliece
Title	Serial Concatenation of Interleaved...
Art Unit	
Examiner Name	
Attorney Docket Number	CIT 3220-C

I hereby revoke all previous powers of attorney given in the above-identified application.

☐ A Power of Attorney is submitted herewith.

OR

☒ I hereby appoint Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith: 29690

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

Practitioner(s) Name	Registration Number

Please recognize or change the correspondence address for the above-identified application to:

☒ The address associated with the above-mentioned Customer Number.

OR

☐ The address associated with Customer Number:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☐ Applicant/Inventor.

OR

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) (Form PTO/SB/96) submitted herewith or filed on ____________________________.

SIGNATURE of Applicant or Assignee of Record

Signature	/Fred Farina/	Date	June 1, 2011
Name	Fred Farina	Telephone	(626) 395-3058
Title and Company	Chief Innovation Officer, California Institute of Technology		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☒ *Total of 1 forms are submitted.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	10303629
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	Hannah Dvorak-Carbone/Melinda Bakarbessy
Filer Authorized By:	Hannah Dvorak-Carbone
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	14-JUN-2011
Filing Date:	03-OCT-2006
Time Stamp:	18:18:01
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	CIT-3220-C.pdf	1467277 08145b64389dab73e5b2207351bba481a7a71ba5	no	2

Warnings:

Information:

Total Files Size (in bytes):	1467277

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,421,032 B2 Page 1 of 1
APPLICATION NO. : 11/542950
DATED : September 2, 2008
INVENTOR(S) : Hui Jin, Aamod Khandekar and Robert J. McEliece

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

At column 4, line 14, please delete " $x_j = x_{j-1} + \sum_{i=1}^{\lambda} v_{(j-1)\lambda+i}$ " and insert

-- $x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$ --.

In claim 1, column 8, line 4, please delete " $x_j = x_{j-1} + \sum_{i=1}^{\lambda} v_{(j-1)\lambda+i}$, " and insert

-- $x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$, --.

In claim 1, column 8, line 13, please delete " $\sum_{i=1}^{a} v_{(j-1)a+1}$ " and insert

-- $\sum_{i=1}^{a} v_{(j-1)a+i}$ --.

Signed and Sealed this

Twenty-seventh Day of July, 2010

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: Hui Jin et al.	Art Unit	: 2611
Patent No.	: 7,421,032	Examiner	: Dac V. Ha
Issue Date	: September 2, 2008		
Serial No.	: 11/542,950		
Filed	: October 3, 2006		
Title	: SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES		

Attn.: Certificate of Corrections Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF REQUEST FOR CERTIFICATE OF CORRECTION

Applicant hereby requests that a Certificate of Correction be issued for the above patent in accordance with the attached request.

One or more of the errors sought to be corrected were made by applicant.

Please apply the required fee under 37 CFR §1.20(a) in the amount of $100 to Deposit Account No. 06-1050.

Respectfully submitted,

Date: June 15, 2010

/John F. Conroy, Reg. #45,485/
John F. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. **20985**
12390 El Camino Real
San Diego, California 92130
Telephone: (858) 678-5070
Facsimile: (858) 678-5099

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

Page 1 of 2

PATENT NO. .: 7,421,032
APPLICATION NO .: 11/542,950
DATED .: SEPTEMBER 2, 2008
INVENTOR(S) .: HUI JIN, AAMOD KHANDEKAR AND ROBERT J. MCELIECE

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

At column 4, line 14, please delete “ $x_j = x_{j-1} + \sum_{i=1}^{\lambda} v_{(j-1)\lambda+i}$ ” and insert

-- $x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$ --.

In claim 1, column 8, line 4, please delete “ $x_j = x_{j-1} + \sum_{i=1}^{\lambda} v_{(j-1)\lambda+i}$,” and insert

-- $x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$,--.

In claim 1, column 8, line 13, please delete “ $\sum_{i=1}^{a} v_{(j-1)a+1}$ ” and insert

-- $\sum_{i=1}^{a} v_{(j-1)a+i}$ --.

MAILING ADDRESS OF SENDER:

John F. Conroy
Fish & Richardson P.C.
P.O. Box 1022
Minneapolis, Minnesota 55440-1022

Electronic Patent Application Fee Transmittal

Application Number:	11542950
Filing Date:	03-Oct-2006
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Filer:	John F. Conroy/Jennifer Canarelli
Attorney Docket Number:	06618-637002/CIT3220-C

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Certificate of correction	1811	1	100	100
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**100**

Electronic Acknowledgement Receipt

EFS ID:	7818509
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	John F. Conroy/Jennifer Canarelli
Filer Authorized By:	John F. Conroy
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	15-JUN-2010
Filing Date:	03-OCT-2006
Time Stamp:	16:26:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$100
RAM confirmation Number	3023
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Request for Certificate of Correction	06618-0637002_CertCorr.pdf	64106 e46abf9885cf7010794e25bc001c99b87cea6b00	no	2
Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee-info.pdf	30139 c574b53b47425d9af8135d911799fdf702cf6645	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	94245		

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New Applications Under 35 U.S.C. 111
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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,421,032 B2 — Page 1 of 1
APPLICATION NO. : 11/542950
DATED : September 2, 2008
INVENTOR(S) : Hui Jin, Aamod Khandekar and Robert J. McEliece

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title Page, item [73] (Assignee), line 1, please delete "Callifornia" and insert --California--, therefor.

Claim 11, Column 9, line 28, delete "V_1" and insert --V_r--, therefor.

Claim 11, Column 9, line 29, delete "U_1" and insert --U_k--, therefor.

Claim 11, Column 9, line 29, delete "X_1" and insert --X_r--, therefor.

Claim 18, Column 10, line 35, delete "V_1" and insert --V_r--, therefor.

Claim 18, Column 10, line 36, delete "U_1" and insert --U_k--, therefor.

Claim 18, Column 10, line 37, delete "X_1" and insert --X_r--, therefor.

Signed and Sealed this

Seventeenth Day of February, 2009

John Doll

JOHN DOLL
Acting Director of the United States Patent and Trademark Office

Attorney's Docket No.: 06618-0637002 / 3220-C

-IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	: Hui Jin et al.	Art Unit	: 2611
Patent No.	: 7,421,032	Examiner	: Dac V. Ha
Issue Date	: September 2, 2008		
Serial No.	: 11/542,950		
Filed	: October 3, 2006		
Title	: SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES		

Attn.: Certificate of Corrections Branch
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF REQUEST FOR CERTIFICATE OF CORRECTION

Applicant hereby requests that a certificate of correction be issued for the above patent in accordance with the attached request.

All errors sought to be corrected were made in printing by the Patent and Trademark Office, and no fee is believed to be due.

Please apply any charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: January 12, 2009

/John F. Conroy, Reg. #45,485/
John F. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. **20985**
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San Diego, California 92130
Telephone: (858) 678-5070
Facsimile: (858) 678-5099

Staple Here Only

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

Page 1 of 1

PATENT NO. .: 7,421,032
APPLICATION NO .: 11/542,950
DATED .: SEPTEMBER 2, 2008
INVENTOR(S) .: HUI JIN, AAMOD KHANDEKAR AND ROBERT J. MCELIECE

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

At page 1, column 1 (Assignee), line 1, please delete --Callifornia-- and insert "California", therefor.

Claim 11, Column 9, line 28, delete --V_1-- and insert "V_r", therefor.

Claim 11, Column 9, line 29, delete --U_1-- and insert "U_k", therefor.

Claim 11, Column 9, line 29, delete --X_1-- and insert "X_r", therefor.

Claim 18, Column 10, line 35, delete --V_1-- and insert "V_r", therefor.

Claim 18, Column 10, line 36, delete --U_1-- and insert "U_k", therefor.

Claim 18, Column 10, line 37, delete --X_1-- and insert "X_r", therefor.

MAILING ADDRESS OF SENDER:

John F. Conroy
Fish & Richardson P.C.
P.O. Box 1022
Minneapolis, Minnesota 55440-1022

Electronic Acknowledgement Receipt

EFS ID:	4593308
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	John F. Conroy/Jennifer Payne
Filer Authorized By:	John F. Conroy
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	12-JAN-2009
Filing Date:	03-OCT-2006
Time Stamp:	12:41:47
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Certificate of Correction	06618-0637002_CertCorr.pdf	55692 1b085caff733714c4f192f9e4805390898b38cfe	no	2

Warnings:

Information:

Total Files Size (in bytes):	55692

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	09/02/2008	7421032	06618-637002/CIT3220-C	6431

20985 7590 08/13/2008

FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Hui Jin, Glen Gardner, NJ;
Aamod Khandekar, Pasadena, CA;
Robert J. McEliece, Pasadena, CA;

IR103 (Rev. 11/05)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C	6431

20985 7590 06/02/2008

FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER	
HA, DAC V	

ART UNIT	PAPER NUMBER
2611	

MAIL DATE	DELIVERY MODE
06/02/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Response to Rule 312 Communication	**Application No.**	**Applicant(s)**
	11/542,950	JIN ET AL.
	Examiner	**Art Unit**
	Dac V. Ha	2611

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address –

1. ☒ The amendment filed on *23 May 2008* under 37 CFR 1.312 has been considered, and has been:

   a) ☒ entered.

   b) ☐ entered as directed to matters of form not affecting the scope of the invention.

   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
   Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

   d) ☐ disapproved. See explanation below.

   e) ☐ entered in part. See explanation below.

05/28/08

/Dac V. Ha/
Primary Examiner, Art Unit 2611

Notice of Allowability	**Application No.** 11/542,950	**Applicant(s)** JIN ET AL.	
	Examiner Dac V. Ha	**Art Unit** 2611	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *amendment filed on 02/13/08*.
2. ☒ The allowed claim(s) is/are *1-12, 14-17, 13, 18, 19, 21-24, renumbered as 1-23, respectively*.
3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Dac V. Ha
Primary Examiner
Art Unit: 2611

Allowable Subject Matter

1. Claims 1-19, 21-24 are allowed.

2. The following is a statement of reasons for the indication of allowable subject matter:

Applicant has amended the claims in accordance with the office action dated 09/06/07. Upon further consideration, prior art of record, taking individually or collectively, fails to fairly teach method and apparatus for encoding the signal as particularly claimed in independent claims 1, 11, 18 (claims 2-10, 12-17, 19, 21-24 depend therefrom). Thus, claims 1-19, 21-24 are found to be novel and unobvious over prior art of record.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dac V. Ha whose telephone number is 571-272-3040. The examiner can normally be reached on 4/4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Payne can be reached on 571-272-3024. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic

Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dac V. Ha
Primary Examiner
Art Unit 2611

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/542,950	JIN ET AL.	
	Examiner	**Art Unit**	
	Dac V. Ha	2611	

ISSUE CLASSIFICATION

ORIGINAL						CROSS REFERENCE(S)							
CLASS				SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)							
375				262	375	265	348						
INTERNATIONAL CLASSIFICATION					714	755	786	792					
H	0	4	L	5/12	341	52	102						
				/									
				/									
				/									
				/									

		Total Claims Allowed: 23	
(Assistant Examiner) (Date)	Dac V. Ha	O.G. Print Claim(s)	O.G. Print Fig.
(Legal Instruments Examiner) (Date)	(Primary Examiner) (Date)	1	3

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		31		61		91		121		151		181
	2		32		62		92		122		152		182
	3		33		63		93		123		153		183
	4		34		64		94		124		154		184
	5		35		65		95		125		155		185
	6		36		66		96		126		156		186
	7		37		67		97		127		157		187
	8		38		68		98		128		158		188
	9		39		69		99		129		159		189
	10		40		70		100		130		160		190
	11		41		71		101		131		161		191
	12		42		72		102		132		162		192
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	14		44		74		104		134		164		194
	15		45		75		105		135		165		195
	16		46		76		106		136		166		196
	17		47		77		107		137		167		197
	18		48		78		108		138		168		198
	19		49		79		109		139		169		199
	20		50		80		110		140		170		200
	21		51		81		111		141		171		201
	22		52		82		112		142		172		202
	23		53		83		113		143		173		203
	24		54		84		114		144		174		204
	25		55		85		115		145		175		205
	26		56		86		116		146		176		206
	27		57		87		117		147		177		207
	28		58		88		118		148		178		208
	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

Office Action Summary	**Application No.** 11/542,950	**Applicant(s)** JIN ET AL.	
	Examiner Dac V. Ha	**Art Unit** 2611	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _03 October 2006_.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-24_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) _1-17_ is/are allowed.

6)☒ Claim(s) _18,19 and 21-24_ is/are rejected.

7)☒ Claim(s) _20_ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on _03 October 2006_ is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 18, 19, 21-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lin (US 5,530,707) in view of Hammons et al. (US 6,859,906) (hereafter Hommons).

Regarding claim 18, Lin discloses the claimed subject matter "decoder configured to decode a received data stream" "the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes" in Fig. 2(a), 3(a); col. 10,lines 15-63). Lin differs from the claimed invention in that Lin doesn't discloses a received data stream "that includes a collection of parity bits". However, such use of parity bits in the art of encoding (i.e. turbo encoding) is well known (see Hammons, col. 1, line 56 to col. 2, line 13). Thus, it would have been easily to one skilled in the art to realized that the decoder discloses by Lin would also decode signal that includes parity bits.

Regarding claim 19, Lin further discloses the claimed subject matter “wherein the message passing decoder is configured to decode the received data stream that includes the message bits” in col. 9, line 51 to col. 10, line 63.

Regarding claim 21, Lin discloses the claimed subject matter “wherein the message passing decoder is configured to decode the received data stream as if a number of inputs into nodes v_i was not constant in Fig. 2(a); 3(a); 4(a).

Regarding claims 22-24, theses claimed subject matter would have been easily realized by one skilled in the art as conventional.

Allowable Subject Matter

3. Claims 1-17 are allowed.

4. Claim 20 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

5. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Miller et al. (US 6,094,739).

Meyer (US 5,802,115)

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dac V. Ha whose telephone number is 571-272-3040. The examiner can normally be reached on 4/4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Payne can be reached on 571-272-3024. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dac V. Ha
Primary Examiner
Art Unit 2611

Notice of References Cited	Application/Control No. 11/542,950	Applicant(s)/Patent Under Reexamination JIN ET AL.	
	Examiner Dac V. Ha	Art Unit 2611	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-5,530,707	06-1996	Lin, Horng-Dar	714/792
*	B	US-6,859,906	02-2005	Hammons et al.	714/786
*	C	US-6,094,739	07-2000	Miller et al.	714/792
*	D	US-5,802,115	09-1998	Meyer, Jacques	375/341
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No. 11/542,950	Applicant(s)/Patent under Reexamination JIN ET AL.	
	Examiner Dac V. Ha	Art Unit 2611	

SEARCHED

Class	Subclass	Date	Examiner
375	259,262	8/27/2007	DH
	265,285		
	296,341		
	346,348		
714	746,752		
	755,756		
	786,792		
	794-796		
341	51,52,56		
	102,103		

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
BRS	8/27/2007	DH

U.S. Patent and Trademark Office Part of Paper No. 20070828

Index of Claims

Application/Control No.	Applicant(s)/Patent under Reexamination	
11/542,950	JIN ET AL.	
Examiner	**Art Unit**	
Dac V. Ha	2611	

√	**Rejected**	–	**(Through numeral) Cancelled**	N	**Non-Elected**	A	**Appeal**
=	**Allowed**	÷	**Restricted**	I	**Interference**	O	**Objected**

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Hui Jin et al. Art Unit : 2611
Serial No. : 11/542,950 Examiner : Dac V. Ha
Filed : October 3, 2006
Title : SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

MAIL STOP ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Notice of Allowance Date: February 25, 2008

RESPONSE TO NOTICE OF ALLOWANCE

In response to the Notice of Allowance mailed February 25, 2008, enclosed is a completed issue fee transmittal form PTOL-85b. Also enclosed is an Application Data Sheet, an Amendment under 37 CFR § 1.312, and a Request for Corrected Filing Receipt.

COMMENTS ON EXAMINER'S REASONS FOR ALLOWANCE

It is agreed that the limitations recited in the examiner's Reasons for Allowance are not taught or suggested by the art of record, and that the allowed independent claims 1, 11, and 18 are distinguished from the cited prior art for at least the reasons stated in the Reasons for Allowance. Applicant does not concede that the stated reasons are the only grounds for patentability of the allowed claims, that the limitations excluded from the Reasons for Allowance are taught or suggested by the art of record, or that all of the limitations are necessary for patentability of the allowed claims or other claims directed to the disclosed subject matter. For example, other claims including different limitations are patentable over the cited prior art.

Please apply the required fees in the amount of $1,020 to our Deposit Account No. 06-1050.

Respectfully submitted,

Date: May 23, 2008

/John F. Conroy, Reg. # 45,485/
John F. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. **20985**
12390 El Camino Real
San Diego, California 92130
Telephone: (858) 678-5070
Facsimile: (858) 678-5099

10833903.doc

PART B – FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571) 273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 4 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Legibly mark-up with any corrections or use Block 1)

20985 7590 02/25/2008

FISH & RICHARDSON P.C.
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C	6431

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

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$720	$300	$1020	05/25/2008

EXAMINER	ART UNIT	CLASS-SUBCLASS
HA, DAC V.	2611	375-262000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

[ ] Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

[ ] "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1. Fish & Richardson P.C.
2. ____
3. ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been previously submitted to the USPTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: California Institute of Technology

(B) RESIDENCE (CITY and STATE OR COUNTRY): Pasadena, CA

Please check the appropriate assignee category or categories (will not be printed on the patent): [ ] individual [X] corporation or other private group entity [ ] government

4a. The following fee(s) are enclosed:
[X] Issue Fee
[X] Publication Fee (No small entity discount permitted)
[ ] Advance Order - # of Copies ____

4b. Payment of Fee(s):
[ ] A check in the amount of the fee(s) is enclosed.
[ ] Payment by credit card. Form PTO-2038 is attached.
[X] The Director is hereby authorized to charge the required fee(s), or credit any overpayment, to Deposit Account Number 06-1050 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
[ ].a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
[ ]b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant, a registered agent or; or the assignee or other party in interest as shown by the records of the Untied States Patent and Trademark Office.

(Authorized Signature) /John F. Conroy, Reg. # 45,485/ (Date) May 23, 2008

Typed or Printed Name John F. Conroy Registration No. 45,485

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMIT THIS FORM WITH FEE(S)

SUBSTITUTE PTOL-85 (Rev. 12/04) Approved for use through 04/30/2007. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Attorney Docket No. 06618-637002/3220-C

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Hui Jin et al. Art Unit: 2611
Serial No.: 11/542,950 Examiner: Dac V. Ha
Filed : October 3, 2006
Title : SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

MAIL STOP ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Notice of Allowance Date: February 25, 2008

AMENDMENT UNDER 37 C.F.R. §1.312

Please amend the application as indicated below. This amendment is being filed concurrently with the payment of the issue fee.

Amendments to the Specification begin on page **2**.

Remarks begin on page **3** of this paper.

Amendments to the Specification:

Please replace paragraph **[0001]**, beginning at page **1**, with the following amended paragraph:

This application is a continuation of U.S. application serial no. 09/861,102, filed May 18, 2001, now U.S. patent no. 7,116,710, which claims the priority [[to]] of U.S. provisional application serial no. 60/205,095, filed May 18, 2000, and ~~to~~ is a continuation-in-part of U.S. application serial no. 09/922,852, filed August 18, 2000, now U.S. patent no. 7,089,477.

REMARKS

Applicant respectfully requests entry of the amendment to the specification as filed herewith. The amendment clarifies the priority claim listed in the specification. No new matter has been added.

Please apply any credits or additional charges to deposit account 06-1050.

Respectfully submitted,

Date: May 23, 2008

/John F. Conroy, Reg. # 45,485/
John F. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. **20985**
12390 El Camino Real
San Diego, California 92130
Telephone: (858) 678-5070
Facsimile: (858) 678-5099

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	11/542,950
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority	◉ Inventor	◯ Legal Representative under 35 U.S.C. 117	◯ Party of Interest under 35 U.S.C. 118		
Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**	
	Hui		Jin		
Residence Information (Select One)	◉ US Residency	◯ Non US Residency	◯ Active US Military Service		
City		**State/Province**		**Country of Residence** i	US
Citizenship under 37 CFR 1.41(b) i	CN				
Mailing Address of Applicant:					
Address 1					
Address 2					
City		**State/Province**			
Postal Code		**Country**i			

Applicant 2 Remove

Applicant Authority	◉ Inventor	◯ Legal Representative under 35 U.S.C. 117	◯ Party of Interest under 35 U.S.C. 118		
Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**	
	Aamod		Khandekar		
Residence Information (Select One)	◉ US Residency	◯ Non US Residency	◯ Active US Military Service		
City		**State/Province**		**Country of Residence** i	
Citizenship under 37 CFR 1.41(b) i	IN				
Mailing Address of Applicant:					
Address 1					
Address 2					
City		**State/Province**			
Postal Code		**Country**i			

Applicant 3 Remove

Applicant Authority	◉ Inventor	◯ Legal Representative under 35 U.S.C. 117	◯ Party of Interest under 35 U.S.C. 118		
Prefix	**Given Name**	**Middle Name**	**Family Name**	**Suffix**	
	Robert	J.	McEliece		
Residence Information (Select One)	◉ US Residency	◯ Non US Residency	◯ Active US Military Service		
City	Pasadena	**State/Province**	CA	**Country of Residence** i	US

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	11/542,950
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

Citizenship under 37 CFR 1.41(b) i	US		
Mailing Address of Applicant:			
Address 1	1086 Armada Dr.		
Address 2			
City	Pasadena	**State/Province**	CA
Postal Code	91103	**Country**i	US
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.	Add		

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ **An Address is being provided for the correspondence Information of this application.**			
Customer Number	20985		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES		
Attorney Docket Number	06618-637002	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)		**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	○ Customer Number	◉ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	11/542,950
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix	Remove
	John	F.	Conroy		
Registration Number	45485				

Additional Representative Information blocks may be generated within this form by selecting the **Add** button. Add

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Patented		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
11542950	Continuation of	09861102	2001-05-18
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
09861102	non provisional of	60205095	2000-05-18

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11542950	Continuation in part of	09922852	2000-08-18	7089477	2006-08-08

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country i	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			◯ Yes ◯ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

If the Assignee is an Organization check here. ☒

Organization Name	California Institute of Technology

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

Mailing Address Information:			
Address 1	1200 East California Boulevard		
Address 2			
City	Pasadena	**State/Province**	CA
Country i	US	Postal Code	91125
Phone Number		Fax Number	
Email Address			
Additional Assignee Data may be generated within this form by selecting the **Add** button.			Add

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.					
Signature	/John F. Conroy, Reg. # 45,485/			Date (YYYY-MM-DD)	2008-05-23
First Name	John	Last Name	Conroy	Registration Number	45485

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Attorney's Docket No.: 06618-637002 / CIT3220-C

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Hui Jin et al.	Art Unit	:	2611
Serial No.	:	11/542,950	Examiner	:	Dac V. Ha
Filed	:	October 3, 2006			
Title	:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES			

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CORRECTED OFFICIAL FILING RECEIPT

Please correct the Filing Receipt for the above-referenced application to include the correct priority data as claimed by the applicant as follows:

This application is a CON of 09/861,102 05/18/2001 PAT 7,116,710

which claims the benefit of 60/205,095 05/18/2000

and is a CIP of 09/922,852 08/18/2000 PAT 7,089,477

Please supply a corrected Filing Receipt to the undersigned with respect to this application. A copy of the original Filing Receipt showing the desired changes is attached for your convenience.

No fee is believed to be due. If, however, there are any charges or credits, please apply them to Deposit Account No. 06-1050.

Respectfully submitted,

Date: May 23, 2008

/John F. Conroy, Reg. # 45,485/
John F. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. **20985**
12390 El Camino Real
San Diego, California 92130
Telephone: (858) 678-5070
Facsimile: (858) 678-5099

10833728.doc

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C

CONFIRMATION NO. 6431

20985
FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Date Mailed: 09/25/2007

RESPONSE TO REQUEST FOR CORRECTED FILING RECEIPT

Domestic Continuity and Foreign Priority

In response to your request for a corrected Filing Receipt, the Office is unable to comply with the request because:

- ☐ The priority or continuity claim has not been entered because it was not filed during the required time period. Applicant may wish to consider filing a petition to accept an unintentionally delayed claim for priority. See 37 CFR 1.55 or 1.78.

- ☒ Continuity claimed under 35 U.S.C. § 120 cannot be added to the Filing Receipt without the applicant supplying the relationship (continuation, divisional, or continuation-in-part) in an Application Data Sheet or amendment to the first page of the specification.

- ☐ A claim for priority cannot be made based on an application filed after the application making the claim.

- ☐ Domestic benefit and foreign priority claims will not be captured in a provisional application. A provisional application is not entitled to a right of priority or to the benefit of an earlier filing date of any other application. See 35 U.S.C. § 111(b)(7) and 37 CFR 1.53(c)(4).

- ☐ A domestic continuity claim cannot be made to a foreign application and the filing receipt will only list the foreign country, application number, and filing date.

- ☐ Foreign priority will appear on the Filing Receipt in the following order: **Country, Application number, Filing date**.

- ☐ This application is the result of a conversion from a provisional application. Priority based on such application cannot be made since it no longer exists as a provisional application.

- ☐ The application(s) to which priority is claimed were filed over a year prior to the filing date of this application. Therefore, the referenced application(s) cannot be claimed as domestic or foreign priority.

- ☐ To change the benefit claim of a U.S. prior-filed application, applicant must amend the first sentence of the specification (if the benefit claim is referenced in the specification), or provide a supplemental application data sheet (ADS) (if the benefit claim was submitted in an ADS), with the desired benefit claim. Note that once a benefit claim is deleted, applicant will not be able to claim such prior-filed application again, if the above-identified application was filed on or after November 29, 2000.

- ☐ To change a foreign priority claim, applicant must submit a supplemental oath or declaration (if the priority claim is referenced in the oath or declaration), or a supplemental application data sheet (ADS) (if the priority claim was submitted in an ADS), with the desired priority claim. If a supplemental ADS is submitted, any deletions should be shown with strikeouts. Note that once a priority claim is deleted, applicant will not be able to claim such foreign application again, if the above-identified application was filed on or after November 29, 2000.

uw

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199

PART 1 - ATTORNEY/APPLICANT COPY

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPL NO.	FILING OR 371(c) DATE	ART UNIT	FIL FEE REC'D	ATTY.DOCKET NO	TOT CLMS	IND CLMS
11/542,950	10/03/2006	2611	600	06618-637002/CIT3220-C	24	3

CONFIRMATION NO. 6431

20985
FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

CORRECTED FILING RECEIPT

OC000000025998706

Date Mailed: 09/25/2007

Receipt is acknowledged of this nonprovisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).**

Applicant(s)

Hui Jin, Glen Gardner, NJ;
Aamod Khandekar, Pasadena, CA;
Robert J. McEliece, Pasadena, CA;

Power of Attorney:

David Feigenbaum--30378
Scott Harris--32030
John Phillips--35322
John Hayden--37640
Terry Stalford--39522
Bing Ai--43312
John Conroy--45485
William Hunter--47671

Domestic Priority data as claimed by applicant

This application is a CON of 09/861,102 05/18/2001 PAT 7,116,710
which claims benefit of 60/205,095 05/18/2000
<u>and is a CIP of 09/922,852 08/18/2000 PAT 7,089,477</u>

Foreign Applications

If Required, Foreign Filing License Granted: 10/25/2006

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is US11/542,950

Projected Publication Date: *Not Applicable*

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

Serial concatenation of interleaved convolutional codes forming turbo-like codes

Preliminary Class

375

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING

LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

Electronic Patent Application Fee Transmittal

Application Number:	11542950
Filing Date:	03-Oct-2006
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Filer:	John F. Conroy/Jennifer Payne
Attorney Docket Number:	06618-637002/CIT3220-C

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	720	720
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1020**

Electronic Acknowledgement Receipt

EFS ID:	3354540
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	John F. Conroy/mary ann reed
Filer Authorized By:	John F. Conroy
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	23-MAY-2008
Filing Date:	03-OCT-2006
Time Stamp:	20:29:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1020
RAM confirmation Number	4205
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)

1	Issue Fee Payment (PTO-85B)	06618-637002_IssueFee.pdf	68978 875ac85232bdf1665b5acc596528a0638633f9b1	no	3
Warnings:					
Information:					
2	Amendment after Notice of Allowance (Rule 312)	06618-637002_312Amend.pdf	26065 cc69159212eb77f37607037e442b891ba9f8b5f8	no	3
Warnings:					
Information:					
3	Application Data Sheet	06618-637002_ADS.pdf	1963741 ee84ae7e4366a3d47bc53fb42009b96f1d2449a0	no	5
Warnings:					
Information:					
4	Request for Corrected Filing Receipt	06618-637002_RequestCorrOFR.pdf	272221 bc17d718b6f666ee99610d648c2e272b411ff2d5	no	6
Warnings:					
Information:					
5	Fee Worksheet (PTO-06)	fee-info.pdf	8327 a01cd54527fed3a491fdf8bc9a3f66133a6f7db9	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2339332		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

20985 7590 02/25/2008

FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER	
HA, DAC V	
ART UNIT	PAPER NUMBER
2611	

DATE MAILED: 02/25/2008

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C	6431

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

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$720	$300	$0	$1020	05/27/2008

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20985 7590 02/25/2008

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Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C	6431

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

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$720	$300	$0	$1020	05/27/2008

EXAMINER	ART UNIT	CLASS-SUBCLASS
HA, DAC V	2611	375-262000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 __________
   2 __________
   3 __________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies __________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number __________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature __________ Date __________

Typed or printed name __________ Registration No. __________

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C	6431

20985 7590 02/25/2008

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MINNEAPOLIS, MN 55440-1022

EXAMINER	
HA, DAC V	
ART UNIT	PAPER NUMBER
2611	

DATE MAILED: 02/25/2008

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

Notice of Allowability	Application No. 11/542,950	Applicant(s) JIN ET AL.
	Examiner Dac V. Ha	Art Unit 2611

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *amendment filed on 02/13/08*.

2. ☒ The allowed claim(s) is/are *1-12, 14-17, 13, 18, 19, 21-24, renumbered as 1-23, respectively*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Dac V. Ha
Primary Examiner
Art Unit: 2611

Allowable Subject Matter

1. Claims 1-19, 21-24 are allowed.

2. The following is a statement of reasons for the indication of allowable subject matter:

Applicant has amended the claims in accordance with the office action dated 09/06/07. Upon further consideration, prior art of record, taking individually or collectively, fails to fairly teach method and apparatus for encoding the signal as particularly claimed in independent claims 1, 11, 18 (claims 2-10, 12-17, 19, 21-24 depend therefrom). Thus, claims 1-19, 21-24 are found to be novel and unobvious over prior art of record.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dac V. Ha whose telephone number is 571-272-3040. The examiner can normally be reached on 4/4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Payne can be reached on 571-272-3024. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic

Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dac V. Ha
Primary Examiner
Art Unit 2611

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/542,950	JIN ET AL.	
	Examiner	**Art Unit**	
	Dac V. Ha	2611	

ISSUE CLASSIFICATION

ORIGINAL						CROSS REFERENCE(S)							
CLASS	SUBCLASS				CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)							
375	262				375	265	348						
INTERNATIONAL CLASSIFICATION					714	755	786	792					
H	0	4	L	5/12	341	52	102						
				/									
				/									
				/									
				/									

(Assistant Examiner) (Date)

2/20/08

(Legal Instruments Examiner) (Date)

2/18/08

Dac V. Ha

(Primary Examiner) (Date)

Total Claims Allowed: 23

O.G. Print Claim(s)	O.G. Print Fig.
1	3

☐ **Claims renumbered in the same order as presented by applicant** ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1		31		61		91		121		151		181
2	2		32		62		92		122		152		182
3	3		33		63		93		123		153		183
4	4		34		64		94		124		154		184
5	5		35		65		95		125		155		185
6	6		36		66		96		126		156		186
7	7		37		67		97		127		157		187
8	8		38		68		98		128		158		188
9	9		39		69		99		129		159		189
10	10		40		70		100		130		160		190
11	11		41		71		101		131		161		191
12	12		42		72		102		132		162		192
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14	15		45		75		105		135		165		195
15	16		46		76		106		136		166		196
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18	18		48		78		108		138		168		198
19	19		49		79		109		139		169		199
	~~20~~		50		80		110		140		170		200
20	21		51		81		111		141		171		201
21	22		52		82		112		142		172		202
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	27		57		87		117		147		177		207
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	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

Index of Claims

Application/Control No.	Applicant(s)/Patent under Reexamination
11/542,950	JIN ET AL.
Examiner	**Art Unit**
Dac V. Ha	2611

√	Rejected	–	(Through numeral) Cancelled	N	Non-Elected	A	Appeal
=	Allowed	+	Restricted	I	Interference	O	Objected

Claim Final	Claim Original	Date 8/27/07	Date 2/18/08	Claim Final	Claim Original	Claim Final	Claim Original
1	1	=	=		51		101
2	2				52		102
3	3				53		103
4	4				54		104
5	5				55		105
6	6				56		106
7	7				57		107
8	8				58		108
9	9				59		109
10	10				60		110
11	11				61		111
12	12				62		112
17	13				63		113
13	14				64		114
14	15				65		115
15	16				66		116
16	17	=			67		117
18	18	√			68		118
19	19	√	=		69		119
	~~20~~	O			70		120
20	21	√	=		71		121
21	22	√			72		122
22	23	√			73		123
23	24	√	=		74		124
	25				75		125
	26				76		126
	27				77		127
	28				78		128
	29				79		129
	30				80		130
	31				81		131
	32				82		132
	33				83		133
	34				84		134
	35				85		135
	36				86		136
	37				87		137
	38				88		138
	39				89		139
	40				90		140
	41				91		141
	42				92		142
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	44				94		144
	45				95		145
	46				96		146
	47				97		147
	48				98		148
	49				99		149
	50				100		150

Search Notes	Application/Control No. 11/542,950	Applicant(s)/Patent under Reexamination JIN ET AL.	
	Examiner Dac V. Ha	Art Unit 2611	

SEARCHED

Class	Subclass	Date	Examiner
375	259,262	8/27/2007	DH
	265,285		
	296,341		
	346,348		
714	746,752		
	755,756		
	786,792		
	794-796		
341	51,52,56		
	102,103		
*Update		2/18/08	DH

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
* Same as above		2/18/08	DH

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
BRS	8/27/2007	DH

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Hui Jin et al. Art Unit: 2611
Serial No.: 11/542,950 Examiner: Dac V. Ha
Filed : October 3, 2006 Conf. No.: 6431
Title : SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

Mail Stop Amendment
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

In response to the Office action mailed September 6, 2007, please reconsider this application in light of the following:

Amendments to the claims set forth in the **Listing of Claims** beginning on page 2; and

Remarks beginning on page 8.

Listing of Claims

This listing of claims replaces all prior versions, and listings, of claims in the application:

1. (Original) A method comprising:

receiving a collection of message bits having a first sequence in a source data stream;

generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula

$$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i} \quad ,$$

where

"x_{j-1}" is the value of a parity bit "j-1," and

" $\sum_{i=1}^{a} v_{(j-1)a+1}$ " is the value of a sum of "a" randomly chosen irregular repeats of the message bits; and

making the sequence of parity bits available for transmission in a transmission data stream.

2. (Original) The method of claim 1, wherein the sequence of parity bits is generated is in accordance with "a" being constant.

3. (Original) The method of claim 1, wherein the sequence of parity bits is generated is in accordance with "a" varying for different parity bits.

4. (Original) The method of claim 1, wherein generating the sequence of parity bits comprises performing recursive modulo two addition operations on the random sequence of bits.

5. (Original) The method of claim 1, wherein generating the sequence of parity bits comprises:

generating a random sequence of bits that repeats each of the message bits one or more times with the repeats of the message bits being distributed in a random sequence, wherein different fractions of the message bits are each repeated a different number of times and the number of repeats for each message bit is irregular; and

XOR summing in linear sequential fashion a predecessor parity bit and "a" bits of the random sequence of bits.

6. (Original) The method of claim 5, wherein generating the random sequence of bits comprises coding the collection of message bits using a low-density generator matrix (LDGM) coder.

7. (Original) The method of claim 5, wherein generating the random sequence of bits comprises:

producing a block of data bits, wherein different message bits are each repeated a different number of times in a sequence that matches the first sequence; and

randomly permuting the different bits to generate the random sequence.

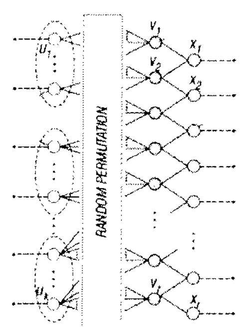
8. (Original) The method of claim 1, further comprising transmitting the sequence of parity bits.

9. (Original) The method of claim 8, wherein transmitting the sequence of parity bits comprises transmitting the sequence of parity bits as part of a nonsystematic code.

10. (Original) The method of claim 8, wherein transmitting the sequence of parity bits comprises transmitting the sequence of parity bits as part of a systematic code.

11. (Original) A device comprising:

an encoder configured to receive a collection of message bits and encode the
message bits to generate a collection of parity bits in accordance with the following Tanner graph:



12. (Original) The device of claim 11, wherein the encoder is configured to generate the collection of parity bits as if a number of inputs into nodes v_i was not constant.

13. (Original) The device of claim 11, wherein the encoder comprises:

a low-density generator matrix (LDGM) coder configured to perform an irregular repeat on message bits having a first sequence in a source data stream to output a random sequence of repeats of the message bits; and

an accumulator configured to XOR sum in linear sequential fashion a predecessor parity bit and "a" bits of the random sequence of repeats of the message bits.

14. (Original) The device of claim 12, wherein the accumulator comprises a recursive convolutional coder.

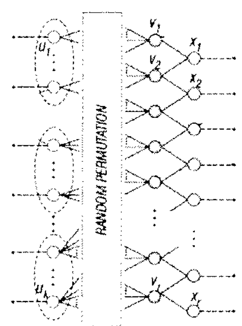
15. (Original) The device of claim 14, wherein the recursive convolutional coder comprises a truncated rate-1 recursive convolutional coder.

16. (Original) The device of claim 14, wherein the recursive convolutional coder has a transfer function of 1/(1+D).

17. (Original) The device of claim 12, further comprising a second accumulator configured to determine a second sequence of parity bits that defines a second condition that constrains the random sequence of repeats of the message bits.

18. (Currently Amended) A device comprising:

a message passing decoder configured to decode a received data stream that includes a collection of parity bits, the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes, wherein the message passing decoder is configured to decode the received data stream that has been encoded in accordance with the following Tanner graph:



.

19. (Original) The device of claim 18, wherein the message passing decoder is configured to decode the received data stream that includes the message bits.

20. (Canceled)

21. (Currently Amended) The device of claim [[20]] 18, wherein the message passing decoder is configured to decode the received data stream as if a number of inputs into nodes v_i was not constant.

22. (Original) The device of claim 18, wherein the message passing decoder is configured to decode in linear time at rates that approach a capacity of a channel.

23. (Original) The device of claim 18, wherein the message passing decoder comprises a belief propagation decoder.

24. (Original) The device of claim 18, wherein the message passing decoder is configured to decode the received data stream without the message bits.

REMARKS

Claims 1-19 and 21-24 are pending. Claims 1, 11, and 18 are in independent form.

In the action mailed September 6, 2007, claims 1-17 were allowed and claim 20 was recognized as reciting allowable subject matter. Applicant acknowledges the recognition of allowable subject matter with appreciation.

In response thereto, claim 18 has been amended to recite subject matter drawn from former claim 20. Accordingly, claim 18 and the claims dependent therefrom are believed to be allowable on the same basis as former claim 20.

It is believed that all of the pending claims have been addressed. However, the absence of a reply to a specific rejection, issue, or comment does not signify agreement with or concession of that rejection, issue, or comment. In addition, because the arguments made above may not be exhaustive, there may be reasons for patentability of any or all pending claims (or other claims) that have not been expressed. Finally, nothing in this paper should be construed as an intent to concede any issue with regard to any claim, except as specifically stated in this paper, and the amendment of any claim does not necessarily signify concession of unpatentability of the claim prior to its amendment.

Applicant asks that all claims be allowed. Please apply the fee of $230 for a Petition for two (2) months Extension of Time, along with any other charges or credits, to deposit account 06-1050.

Respectfully submitted,

Date: February 4, 2008

John P. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. 20985
12390 El Camino Real
San Diego, California 92130
(858) 678-5070 telephone
(858) 678-5099 facsimile

10808033.doc

Electronic Patent Application Fee Transmittal

Application Number:	11542950
Filing Date:	03-Oct-2006
Title of Invention:	Serial concatenation of interleaved convolutional codes forming turbo-like codes
First Named Inventor/Applicant Name:	Hui Jin
Filer:	John F. Conroy/Cecilia Tobin
Attorney Docket Number:	06618-637002/CIT3220-C

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 2 months with $0 paid	2252	1	230	230

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**230**

Electronic Acknowledgement Receipt

EFS ID:	2812850
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	Serial concatenation of interleaved convolutional codes forming turbo-like codes
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	John F. Conroy/Cecilia Tobin
Filer Authorized By:	John F. Conroy
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	04-FEB-2008
Filing Date:	03-OCT-2006
Time Stamp:	20:04:46
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$230
RAM confirmation Number	12165
Deposit Account	061050
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)

1		06618637002Response.pdf	235874 eb06f6f99318381f02bd22bbae2a7ccdb639d065	yes	9

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment - After Non-Final Rejection	1	1
	Claims	2	7
	Applicant Arguments/Remarks Made in an Amendment	8	9

Warnings:

Information:

2	Fee Worksheet (PTO-06)	fee-info.pdf	8172 2bd459cc0fd7ffd8831cd2dee3601905e57ecda1	no	2

Warnings:

Information:

Total Files Size (in bytes):	244046

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 11/542,950	Filing Date 10/03/2006	☐ To be Mailed

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☒		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
	02/04/2008	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 23	Minus	** 24	= 0	X $25 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $105 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	0	OR	TOTAL ADD'L FEE	

AMENDMENT		(Column 1)		(Column 2)	(Column 3)					
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/CORALIA -. BETANCOURT/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/542,950	10/03/2006	2611	600	06618-637002/CIT3220-C	24	3

CONFIRMATION NO. 6431

CORRECTED FILING RECEIPT

20985
FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN55440-1022

Date Mailed: 09/25/2007

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Hui Jin, Glen Gardner, NJ;
Aamod Khandekar, Pasadena, CA;
Robert J. McEliece, Pasadena, CA;

Power of Attorney:

David Feigenbaum--30378
Scott Harris--32030
John Phillips--35322
John Hayden--37640
Terry Stalford--39522
Bing Ai--43312
John Conroy--45485
William Hunter--47671

Domestic Priority data as claimed by applicant

This application is a CON of 09/861,102 05/18/2001 PAT 7,116,710
which claims benefit of 60/205,095 05/18/2000

Foreign Applications

If Required, Foreign Filing License Granted: 10/25/2006

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is
US11/542,950

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

** SMALL ENTITY **

Title

Serial concatenation of interleaved convolutional codes forming turbo-like codes

Preliminary Class

375

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C

CONFIRMATION NO. 6431

20985
FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Date Mailed: 09/25/2007

RESPONSE TO REQUEST FOR CORRECTED FILING RECEIPT

Domestic Continuity and Foreign Priority

In response to your request for a corrected Filing Receipt, the Office is unable to comply with the request because:

- ☐ The priority or continuity claim has not been entered because it was not filed during the required time period. Applicant may wish to consider filing a petition to accept an unintentionally delayed claim for priority. See 37 CFR 1.55 or 1.78.

- ☒ Continuity claimed under 35 U.S.C. § 120 cannot be added to the Filing Receipt without the applicant supplying the relationship (continuation, divisional, or continuation-in-part) in an Application Data Sheet or amendment to the first page of the specification.

- ☐ A claim for priority cannot be made based on an application filed after the application making the claim.

- ☐ Domestic benefit and foreign priority claims will not be captured in a provisional application. A provisional application is not entitled to a right of priority or to the benefit of an earlier filing date of any other application. See 35 U.S.C. § 111(b)(7) and 37 CFR 1.53(c)(4).

- ☐ A domestic continuity claim cannot be made to a foreign application and the filing receipt will only list the foreign country, application number, and filing date.

- ☐ Foreign priority will appear on the Filing Receipt in the following order: **Country, Application number, Filing date**.

- ☐ This application is the result of a conversion from a provisional application. Priority based on such application cannot be made since it no longer exists as a provisional application.

- ☐ The application(s) to which priority is claimed were filed over a year prior to the filing date of this application. Therefore, the referenced application(s) cannot be claimed as domestic or foreign priority.

- ☐ To change the benefit claim of a U.S. prior-filed application, applicant must amend the first sentence of the specification (if the benefit claim is referenced in the specification), or provide a supplemental application data sheet (ADS) (if the benefit claim was submitted in an ADS), with the desired benefit claim. Note that once a benefit claim is deleted, applicant will not be able to claim such prior-filed application again, if the above-identified application was filed on or after November 29, 2000.

- ☐ To change a foreign priority claim, applicant must submit a supplemental oath or declaration (if the priority claim is referenced in the oath or declaration), or a supplemental application data sheet (ADS) (if the priority claim was submitted in an ADS), with the desired priority claim. If a supplemental ADS is submitted, any deletions should be shown with strikeouts. Note that once a priority claim is deleted, applicant will not be able to claim such foreign application again, if the above-identified application was filed on or after November 29, 2000.

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199

PART 3 - OFFICE COPY

PTO/SB/14 (07-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	11/542,950
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority	◉ Inventor	○ Legal Representative under 35 U.S.C. 117	○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Hui		Jin	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Glen Gardner	State/Province	NJ	Country of Residence i	US
Citizenship under 37 CFR 1.41(b) i	CN				

Mailing Address of Applicant:

Address 1	2104 Spruce Hills Dr.		
Address 2			
City	Glen Gardner	State/Province	NJ
Postal Code	08826	Country i	US

Applicant 2 Remove

Applicant Authority	◉ Inventor	○ Legal Representative under 35 U.S.C. 117	○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Aamod		Khandekar	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Pasadena	State/Province	CA	Country of Residence i	US
Citizenship under 37 CFR 1.41(b) i	IN				

Mailing Address of Applicant:

Address 1	1-88 Braun House		
Address 2	California Institute of Technology		
City	Pasadena	State/Province	CA
Postal Code	91125	Country i	US

Applicant 3 Remove

Applicant Authority	◉ Inventor	○ Legal Representative under 35 U.S.C. 117	○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
	Robert	J.	McEliece	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Pasadena	State/Province	CA	Country of Residence i	US

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

Citizenship under 37 CFR 1.41(b) i	US		
Mailing Address of Applicant:			
Address 1	1086 Armada Dr.		
Address 2			
City	Pasadena	**State/Province**	CA
Postal Code	91103	**Country**i	US
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.			Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).		
☐ **An Address is being provided for the correspondence Information of this application.**		
Customer Number	20985	
Email Address		Add Email Remove Email

Application Information:

Title of the Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES		
Attorney Docket Number	06618-637002	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	5	**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S. C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

Customer Number	20985

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Patented		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
11542950	Continuation of	09861102	2001-05-18
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
09861102	non provisional of	60205095	2000-05-18
Prior Application Status	Patented		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
09861102	non provisional of	09922852	2000-08-18

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country i	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			◯ Yes ◯ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

If the Assignee is an Organization check here. ☒

Organization Name	California Institute of Technology

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	06618-637002
	Application Number	
Title of Invention	SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES	

Mailing Address Information:			
Address 1	1200 East California Boulevard		
Address 2			
City	Pasadena	**State/Province**	CA
Country i	US	Postal Code	91125
Phone Number		Fax Number	
Email Address			
Additional Assignee Data may be generated within this form by selecting the **Add** button.	Add		

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.					
Signature	/John Conroy 45,485/			Date (YYYY-MM-DD)	2006-11-01
First Name	John	Last Name	Conroy	Registration Number	45485

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	2206942
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	Serial concatenation of interleaved convolutional codes forming turbo-like codes
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	Bing Ai/Jennifer Payne
Filer Authorized By:	Bing Ai
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	17-SEP-2007
Filing Date:	03-OCT-2006
Time Stamp:	21:13:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	06618-637002_ADS.pdf	1931544 e9fddaa97e788f8a4de31e8da2ab3f3caf1acb81	no	5
Warnings:					

Information:	
Total Files Size (in bytes):	1931544

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Hui Jin et al.
Serial No.: 11/542,950
Filed : October 3, 2006
Title : SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CORRECTED OFFICIAL FILING RECEIPT

Please correct the Filing Receipt for the above-referenced application to include the correct residence address information for the inventor, Hui Jin:

Hui Jin, Glen Gardner, NJ

Further please correct the priority data as claimed by the applicant as follows:

This application is a CON of 09/861,102 05/18/2001 PAT 7,116,710
which claims the benefit of 60/205,095 05/18/2000
and claims the benefit of 09/922,852 08/18/2000

Please supply a corrected Filing Receipt to the undersigned with respect to this application. A copy of the original Filing Receipt showing the desired changes is attached for your convenience.

No fee is believed to be due. If, however, there are any charges or credits, please apply them to Deposit Account No. 06-1050.

Respectfully submitted,

Date: September 17, 2007

/John F. Conroy Reg. # 45,485/
John F. Conroy
Reg. No. 45,485

Fish & Richardson P.C.
PTO Customer No. **20985**
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San Diego, California 92130
Telephone: (858) 678-5070
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10679323.doc

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPL NO.	FILING OR 371 (c) DATE	ART UNIT	FIL FEE REC'D	ATTY.DOCKET NO	DRAWINGS	TOT CLMS	IND CLMS
11/542,950	10/03/2006	2611	600	06618-637002/CIT3220-C	5	24	3

CONFIRMATION NO. 6431

20985
FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

FILING RECEIPT

OC000000020974950

Date Mailed: 10/25/2006

Receipt is acknowledged of this regular Patent Application. It will be considered in its order and you will be notified as to the results of the examination. Be sure to provide the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please mail to the Commissioner for Patents P.O. Box 1450 Alexandria Va 22313-1450. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).**

Applicant(s) Gardner

Hui Jin, Glen ~~Gardoer~~, NJ;
Aamod Khandekar, Pasadena, CA;
Robert J. McEliece, Pasadena, CA;

Power of Attorney:

David Feigenbaum--30378
Scott Harris--32030
John Phillips--35322
John Hayden--37640
Terry Stalford--39522
Bing Ai--43312
John Conroy--45485
William Hunter--47671

Domestic Priority data as claimed by applicant

This application is a CON of 09/861,102 05/18/2001 PAT 7,116,710
which claims benefit of 60/205,095 05/18/2000
AND 09/922,852 08/18/2000

Foreign Applications

If Required, Foreign Filing License Granted: 10/25/2006

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is US11/542,950

Projected Publication Date: 02/01/2007

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

Serial concatenation of interleaved convolutional codes forming turbo-like codes

Preliminary Class

375

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

Electronic Acknowledgement Receipt

EFS ID:	2206947
Application Number:	11542950
International Application Number:	
Confirmation Number:	6431
Title of Invention:	Serial concatenation of interleaved convolutional codes forming turbo-like codes
First Named Inventor/Applicant Name:	Hui Jin
Customer Number:	20985
Filer:	Bing Ai/Jennifer Payne
Filer Authorized By:	Bing Ai
Attorney Docket Number:	06618-637002/CIT3220-C
Receipt Date:	17-SEP-2007
Filing Date:	03-OCT-2006
Time Stamp:	21:16:11
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Corrected Filing Receipt	06618-637002_Request.PDF	184951 f419c77eb02666a08c10dcb864685b30de4943f0	no	5
Warnings:					

Information:	
Total Files Size (in bytes):	184951

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C	6431

20985 7590 09/06/2007

FISH & RICHARDSON, PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER	
HA, DAC V	
ART UNIT	**PAPER NUMBER**
2611	

MAIL DATE	DELIVERY MODE
09/06/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 11/542,950	Applicant(s) JIN ET AL.	
	Examiner Dac V. Ha	Art Unit 2611	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *03 October 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-24* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *1-17* is/are allowed.

6)☒ Claim(s) *18,19 and 21-24* is/are rejected.

7)☒ Claim(s) *20* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *03 October 2006* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 18, 19, 21-24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lin (US 5,530,707) in view of Hammons et al. (US 6,859,906) (hereafter Hommons).

Regarding claim 18, Lin discloses the claimed subject matter "decoder configured to decode a received data stream" "the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes" in Fig. 2(a), 3(a); col. 10,lines 15-63). Lin differs from the claimed invention in that Lin doesn't discloses a received data stream "that includes a collection of parity bits". However, such use of parity bits in the art of encoding (i.e. turbo encoding) is well known (see Hammons, col. 1, line 56 to col. 2, line 13). Thus, it would have been easily to one skilled in the art to realized that the decoder discloses by Lin would also decode signal that includes parity bits.

Regarding claim 19, Lin further discloses the claimed subject matter "wherein the message passing decoder is configured to decode the received data stream that includes the message bits" in col. 9, line 51 to col. 10, line 63.

Regarding claim 21, Lin discloses the claimed subject matter "wherein the message passing decoder is configured to decode the received data stream as if a number of inputs into nodes v_i was not constant in Fig. 2(a); 3(a); 4(a).

Regarding claims 22-24, theses claimed subject matter would have been easily realized by one skilled in the art as conventional.

Allowable Subject Matter

3. Claims 1-17 are allowed.

4. Claim 20 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

5. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Miller et al. (US 6,094,739).

Meyer (US 5,802,115)

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dac V. Ha whose telephone number is 571-272-3040. The examiner can normally be reached on 4/4.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David Payne can be reached on 571-272-3024. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dac V. Ha
Primary Examiner
Art Unit 2611

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney's Docket No. 06618-637002	Application No. Not yet assigned
Information Disclosure Statement by Applicant (Use several sheets if necessary)	Applicant Hui Jin et al.	
(37 CFR §1.98(b))	Filing Date October 3, 2006	Group Art Unit

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
/DH/	AA	2001/0025358	09/27/01	Eidson et al.			
/DH/	AB	5,392,299	02/21/95	Rhines et al.			
/DH/	AC	5,751,739	05/1998	Seshadri et al.			
/DH/	AD	5,881,093	03/09/99	Wang et al.			
/DH/	AE	6,014,411	01/2000	Wang			
/DH/	AF	6,023,783	02/08/00	Divsalar et al.			
/DH/	AG	6,031,874	02/29/00	Chennakeshu et al.			
/DH/	AH	6,032,284	02/29/00	Bliss			
/DH/	AI	6,044,116	03/28/00	Wang			
/DH/	AJ	6,396,423	05/2002	Laumen et al.			
/DH/	AK	6,437,714	08/2002	Kim et al.			
	AL						

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation	
							Yes	No
	AM							
	AN							
	AO							

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
/DH/	AP	Appendix A.1 "Structure of Parity Check Matrices of Standardized LDPC Codes," Digital Video Broadcasting (DVB) User guidelines for the second generation system for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2) ETSI TR 102 376 V1.1.1. (2005-02) Technical Report, pp. 64
/DH/	AQ	Benedetto et al., "A Soft-Input Soft-Output Maximum A Posteriori (MAP) Module to Decode Parallel and Serial Concatenated Codes," The Telecommunications and Data Acquisition (TDA) Progress Report 42-127 for NASA and California Institute of Technology Jet Propulsion Laboratory, Jospeh H. Yuen, Ed., pp. 1-20 (November 15, 1996)
/DH/	AR	Benedetto et al., "Bandwidth efficient parallel concatenated coding schemes," Electronics Letters 31(24): 2067-2069 (November 23, 1995)

Examiner Signature /Dac Ha/	Date Considered 08/25/2007
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form (PTO-1449)

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney's Docket No. 06618-637002	Application No. Not yet assigned
Information Disclosure Statement by Applicant (Use several sheets if necessary)	Applicant Hui Jin et al.	
(37 CFR §1.98(b))	Filing Date October 3, 2006	Group Art Unit

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
/DH/	AS	Benedetto et al., "Design of Serially Concatenated Interleaved Codes," ICC 97, Montreal, Canada, pp. 710-714, (June 1997)
/DH/	AT	Benedetto et al., "Parallel Concatenated Trellis Coded Modulation," ICC '96, IEEE, pp. 974-978, (June 1996)
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Examiner Signature	Date Considered
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Sheet 3 of 3

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney's Docket No. 06618-637002	Application No. Not yet assigned
Information Disclosure Statement by Applicant (Use several sheets if necessary)	Applicant Hui Jin et al.	
(37 CFR §1.98(b))	Filing Date October 3, 2006	Group Art Unit

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
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Examiner Signature /Dac Ha/	Date Considered 08/25/2007
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Substitute Disclosure Form (PTO-1449)

Notice of References Cited	Application/Control No. 11/542,950	Applicant(s)/Patent Under Reexamination JIN ET AL.	
	Examiner Dac V. Ha	Art Unit 2611	Page 1 of 1

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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No. 11/542,950	Applicant(s)/Patent under Reexamination JIN ET AL.
	Examiner Dac V. Ha	Art Unit 2611

SEARCHED			
Class	Subclass	Date	Examiner
375	259,262	8/27/2007	DH
	265,285		
	296,341		
	346,348		
714	746,752		
	755,756		
	786,792		
	794-796		
341	51,52,56		
	102,103		

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)	DATE	EXMR
BRS	8/27/2007	DH

Index of Claims

Application/Control No.	Applicant(s)/Patent under Reexamination
11/542,950	JIN ET AL.
Examiner	**Art Unit**
Dac V. Ha	2611

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CONFIRMATION NO. 6431

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/542,950	10/03/2006 RULE	375	2611	06618-637002/CIT3220-C

APPLICANTS

Hui Jin, Glen Gardoer, NJ;
Aamod Khandekar, Pasadena, CA;
Robert J. McEliece, Pasadena, CA;

** **CONTINUING DATA** *************************

This application is a CON of 09/861,102 05/18/2001 PAT 7,116,710 which claims benefit of 60/205,095 05/18/2000

DH

** **FOREIGN APPLICATIONS** ********************

DH

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Foreign Priority claimed / 35 USC 119 (a-d) conditions met / Verified and Acknowledged	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ yes ☑ no 35 USC 119 (a-d) conditions met ☐ yes ☑ no ☐ Met after Allowance Verified and Acknowledged ________ Examiner's Signature DH Initials	NJ	5	24	3

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TITLE

Serial concatenation of interleaved convolutional codes forming turbo-like codes

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APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/542,950	10/03/2006	Hui Jin	06618-637002/CIT3220-C

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20985
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Title: Serial concatenation of interleaved convolutional codes forming turbo-like codes

Publication No. US-2007-0025450-A1
Publication Date: 02/01/2007

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The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

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October 3, 2006

Attorney Docket No.: 06618-637002/CIT3220-C

Commissioner for Patents
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Alexandria, VA 22313-1450

Presented for filing is a new continuation patent application of:

Applicant: HUI JIN, AAMOD KHANDEKAR AND ROBERT J. MCELIECE

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

Enclosed are the following papers, including those required to receive a filing date under 37 CFR §1.53(b):

	Pages
Specification	16
Claims	6
Abstract	1
Declaration	4
Drawings	5

Enclosures:

- Form PTO-1449, 3 pages, listing documents cited in the parent applications. Please confirm that these have been considered in this application by returning a copy of the Form PTO-1449 with the examiner's initials.
- Statement re Power of Attorney (1 page).
- Rule 63 declaration, copy from a previous application under rule 63(d) for continuation or divisional only.
- **Small entity statement. This application is entitled to small entity status.**
- Postcard.

This application is a continuation (and claims the benefit of priority under 35 USC 120) of U.S. application serial no. 09/861,102, filed May 18, 2001, which claims priority to U.S. provisional application serial no. 60/205,095, filed May 18, 2000, and to U.S. application serial no. 09/922,852, filed August 18, 2000. The disclosures of

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October 3, 2006
Page 2

the prior applications are considered part of (and are incorporated by reference in) the disclosure of this application.

			Small Entity	Large Entity	
Basic Filing Fee			150	300	$150
Search Fee			250	500	$250
Examination Fee			100	200	$100
Total Claims 24	over 20	**4 x $25**	25	50	$100
Independent Claims 3	over 3	**0 x $100**	100	200	$0
Fee for Multiple Dependent claims			180	360	$0
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Total Filing fee					$600

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BY
JOHN F. CONROY
REG. NO. 45,485

Attorney's Docket No.: 06618-637002 / CIT3220-C

APPLICATION

FOR

UNITED STATES LETTERS PATENT

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

APPLICANT: HUI JIN, AAMOD KHANDEKAR AND ROBERT J. MCELIECE

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SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application serial no. 09/861,102, filed May 18, 2001, which claims priority to U.S. provisional application serial no. 60/205,095, filed May 18, 2000, and to U.S. application serial no. 09/922,852, filed August 18, 2000.

GOVERNMENT LICENSE RIGHTS

[0002] The U.S. Government has a paid-up license in this invention and the right in limited circumstances to require the patent owner to license others on reasonable terms as provided for by the terms of Grant No. CCR-9804793 awarded by the National Science Foundation.

BACKGROUND

[0003] Properties of a channel affect the amount of data that can be handled by the channel. The so-called "Shannon limit" defines the theoretical limit of the amount of data that a channel can carry.

[0004] Different techniques have been used to increase the data rate that can be handled by a channel. "Near Shannon Limit Error-Correcting Coding and Decoding: Turbo Codes," by Berrou et al. ICC, pp 1064-1070, (1993), described a new "turbo code" technique that has revolutionized the field of error correcting codes. Turbo codes have sufficient randomness to allow reliable communication over the channel at a high data rate near capacity. However, they still retain sufficient structure to allow practical encoding and decoding algorithms. Still, the technique for encoding and decoding turbo codes can be relatively complex.

[0005] A standard turbo coder 100 is shown in Figure 1. A block of k information bits is input directly to a first coder 102. A k bit interleaver 106 also receives the k bits and interleaves them prior to applying them to a second coder 104. The second coder produces an output that has more bits than its input, that is, it is a coder with rate that is less than 1. The coders 102, 104 are typically recursive convolutional coders.

[0006] Three different items are sent over the channel 150: the original k bits, first encoded bits 110, and second encoded bits 112. At the decoding end, two decoders are used: a first constituent decoder 160 and a second constituent decoder 162. Each receives both the original k bits, and one of the encoded portions 110, 112. Each decoder sends likelihood estimates of the decoded bits to the other decoders. The estimates are used to decode the uncoded information bits as corrupted by the noisy channel.

SUMMARY

[0007] A coding system according to an embodiment is configured to receive a portion of a signal to be encoded, for example, a data block including a fixed number of bits. The coding system includes an outer coder, which repeats and scrambles bits in the data block. The data block is apportioned into two or more sub-blocks, and bits in different sub-blocks are repeated a different number of times according to a selected degree profile. The outer coder may include a repeater with a variable rate and an interleaver. Alternatively, the outer coder may be a low-density generator matrix (LDGM) coder.

[0008] The repeated and scrambled bits are input to an inner coder that has a rate substantially close to one. The inner coder may include one or more accumulators that perform recursive modulo two addition operations on the input bit stream.

[0009] The encoded data output from the inner coder may be transmitted on a channel and decoded in linear time at a destination using iterative decoding techniques. The decoding techniques may be based on a Tanner graph representation of the code.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a schematic diagram of a prior "turbo code" system.

[0011] Figure 2 is a schematic diagram of a coder according to an embodiment.

[0012] Figure 3 is a Tanner graph for an irregular repeat and accumulate (IRA) coder.

[0013] Figure 4 is a schematic diagram of an IRA coder according to an embodiment.

[0014] Figure 5A illustrates a message from a variable node to a check node on the Tanner graph of Figure 3.

[0015] Figure 5B illustrates a message from a check node to a variable node on the Tanner graph of Figure 3.

[0016] Figure 6 is a schematic diagram of a coder according to an alternate embodiment.

[0017] Figure 7 is a schematic diagram of a coder according to another alternate embodiment.

DETAILED DESCRIPTION

[0018] Figure 2 illustrates a coder 200 according to an embodiment. The coder 200 may include an outer coder 202, an interleaver 204, and inner coder 206. The coder may be used to format blocks of data for transmission, introducing redundancy into the stream of data to protect the data from loss due to transmission errors. The encoded data may then be decoded at a destination in linear time at rates that may approach the channel capacity.

[0019] The outer coder 202 receives the uncoded data. The data may be partitioned into blocks of fixed size, say k bits. The outer coder may be an (n,k) binary linear block coder, where $n > k$. The coder accepts as input a block u of k data bits and produces an output block v of n data bits. The mathematical relationship between u and v is $v=T_0u$, where T_0 is an n x k matrix, and the rate of the coder is k/n.

[0020] The rate of the coder may be irregular, that is, the value of T_0 is not constant, and may differ for sub-blocks of bits in the data block. In an embodiment, the outer coder 202 is a repeater that repeats the k bits in a block a number of times q to produce a block with n bits, where $n = qk$. Since the repeater has an irregular output, different bits in the block may be repeated a different number of times. For example, a fraction of the bits in the block may be repeated two times, a fraction of bits may be repeated three times, and the remainder of bits may be repeated four times. These fractions define a degree sequence, or degree profile, of the code.

[0021] The inner coder 206 may be a linear rate-1 coder, which means that the n-bit output block x can be written as $x=T_I w$, where T_I is a nonsingular n x n matrix. The inner coder 210 can have a rate that is close to 1, e.g., within 50%, more preferably 10% and perhaps even more preferably within 1% of 1.

[0022] In an embodiment, the inner coder 206 is an accumulator, which produces outputs that are the modulo two (mod-2) partial sums of its inputs. The accumulator may be a truncated rate-1 recursive convolutional coder with the transfer function 1/(1+D). Such an accumulator may be considered a block coder whose input block $[x_1,\ldots,x_n]$ and output block $[y_1,\ldots,y_n]$ are related by the formula

$$\begin{aligned}
y_1 &= x_1 \\
y_2 &= x_1 \oplus x_2 \\
y_3 &= x_1 \oplus x_2 \oplus x_3 \\
&\vdots \\
y_n &= x_1 \oplus x_2 \oplus x_3 \oplus \ldots \oplus x_n.
\end{aligned}$$

where "⊕" denotes mod-2, or exclusive-OR (XOR), addition. An advantage of this system is that only mod-2 addition is necessary for the accumulator. The accumulator may be embodied using only XOR gates, which may simplify the design.

[0023] The bits output from the outer coder 202 are scrambled before they are input to the inner coder 206. This scrambling may be performed by the interleaver 204, which performs a pseudo-random permutation of an input block v, yielding an output block w having the same length as v.

[0024] The serial concatenation of the interleaved irregular repeat code and the accumulate code produces an irregular repeat and accumulate (IRA) code. An IRA code is a linear code, and as such, may be represented as a set of parity checks. The set of parity checks may be represented in a bipartite graph, called the Tanner graph, of the code. Figure 3 shows a Tanner graph 300 of an IRA code with parameters $(f_1, \ldots, f_j; a)$, where $f_i \geq 0$, $\Sigma_i f_i = 1$ and "a" is a positive integer. The Tanner graph includes two kinds of nodes: variable nodes (open circles) and check nodes (filled circles). There are k variable nodes 302 on the left, called information nodes. There are r variable nodes 306 on the right, called parity nodes. There are r =

$(k\Sigma_i if_i)/a$ check nodes 304 connected between the information nodes and the parity nodes. Each information node 302 is connected to a number of check nodes 304. The fraction of information nodes connected to exactly i check nodes is f_i. For example, in the Tanner graph 300, each of the f_2 information nodes are connected to two check nodes, corresponding to a repeat of q = 2, and each of the f_3 information nodes are connected to three check nodes, corresponding to q = 3.

[0025] Each check node 304 is connected to exactly "a" information nodes 302. In Figure 3, a = 3. These connections can be made in many ways, as indicated by the arbitrary permutation of the ra edges joining information nodes 302 and check nodes 304 in permutation block 310. These connections correspond to the scrambling performed by the interleaver 204.

[0026] In an alternate embodiment, the outer coder 202 may be a low-density generator matrix (LDGM) coder that performs an irregular repeat of the k bits in the block, as shown in Figure 4. As the name implies, an LDGM code has a sparse (low-density) generator matrix. The IRA code produced by the coder 400 is a serial concatenation of the LDGM code and the accumulator code. The interleaver 204 in

Figure 2 may be excluded due to the randomness already present in the structure of the LDGM code.

[0027] If the permutation performed in permutation block 310 is fixed, the Tanner graph represents a binary linear block code with k information bits $(u_1, \ldots, u_k)$ and r parity bits $(x_1, \ldots, x_r)$, as follows. Each of the information bits is associated with one of the information nodes 302, and each of the parity bits is associated with one of the parity nodes 306. The value of a parity bit is determined uniquely by the condition that the mod-2 sum of the values of the variable nodes connected to each of the check nodes 304 is zero. To see this, set $x_0=0$. Then if the values of the bits on the ra edges coming out the permutation box are $(v_1, \ldots, v_{ra})$, then we have the recursive formula

$$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i}$$

for j = 1, 2, ..., r. This is in effect the encoding algorithm.

[0028] Two types of IRA codes are represented in Figure 3, a nonsystematic version and a systematic version. The nonsystematic version is an (r,k) code, in which the codeword corresponding to the information bits $(u_1, \ldots, u_k)$ is $(x_1, \ldots, x_r)$. The systematic version is a (k+r, k) code, in which the codeword is $(u_1, \ldots, u_k; x_1, \ldots, x_r)$.

[0029] The rate of the nonsystematic code is

$$R_{nsys} = \frac{a}{\sum_i i f_i}$$

[0030] The rate of the systematic code is

$$R_{sys} = \frac{a}{a + \sum_i i f_i}$$

[0031] For example, regular repeat and accumulate (RA) codes can be considered nonsystematic IRA codes with a = 1 and exactly one f_i equal to 1, say $f_q = 1$, and the rest zero, in which case R_{nsys} simplifies to R = 1/q.

[0032] The IRA code may be represented using an alternate notation. Let λ_i be the fraction of edges between the information nodes 302 and the check nodes 304 that are adjacent to an information node of degree i, and let ρ_i be the fraction of such edges that are adjacent to a check node of degree i+2 (i.e., one that is adjacent to i information nodes). These edge fractions may be used to represent the IRA code rather than the corresponding node fractions. Define $\lambda(x) = \Sigma_i \lambda_i x^{i-1}$ and $\rho(x) = \Sigma_i \rho_i x^{i-1}$ to be the generating functions of these sequences. The pair (λ, ρ) is called a degree distribution. For $L(x) = \Sigma_i f_i x_i$,

$$f_i = \frac{\lambda_i / i}{\sum_j \lambda_j / j}$$

$$L(x) = \int_0^x \lambda(t)\,dt / \int_0^1 \lambda(t)\,dt$$

[0033] The rate of the systematic IRA code given by the degree distribution is given by

$$\text{Rate} = \left(1 + \frac{\sum_j \rho_j / j}{\sum_j \lambda_j / j}\right)^{-1}$$

[0034] "Belief propagation" on the Tanner Graph realization may be used to decode IRA codes. Roughly speaking, the belief propagation decoding technique allows the messages passed on an edge to represent posterior densities on the bit associated with the variable node. A probability density on a bit is a pair of non-negative real numbers p(0), p(1) satisfying p(0) + p(1) = 1, where p(0) denotes the probability of the bit being 0, p(1) the probability of it being 1. Such a pair can be represented by its log likelihood ratio, m = log(p(0)/p(1)). The outgoing message from a variable node u to a check node v represents information about u, and a message from a check node u to a variable node v represents information about u, as shown in Figures 5A and 5B, respectively.

[0035] The outgoing message from a node u to a node v depends on the incoming messages from all neighbors w of u except v. If u is a variable message node, this outgoing message is

$$m(u \to v) = \sum_{w \neq v} m(w \to u) + m_0(u)$$

where $m_0(u)$ is the log-likelihood message associated with u. If u is a check node, the corresponding formula is

$$\tanh \frac{m(u \to v)}{2} = \prod_{w \neq v} \tanh \frac{m(w \to u)}{2}$$

[0036] Before decoding, the messages $m(w \to u)$ and $m(u \to v)$ are initialized to be zero, and $m_0(u)$ is initialized to be the log-likelihood ratio based on the channel received information. If the channel is memoryless, i.e., each channel output only relies on its input, and y is the output of the channel code bit u, then $m_0(u) = \log(p(u = 0|y)/p(u = 1|y))$. After this initialization, the decoding process may run in a fully parallel and local manner. In each iteration, every variable/check node receives messages from its neighbors, and sends back updated messages. Decoding is terminated after a fixed number of iterations or detecting that all the constraints are satisfied. Upon termination, the decoder outputs a decoded sequence based on the messages $m(u) = \sum w_m(w \to u)$.

[0037] Thus, on various channels, iterative decoding only differs in the initial messages $m_0(u)$. For example, consider three memoryless channel models: a binary erasure channel (BEC); a binary symmetric channel (BSC); and an additive white Gaussian noise (AGWN) channel.

[0038] In the BEC, there are two inputs and three outputs. When 0 is transmitted, the receiver can receive either 0 or an erasure E. An erasure E output means that the receiver does not know how to demodulate the output. Similarly, when 1 is transmitted, the receiver can receive either 1 or E. Thus, for the BEC, $y \in \{0, E, 1\}$, and

$$m_0(u) = \begin{cases} +\infty & \text{if} \quad y = 0 \\ 0 & \text{if} \quad y = E \\ -\infty & \text{if} \quad y = 1 \end{cases}$$

[0039] In the BSC, there are two possible inputs (0,1) and two possible outputs (0, 1). The BSC is characterized by a set of conditional probabilities relating all possible outputs to possible inputs. Thus, for the BSC $y \in \{0, 1\}$,

$$m_0(u) = \begin{cases} \log\frac{1-p}{p} & \text{if} \quad y = 0 \\ -\log\frac{1-p}{p} & \text{if} \quad y = 1 \end{cases}$$

and

[0040] In the AWGN, the discrete-time input symbols X take their values in a finite alphabet while channel output symbols Y can take any values along the real line. There is assumed to be no distortion or other effects other than the addition of white Gaussian noise. In an AWGN with a Binary Phase Shift Keying (BPSK) signaling which maps 0 to the symbol with amplitude $\sqrt{Es}$ and 1 to the symbol with amplitude $-\sqrt{Es}$, output $y \in R$, then

$$m_0(u) = 4y\sqrt{E_s} / N_0$$

where $N_0/2$ is the noise power spectral density.

[0041] The selection of a degree profile for use in a particular transmission channel is a design parameter, which may be affected by various attributes of the channel. The criteria for selecting a particular degree profile may include, for example, the type of channel and the data rate on the channel. For example, Table 1 shows degree profiles that have been found to produce good results for an AWGN channel model.

a	2	3	4
λ2	0.139025	0.078194	0.054485
λ3	0.2221555	0.128085	0.104315
λ5		0.160813	
λ6	0.638820	0.036178	0.126755
λ10			0.229816
λ11			0.016484
λ12		0.108828	
λ13		0.487902	
λ14			
λ16			
λ27			0.450302
λ28			0.017842
Rate	0.333364	0.333223	0.333218
σGA	1.1840	1.2415	1.2615
σ*	1.1981	1.2607	1.2780
(Eb/N0)*(dB)	0.190	-0.250	-0.371
S.L. (dB)	-0.4953	-0.4958	-0.4958

TABLE 1

[0042] Table 1 shows degree profiles yielding codes of rate approximately 1/3 for the AWGN channel and with a = 2, 3, 4. For each sequence, the Gaussian approximation noise threshold, the actual sum-product decoding threshold and the corresponding energy per bit (E_b)-noise power (N_0) ratio in dB are given. Also listed is the Shannon limit (S.L.).

[0043] As the parameter "a" is increased, the performance improves. For example, for a = 4, the best code found has an iterative decoding threshold of E_b/N_0 = -0.371 dB, which is only 0.12 dB above the Shannon limit.

[0044] The accumulator component of the coder may be replaced by a "double accumulator" 600 as shown in Figure 6. The double accumulator can be viewed as a truncated rate 1 convolutional coder with transfer function $1/(1 + D + D^2)$.

[0045] Alternatively, a pair of accumulators may be the added, as shown in Figure 7. There are three component codes: the "outer" code 700, the "middle" code 702, and the "inner" code 704. The outer code is an irregular repetition code, and the middle and inner codes are both accumulators.

[0046] IRA codes may be implemented in a variety of channels, including memoryless channels, such as the BEC, BSC, and AWGN, as well as channels having non-binary input, non-symmetric and fading channels, and/or channels with memory.

[0047] A number of embodiments have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, other embodiments are within the scope of the following claims.

CLAIMS

1. A method comprising:

receiving a collection of message bits having a first sequence in a source data stream;

generating a sequence of parity bits, wherein each parity bit "x_j" in the sequence is in accordance with the formula

$$x_j = x_{j-1} + \sum_{i=1}^{a} v_{(j-1)a+i} ,$$

where

"x_{j-1}" is the value of a parity bit "j-1," and

"$\sum_{i=1}^{a} v_{(j-1)a+1}$" is the value of a sum of "a" randomly chosen irregular repeats of the message bits; and

making the sequence of parity bits available for transmission in a transmission data stream.

2. The method of claim 1, wherein the sequence of parity bits is generated is in accordance with "a" being constant.

3. The method of claim 1, wherein the sequence of parity bits is generated is in accordance with "a" varying for different parity bits.

4. The method of claim 1, wherein generating the sequence of parity bits comprises performing recursive

modulo two addition operations on the random sequence of bits.

5. The method of claim 1, wherein generating the sequence of parity bits comprises:

generating a random sequence of bits that repeats each of the message bits one or more times with the repeats of the message bits being distributed in a random sequence, wherein different fractions of the message bits are each repeated a different number of times and the number of repeats for each message bit is irregular; and

XOR summing in linear sequential fashion a predecessor parity bit and "a" bits of the random sequence of bits.

6. The method of claim 5, wherein generating the random sequence of bits comprises coding the collection of message bits using a low-density generator matrix (LDGM) coder.

7. The method of claim 5, wherein generating the random sequence of bits comprises:

producing a block of data bits, wherein different message bits are each repeated a different number of times in a sequence that matches the first sequence; and

randomly permuting the different bits to generate the random sequence.

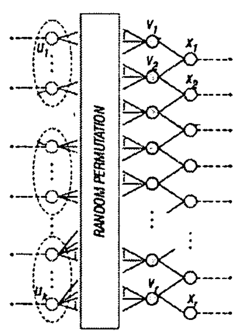
8. The method of claim 1, further comprising transmitting the sequence of parity bits.

9. The method of claim 8, wherein transmitting the sequence of parity bits comprises transmitting the sequence of parity bits as part of a nonsystematic code.

10. The method of claim 8, wherein transmitting the sequence of parity bits comprises transmitting the sequence of parity bits as part of a systematic code.

11. A device comprising:

an encoder configured to receive a collection of message bits and encode the message bits to generate a collection of parity bits in accordance with the following Tanner graph:



12. The device of claim 11, wherein the encoder is configured to generate the collection of parity bits as if a number of inputs into nodes v_i was not constant.

13. The device of claim 11, wherein the encoder comprises:

a low-density generator matrix (LDGM) coder configured to perform an irregular repeat on message bits having a first sequence in a source data stream to output a random sequence of repeats of the message bits; and

an accumulator configured to XOR sum in linear sequential fashion a predecessor parity bit and "a" bits of the random sequence of repeats of the message bits.

14. The device of claim 12, wherein the accumulator comprises a recursive convolutional coder.

15. The device of claim 14, wherein the recursive convolutional coder comprises a truncated rate-1 recursive convolutional coder.

16. The device of claim 14, wherein the recursive convolutional coder has a transfer function of 1/(1+D).

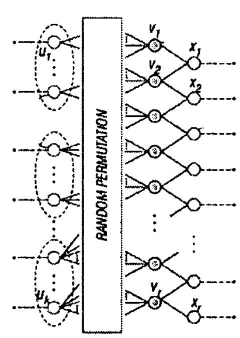
17. The device of claim 12, further comprising a second accumulator configured to determine a second sequence of parity bits that defines a second condition that constrains the random sequence of repeats of the message bits.

18. A device comprising:

a message passing decoder configured to decode a received data stream that includes a collection of parity bits, the message passing decoder comprising two or more check/variable nodes operating in parallel to receive messages from neighboring check/variable nodes and send updated messages to the neighboring variable/check nodes.

19. The device of claim 18, wherein the message passing decoder is configured to decode the received data stream that includes the message bits.

20. The device of claim 18, wherein the message passing decoder is configured to decode the received data stream that has been encoded in accordance with the following Tanner graph:



21. The device of claim 20, wherein the message passing decoder is configured to decode the received data stream as if a number of inputs into nodes v_i was not constant.

22. The device of claim 18, wherein the message passing decoder is configured to decode in linear time at rates that approach a capacity of a channel.

23. The device of claim 18, wherein the message passing decoder comprises a belief propagation decoder.

24. The device of claim 18, wherein the message passing decoder is configured to decode the received data stream without the message bits.

ABSTRACT OF THE DISCLOSURE

[0048] A serial concatenated coder includes an outer coder and an inner coder. The outer coder irregularly repeats bits in a data block according to a degree profile and scrambles the repeated bits. The scrambled and repeated bits are input to an inner coder, which has a rate substantially close to one.

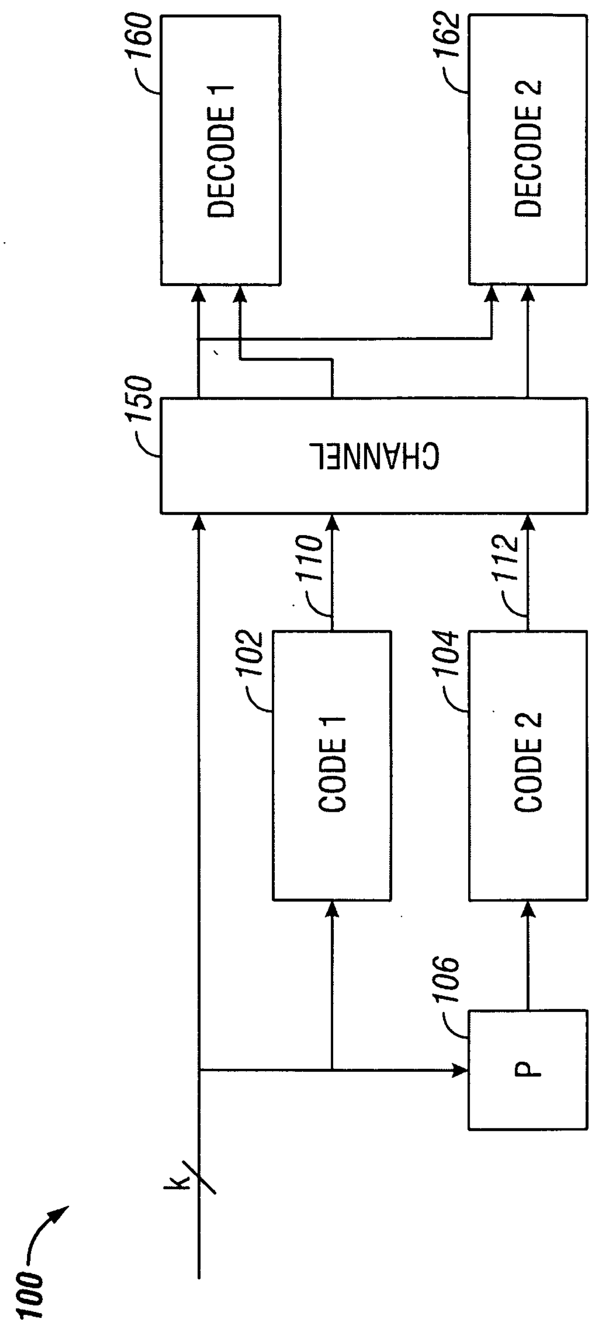


FIG. 1
(Prior Art)

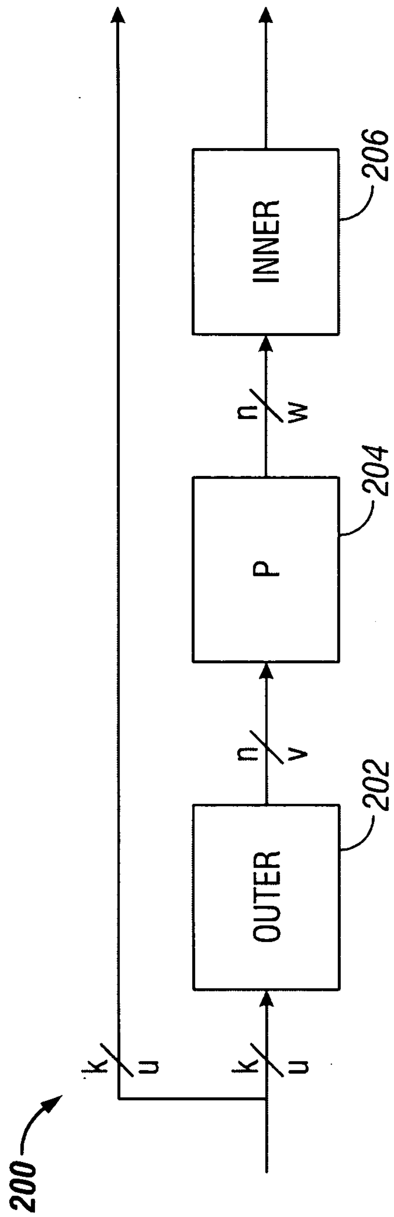


FIG. 2

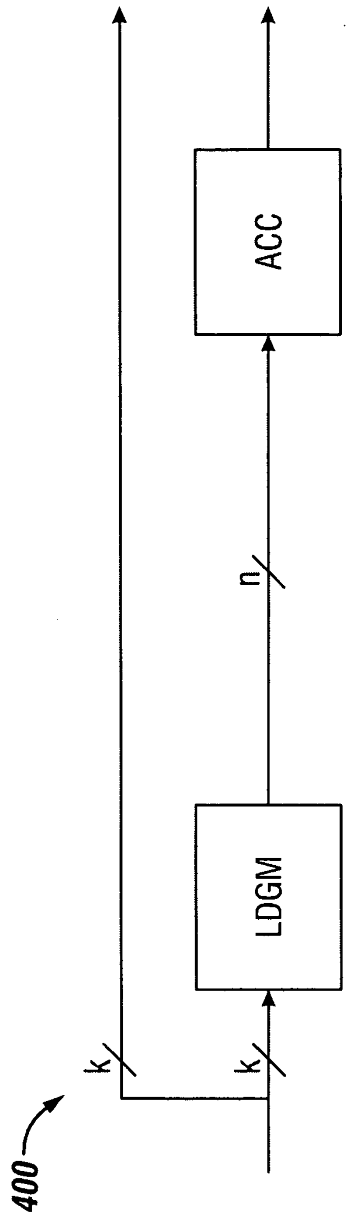


FIG. 4

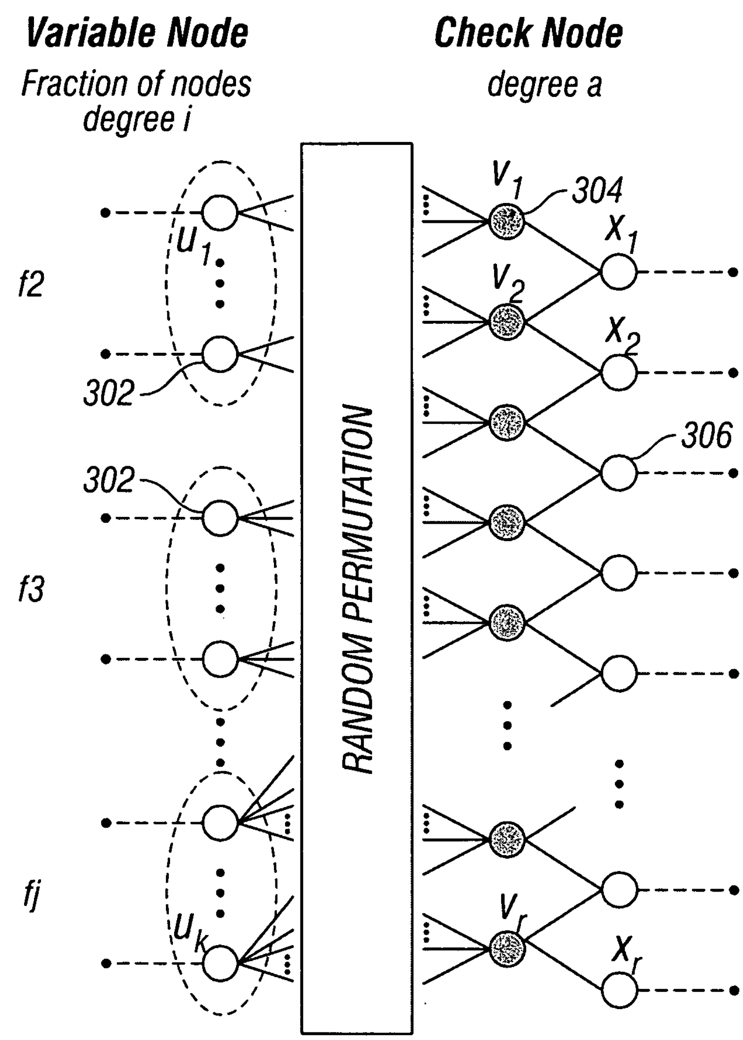

Variable Node
Fraction of nodes degree i
Check Node
degree a
f2
f3
fj
U_1
U_k
302
302
RANDOM PERMUTATION
V_1
V_2
V_r
304
X_1
X_2
X_r
306

FIG. 3

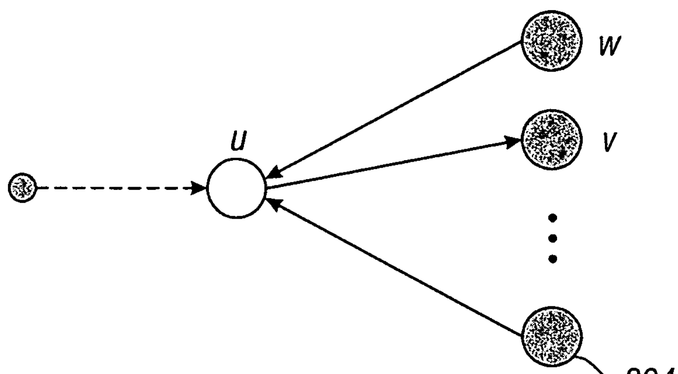


FIG. 5A

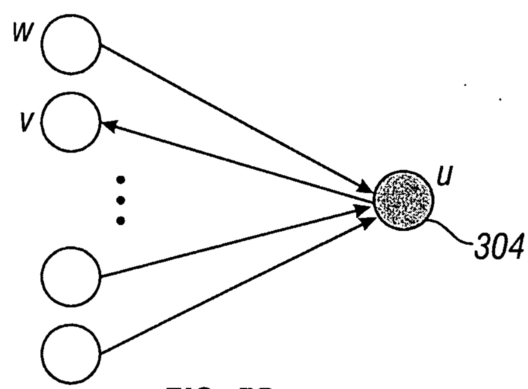


FIG. 5B

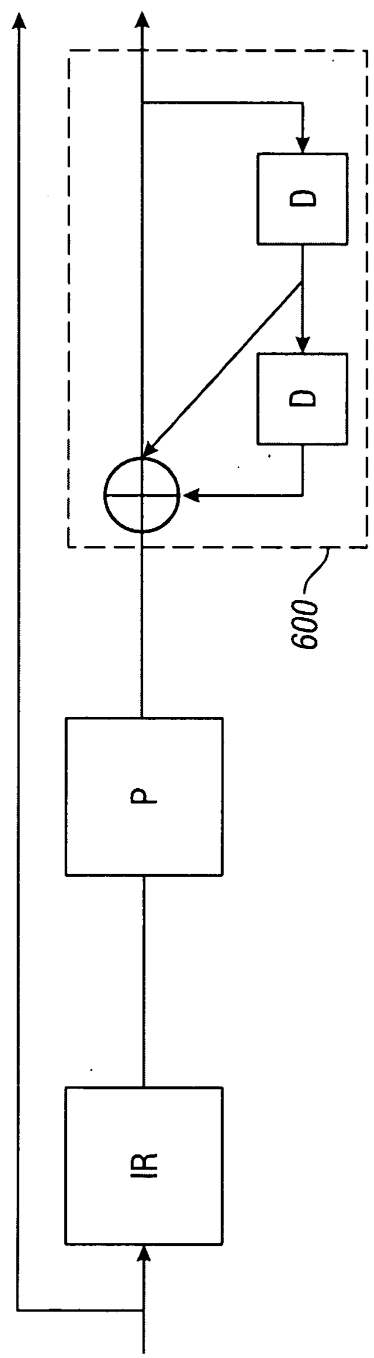


FIG. 6

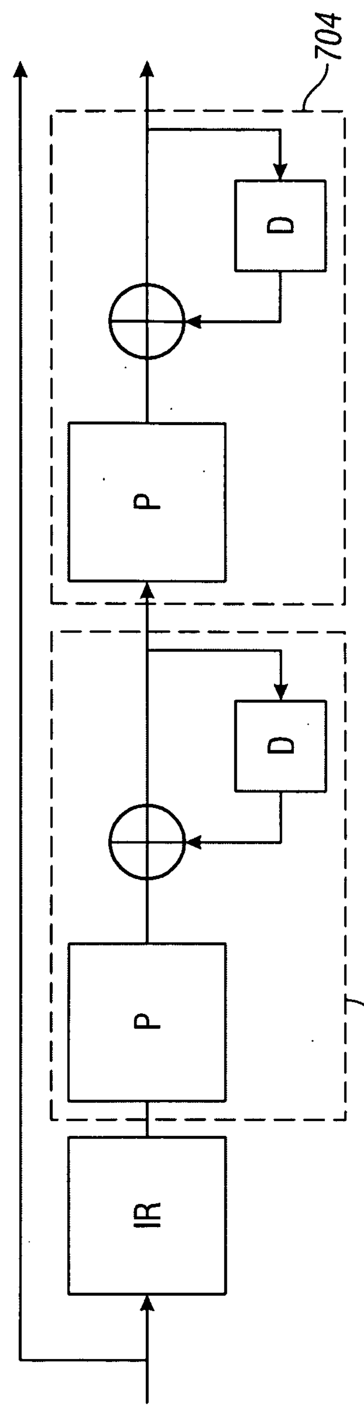


FIG. 7

Attorney's Docket No.: 06618-637001/CIT3220

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES, the specification of which:

[] is attached hereto.
[X] was filed on May 18, 2001 as Application Serial No. 09/861,102 and was amended on _______.
[] was described and claimed in PCT International Application No. ________________ filed on ________________ and as amended under PCT Article 19 on ________________.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §119(e)(1) of any United States provisional application(s) listed below:

U.S. Serial No.	Filing Date	Status
60/205,095	05/18/2000	Abandoned

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Serial No.	Filing Date	Status

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Country	Application No.	Filing Date	Priority Claimed
			[] Yes [] No

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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Page 2 of 2 Pages

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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Full Name of Inventor: ROBERT J. MCELIECE

Inventor's Signature: ________ Date: ________

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Attorney's Docket No.: 06618-637002 / CIT3220-C

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Hui Jin et al.
Serial No.: Not yet assigned
Filed : October 3, 2006
Title : SERIAL CONCATENATION OF INTERLEAVED CONVOLUTIONAL CODES FORMING TURBO-LIKE CODES

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

STATEMENT REGARDING POWER OF ATTORNEY

Under 37 C.F.R. § 1.32(c)(3), please recognize the following registered patent practitioners as representatives for the above-referenced application.

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John Hayden, Reg. No. 37,640

A copy of the Power of Attorney filed in the parent of the above-identified application is attached.

Please apply any charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: October 3, 2006

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10/06/2006 CNGUYEN2 00000030 11542950

01 FC:2011	150.00 OP
02 FC:2111	250.00 OP
03 FC:2311	100.00 OP
04 FC:2202	100.00 OP

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002 — 489-267/69033

PTO/SB/06 (12-04)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875 Effective December 8, 2004

Application or Docket Number: 11/529,950

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	150.00		N/A	300.00
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	$250		N/A	$500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	$100		N/A	$200
TOTAL CLAIMS (37 CFR 1.16(i))	24 minus 20 =	* 4	X$ 25 =	100	OR	X$50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	* —	X100 =			X200 =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			+180=			+360=	
			TOTAL	500		TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II 1/11/18

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X$ 25 =		OR	X$50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X100 =		OR	X200 =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180=		OR	+360=	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X$ 25 =		OR	X$50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X100 =		OR	X200 =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					+180=		OR	+360=	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney's Docket No. 06618-637002	Application No. Not yet assigned
Information Disclosure Statement by Applicant (Use several sheets if necessary)	Applicant Hui Jin et al.	
(37 CFR §1.98(b))	Filing Date October 3, 2006	Group Art Unit

U.S. Patent Documents

Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Class	Subclass	Filing Date If Appropriate
	AA	2001/0025358	09/27/01	Eidson et al.			
	AB	5,392,299	02/21/95	Rhines et al.			
	AC	5,751,739	05/1998	Seshadri et al.			
	AD	5,881,093	03/09/99	Wang et al.			
	AE	6,014,411	01/2000	Wang			
	AF	6,023,783	02/08/00	Divsalar et al.			
	AG	6,031,874	02/29/00	Chennakeshu et al.			
	AH	6,032,284	02/29/00	Bliss			
	AI	6,044,116	03/28/00	Wang			
	AJ	6,396,423	05/2002	Laumen et al.			
	AK	6,437,714	08/2002	Kim et al.			
	AL						

Foreign Patent Documents or Published Foreign Patent Applications

Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Class	Subclass	Translation Yes	Translation No
	AM							
	AN							
	AO							

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	AP	Appendix A.1 "Structure of Parity Check Matrices of Standardized LDPC Codes," Digital Video Broadcasting (DVB) User guidelines for the second generation system for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2) ETSI TR 102 376 V1.1.1. (2005-02) Technical Report, pp. 64
	AQ	Benedetto et al., "A Soft-Input Soft-Output Maximum A Posteriori (MAP) Module to Decode Parallel and Serial Concatenated Codes," The Telecommunications and Data Acquisition (TDA) Progress Report 42-127 for NASA and California Institute of Technology Jet Propulsion Laboratory, Jospeh H. Yuen, Ed., pp. 1-20 (November 15, 1996)
	AR	Benedetto et al., "Bandwidth efficient parallel concatenated coding schemes," Electronics Letters 31(24): 2067-2069 (November 23, 1995)

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form (PTO-1449)

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney's Docket No. 06618-637002	Application No. Not yet assigned
Information Disclosure Statement by Applicant (Use several sheets if necessary)	Applicant Hui Jin et al.	
(37 CFR §1.98(b))	Filing Date October 3, 2006	Group Art Unit

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	AS	Benedetto et al., "Design of Serially Concatenated Interleaved Codes," ICC 97, Montreal, Canada, pp. 710-714, (June 1997)
	AT	Benedetto et al., "Parallel Concatenated Trellis Coded Modulation," ICC '96, IEEE, pp. 974-978, (June 1996)
	AU	Benedetto et al., "Serial Concatenated Trellis Coded Modulation with Iterative Decoding," Proceedings from the IEEE 1997 International Symposium on Information Theory (ISIT), Ulm, Germany, p. 8, June 29-July 4, 1997
	AV	Benedetto et al., "Serial Concatenation of Interleaved Codes: Performace Analysis, Design, and Iterative Decoding," The Telecommunications and Data Acquisition (TDA) Progress Report 42-126 for NASA and California Institute of Technology Jet Propulsion Laboratory, Jospeh H. Yuen, Ed., pp. 1-26 (August 15, 1996)
	AW	Benedetto et al., "Serial Concatenation of interleaved codes: performance analysis, design, and iterative decoding," Proceedings from the IEEE 1997 International Symposium on Information Theory (ISIT), Ulm, Germany, p. 106, June 29-July 4, 1997
	AX	Benedetto et al., "Soft-output decoding algorithms in iterative decoding of turbo codes," The Telecommunications and Data Acquisition (TDA) Progress Report 42-124 for NASA and California Institute of Technology Jet Propulsion Laboratory, Jospeh H. Yuen, Ed., pp. 63-87 (Feburary 15, 1996)
	AY	Benedetto, S. et al., "A Soft-Input Soft-Output APP Module for Iterative Decoding of Concatenated Codes," IEEE Communications Letters 1(1): 22-24 (January 1997)
	AZ	Berrou et al., "Near Shannon Limit Error-Correcting Coding and Decoding: Turbo Codes," ICC pp. 1064-1070 (1993)
	AAA	Digital Video Broadcasting (DVB) User guidelines for the second generation system for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2) ETSI TR 102 376 V1.1.1. (2005-02) Technical Report, pp. 1-104 (Feb. 15, 2005)
	ABB	Divsalar et al., "Coding Theorems for 'Turbo-Like' Codes," Proceedings of the 36th Annual Allerton Conference on Communication, Control, and Computing, 23-25 September 1998, Allerton House, Monticello, Illinois, pp. 201-210 (1998)
	ACC	Divsalar et al., "Effective free distance of turbo codes," Electronics Letters 32(5): 445-446 (February 29, 1996)
	ADD	Divsalar, D. et al., "Hybrid Concatenated Codes and Iterative Decoding," Proceedings from the IEEE 1997 International Symposium on Information Theory (ISIT), Ulm, Germany, p. 10 (June 29-July 4, 1997)
	AEE	Divsalar, D. et al., "Low-rate turbo codes for Deep Space Communications," Proceedings from the 1995 IEEE International Symposium on Information Theory, 17-22 September 1995, Whistler, British Columbia, Canada, pp. 35
	AFF	Divsalar, D. et al., "Multiple Turbo Codes for Deep-Space Communications," The Telecommunications and Data Acquisition (TDA) Progress Report 42-121 for NASA and California Institute of Technology Jet Propulsion Laboratory, Jospeh H. Yuen, Ed., pp. 60-77 (May 15, 1995)
	AGG	Divsalar, D. et al., "Multiple Turbo Codes," MILCOM 95, San Diego, CA pp. 279-285 (November 5-6, 1995)
	AHH	Divsalar, D. et al., "On the Design of Turbo Codes," The Telecommunications and Data Acquisition (TDA) Progress Report 42-123 for NASA and California Institute of Technology Jet Propulsion Laboratory, Jospeh H. Yuen, Ed., pp. 99-131 (November 15, 1995)

Examiner Signature	Date Considered

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Sheet 3 of 3

Substitute Form PTO-1449 (Modified) U.S. Department of Commerce Patent and Trademark Office	Attorney's Docket No. 06618-637002	Application No. Not yet assigned
Information Disclosure Statement by Applicant (Use several sheets if necessary)	Applicant Hui Jin et al.	
(37 CFR §1.98(b))	Filing Date October 3, 2006	Group Art Unit

Other Documents (include Author, Title, Date, and Place of Publication)

Examiner Initial	Desig. ID	Document
	AII	Divsalar, D. et al., "Serial Turbo Trellis Coded Modulation with Rate-1 Inner Code," Proceedings from the IEEE 2000 International Symposium on Information Theory (ISIT), Italy, pp. 1-14 (June, 2000)
	AJJ	Divsalar, D. et al., "Turbo Codes for PCS Applications," ICC 95, IEEE, Seattle, WA, pp. 54-59 (June 1995)
	AKK	Jin et al., "Irregular Repeat - Accumulate Codes," 2nd International Symposium on Turbo Codes & Related Topics, 4-7 September 2000, Brest, France, 25 slides, (presented on 4 September 2000)
	ALL	Jin et al., "Irregular Repeat – Accumulate Codes," 2nd International Symposium on Turbo Codes & Related Topics, 4-7 September 2000, Brest, France, pp. 1-8 (2000)
	AMM	Richardson et al., "Design of capacity approaching irregular low density parity check codes," IEEE Trans. Inform. Theory 47: 619-637 (February 2001)
	ANN	Richardson, T. and R. Urbanke, "Efficient encoding of low-density parity check codes," IEEE Trans. Inform. Theory 47: 638-656 (February 2001)
	AOO	Wilberg, et al., "Codes and Iteratie Decoding on General Graphs", 1995 Intl. Symposium on Information Theory, Sept. 1995, p. 468.
	APP	

Examiner Signature	Date Considered
EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

Substitute Disclosure Form (PTO-1449)

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October 3, 2006

Attorney Docket No.: 06618-637002/CIT3220-C

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Presented for filing is a new continuation patent application of:

Applicant: HUI JIN, AAMOD KHANDEKAR AND ROBERT J. MCELIECE

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

ATLANTA
AUSTIN
BOSTON
DALLAS
DELAWARE
NEW YORK
SAN DIEGO
SILICON VALLEY
TWIN CITIES
WASHINGTON, DC

Enclosed are the following papers, including those required to receive a filing date under 37 CFR §1.53(b):

	Pages
Specification	16
Claims	6
Abstract	1
Declaration	4
Drawings	5

Enclosures:

- Form PTO-1449, 3 pages, listing documents cited in the parent applications. Please confirm that these have been considered in this application by returning a copy of the Form PTO-1449 with the examiner's initials.
- Statement re Power of Attorney (1 page).
- Rule 63 declaration, copy from a previous application under rule 63(d) for continuation or divisional only.
- **Small entity statement. This application is entitled to small entity status.**
- Postcard.

This application is a continuation (and claims the benefit of priority under 35 USC 120) of U.S. application serial no. 09/861,102, filed May 18, 2001, which claims priority to U.S. provisional application serial no. 60/205,095, filed May 18, 2000, and to U.S. application serial no. 09/922,852, filed August 18, 2000. The disclosures of

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October 3, 2006
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the prior applications are considered part of (and are incorporated by reference in) the disclosure of this application.

			Small Entity	Large Entity	
Basic Filing Fee			150	300	$150
Search Fee			250	500	$250
Examination Fee			100	200	$100
Total Claims 24	over 20	**4 x $25**	25	50	$100
Independent Claims 3	over 3	**0 x $100**	100	200	$0
Fee for Multiple Dependent claims			180	360	$0
Fee for each additional 50 pages of Specification and Drawings over 100		(16+5-100)/50 = 0 x	125	250	$0
Total Filing fee					$600

A check for the filing fee is enclosed. Please apply any other required fees or any credits to deposit account 06-1050, referencing the attorney docket number shown above.

If this application is found to be incomplete, or if a telephone conference would otherwise be helpful, please call the undersigned at (858) 678-5070.

Kindly acknowledge receipt of this application by returning the enclosed postcard.

Please direct all correspondence to the following:

20985
PTO Customer Number

Respectfully submitted,

Scott C. Harris
Reg. No. 32,030

BY
JOHN F. CONROY
REG. NO. 45,485

Enclosures
SCH/jhp
10670991.doc