

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HULU, LLC,
AMAZON.COM, INC., and
NETFLIX, INC.,
Petitioners,

v.

REALTIME ADAPTIVE STREAMING LLC,
Patent Owner.

Case IPR2018-01187
Patent No. 9,769,477

**DECLARATION OF KENNETH A. ZEGER, PH.D., IN SUPPORT OF
PATENT OWNER'S RESPONSE**

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I, Kenneth A. Zeger, Ph.D., a resident of San Diego, California, declare as follows:

I. Introduction

A. Engagement

1. I have been retained by Patent Owner Realtime Adaptive Streaming LLC (“Realtime” or “Patent Owner”) through Zunda LLC to provide my opinions with respect to their Response to the Petition for *Inter Partes* Review in IPR2018-01187 (the “Petition”) as to U.S. Patent 9,769,477. Zunda LLC is being compensated at a per hour rate for my time spent on non-deposition tasks and for deposition time. I have no interest in the outcome of this proceeding and the payment of my fees is in no way contingent on my providing any particular opinions.

2. As a part of this engagement, I have also been asked to provide my technical review, analysis, insights, and opinions regarding the Declaration of Dr. James E. Storer (“Storer Declaration,” Ex. 1003 to the Petition) with respect to the challenged claims of the ’477 patent.

3. The statements made herein are based on my own knowledge and opinions.

B. Background And Qualifications

4. I received a Bachelor's degree in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology in 1984.

5. I received a Master of Science degree in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology in 1984.

6. I received a Master of Arts degree in Mathematics from the University of California, Santa Barbara, CA in 1989.

7. I received a Ph.D. degree in Electrical and Computer Engineering from the University of California, Santa Barbara, CA in 1990.

8. I am currently a Full Professor of Electrical and Computer Engineering at the University of California, San Diego (UCSD). I have held this position since 1998, having been promoted from Associated Professor after two years at UCSD. I have been an active member of the UCSD Center for Wireless Communications for 20 years. I teach courses full-time at UCSD in the fields of Electrical and Computer Engineering, and specifically in subfields including communications, information theory, and data compression at the undergraduate and graduate levels. Prior to my employment at UCSD, I taught and conducted research as a faculty member at the University of Illinois, Urbana-Champaign for four years, and at the University of Hawaii for two years.

9. My twenty-plus years of industry experience includes consulting work for the United States Department of Defense as well as for private companies such as Xerox, Nokia, MITRE, ADP, and Hewlett-Packard. The topics upon which I provide consulting expertise include data communications for wireless networks, digital communications, information theory, computer software, and mathematical analyses.

10. I have authored approximately 75 peer-reviewed journal articles, the majority of which are on the topic of communications, information theory, or signal processing. I have also authored over 110 papers at various conferences and symposia over the past thirty-plus years, such as the: IEEE International Conference on Communications; IEEE Radio and Wireless Symposium; Wireless Communications and Networking Conference; IEEE Global Telecommunications Conference; International Symposium on Network Coding; IEEE International Symposium on Information Theory; UCSD Conference on Wireless Communications; International Symposium on Information Theory and Its Applications; Conference on Advances in Communications and Control Systems; IEEE Communication Theory Workshop; Conference on Information Sciences and Systems; Allerton Conference on Communications, Control, and Computing; Information Theory and Its Applications Workshop; Asilomar Conference on Signals, Systems, and Computers. Roughly half of those papers relate to data

compression. I also am co-inventor on a US patent disclosing a memory saving technique for image compression.

11. I was elected a Fellow of the IEEE in 2000, an honor bestowed upon only a small percentage of IEEE members. I was awarded the National Science Foundation Presidential Young Investigator Award in 1991, which included \$500,000 in research funding. I received this award one year after receiving my Ph.D.

12. I have served as an Associate Editor for the IEEE Transactions on Information Theory and have been an elected member of the IEEE Information Theory Board of Governors for three, three-year terms. I organized and have been on the technical advisory committees of numerous workshops and symposia in the areas of communications and information theory. I regularly review submitted journal manuscripts, government funding requests, conference proposals, student theses, and textbook proposals. I also have given many lectures at conferences, universities, and companies on topics in communications and information theory.

13. I have extensive experience in electronics hardware and computer software, from academic studies, work experience, and supervising students. I personally program computers on an almost daily basis and have fluency in many different computer languages.

14. My curriculum vitae, attached to this declaration as Exhibit A, (“Zeger Curriculum Vitae”), lists my publication record in archival journals, international conferences, and workshops.

II. Materials Considered

15. I have been asked to provide a technical review, analysis, insights, and opinions. My technical review, analysis, insights, and opinions are based on almost 38 years of education, research, and experience, as well as my study of relevant materials.

16. I have reviewed and am familiar with the ’477 patent specification and claims. My understanding of the claims is based on the plain and ordinary meaning of the claims as would be understood by a person of ordinary skill in the art, unless the inventor has provided a special meaning for a term. My opinions set forth herein do not rest on a disagreement with Dr. Storer as to the meaning of any claim term or limitation.

17. I have reviewed and am familiar with the Petition for *Inter Partes* Review, Patent Owner Preliminary Response, and the Board’s Decision to Institute in this proceeding and in IPR2018-01630.

18. I have reviewed the Declaration of Dr. James E. Storer. I have also reviewed the Imai, Pauls, and Chao references submitted by Petitioner in this proceeding, and am familiar with those references. In addition, I have reviewed Dr.

Storer's deposition testimony in this proceeding. I have also reviewed the prosecution history of the '477 patent, the excerpt of Mark Nelson's Data Compression Book submitted in this proceeding as Exhibit 1018, and the H.263 standard submitted in this proceeding as Exhibit 1020.

19. This declaration represents only opinions I have formed to date. I may consider additional documents as they become available or other documents that are necessary to form my opinions. I reserve the right to revise, supplement, or amend my opinions based on new information and on my continuing analysis.

III. RELEVANT LEGAL STANDARDS

20. I am not an attorney. I offer no opinions on the law. But counsel has informed me of the following legal standards relevant to my analysis here. I have applied these standards in arriving at my conclusions.

A. Person of Ordinary Skill in the Art

21. I understand that an analysis of the claims of a patent in view of prior art has to be provided from the perspective of a person having ordinary skill in the art at the time of invention of the '477 patent.

22. In rendering the opinions set forth in this declaration, I understand that I should consider the patent claims through the eyes of "a person having ordinary skill in the art." I understand that I should consider factors such as the educational level and years of experience of those working in the pertinent art; the types of

problems encountered in the art; the teachings of the prior art; patents and publications of other persons or companies; and the sophistication of the technology. I understand that the person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the qualities reflected by the factors discussed above.

23. I understand that Dr. Storer states that a person having ordinary skill in the art “would have been a person with a bachelor’s degree in mechanical engineering, electrical engineering, computer science, or a similar field with at least two years of experience in data compression or a person with a master’s degree in mechanical engineering, electrical engineering, computer science, or a similar field with a specialization in data compression. A person with less education but more relevant practical experience may also meet this standard.” Ex. 1003 ¶ 65. I also note that he “considered the level of ordinary skill in the art on February 13, 2001.” *Id.* at n. 1.

24. I do not disagree with those views, except to add that a qualified POSITA would additionally be trained in evaluating both the costs and benefits of a design choice. Those working in the field of the invention are trained both through formal education and their work experience to recognize that design choices can have complex consequences that have to be evaluated before a

motivation is formed to pursue the design choice, and before an expectation of success as to that design is formed.

25. I would consider anyone who does not recognize those realities or who forms design motivations because a particular combination of known elements or knowledge in the field is possible to not be a POSITA, regardless of that person's education, experience, or technical knowledge. Likewise, a POSITA in this field would not form design motivations because a design may provide some benefit without consideration of the relevance of the benefit in a specific context, or the costs of the design choice. The ordinarily skilled artisan in this field is not impulsive. That person is deliberative and considered.

26. Throughout my declaration, even if I discuss my analysis in the present tense, I am always making my determinations based on what a person of ordinary skill in the art ("POSITA") would have known at the time of the invention. Based on my background and qualifications, I believe I have at least the experience and knowledge of a POSITA, and am qualified to offer the testimony set forth in this declaration.

B. Burden Of Proof

27. I understand that in an *inter partes* review the petitioner has the burden of proving a proposition of unpatentability by a preponderance of the evidence.

C. Claim Construction

28. I understand that in an *inter partes* review the Board applies a broadest reasonable interpretation claim construction standard to claims in an unexpired patent.

29. I understand, however, that the broadest *reasonable* interpretation standard does not mean the broadest *possible* interpretation. I understand that the Board must always consider the claims in light of the specification and teachings in the patent and that a proper claim construction analysis corresponds with how the inventor describes his invention in the specification. I further understand that a proper claim construction should also take into account the patent's prosecution history.

30. I understand that the Board does not construe claim terms unnecessary to resolving the controversy.

D. Obviousness

31. I understand that a patent may not be valid even though the invention is not identically disclosed or described in the prior art if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the art in the relevant subject matter at the time the invention was made.

32. I understand that, to demonstrate obviousness, it is not sufficient for a petition to merely show that all of the elements of the claims at issue are found in separate prior art references or even scattered across different embodiments and teachings of a single reference. The petition must thus go further, to explain how a person of ordinary skill would combine specific prior art references or teachings, which combinations of elements in specific references would yield a predictable result, and how any specific combination would operate or read on the claims. Similarly, it is not sufficient to allege that the prior art could be combined, but rather, the petition must show why and how a person of ordinary skill would have combined them.

33. I understand that where an alleged motivation to combine relies on a particular factual premise, the petitioner bears the burden of providing specific support for that premise. I also understand that a motivation to combine cannot be sufficiently alleged based merely on the purported benefits that would result from a proposed trade off. I understand that obviousness cannot be shown by conclusory statements, and that the petition must provide articulated reasoning with some rational underpinning to support its conclusion of obviousness. I also understand that skill in the art rarely operates to supply missing knowledge or prior art to show obviousness, nor does skill in the art act as a bridge over gaps in substantive presentation of an obviousness case.

IV. The Claims of the '477 Patent

34. In discussing Claim 1, I will refer to its limitations as they are labeled here:

Element	Claim 1
1[PR]	A system, comprising:
1[A]	a plurality of different asymmetric data compression encoders, wherein each asymmetric data compression encoder of the plurality of different asymmetric data compression encoders is configured to utilize one or more data compression algorithms, and
1[B]	wherein a first asymmetric data compression encoder of the plurality of different asymmetric data compression encoders is configured to compress data blocks containing video or image data at a higher data compression rate than a second asymmetric data compression encoder of the plurality of different asymmetric data compression encoders; and
1[C]	one or more processors configured to: determine one or more data parameters, at least one of the determined one or more data parameters relating to a throughput of a communications channel measured in bits per second; and

1[D]	select one or more asymmetric data compression encoders from among the plurality of different asymmetric data compression encoders based upon, at least in part, the determined one or more data parameters.
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35. In discussing Claim 20, I will refer to its limitations as they are labeled here:

Element	Claim 20
20[PR]	A system comprising;
20[A]	a plurality of video data compression encoders;
20[B]	wherein at least one of the plurality of video data compression encoders is configured to utilize an asymmetric data compression algorithm, and
20[C]	wherein at least one of the plurality of video data compression encoders is configured to utilize an arithmetic data compression algorithm,
20[D]	wherein a first video data compression encoder of the plurality of video data compression encoders is configured to compress at a higher compression ratio than a second data compression encoder of the plurality of data compression encoders; and
20[E]	one or more processors configured to: determine one or more data parameters, at least

	one of the determined one or more data parameters relating to a throughput of a communications channel; and
20[F]	select one or more video data compression encoders from among the plurality of video data compression encoders based upon, at least in part, the determined one or more data parameters.

V. Petitioners’ Obviousness Theory As To Claim 1’s “first asymmetric data compression encoder” and “second asymmetric data compression encoder”

36. I understand that the Petition’s Ground 1 alleges that Imai renders the limitations of Claim 1 obvious.

37. Limitation 1[B] recites two encoders: “a first asymmetric data compression encoder” that is “configured to compress . . . video or image data” and “a second asymmetric data compression encoder” that is also configured to compress video or image data. Ex. 1001 at Cl. 1[B].

38. The two encoders of Claim 1 each have different characteristics and thus are not interchangeable. For instance, the “first asymmetric data compression encoder” must be “configured to compress . . . video or image data at a higher data compression rate than a second asymmetric data compression encoder.” Ex. 1001 at Cl. 1[B].

39. Thus, demonstrating that Imai teaches or renders obvious Claim 1's subject matter requires at least specifying a "first asymmetric data compression encoder" that is "configured to compress . . . video or image data" and a "second asymmetric data compression encoder" that is configured to compress video or image data. In my opinion, it is not sufficient to point to at least two encoders and suggest that some unspecified encoder would satisfy the claims' limitations.

40. I have reviewed the Petition, and it does not identify any particular encoder that would constitute the "first" or "second" encoder for purposes of Claim 1 or its dependents.

41. The absence of such a particularized allegation precludes the possibility of concluding that Imai discloses Claim 1's limitations.

42. It is not possible, for example, to tell which of two encoders would be faster because the asserted art does not disclose the compression rate (i.e., computational speed) of any encoder relative to any other encoder. As, I explain below in Sections VII.B and VIII.A, the portions of Imai and Pauls that Petitioners allege refer to compression rates actually refer to other characteristics of the encoders.

43. And the Petition does not disclose enough information to determine which of two encoders would be faster. The Petition lists various algorithms that may be employed by encoders by the names of their encoding standards and output

data rate. But I agree with Dr. Storer that it is not possible to know whether an encoder employing any one algorithm or encoding standard mentioned in the prior art will encode faster than another without knowing specific details of the implementation. *See* Ex. 2003 at 88:22-89:16, 87:7-14, 96:19-97:5.

44. I also agree with Dr. Storer that a POSITA could not determine which of two encoders is faster even if the POSITA knows their relative compression ratios.

45. It is therefore my opinion that it is impossible to determine that Ground 1 renders the “first” and “second” encoders of Claim 1 obvious.

VI. The Requirements of Limitation 1[B]

46. Claim 1 requires that its “first asymmetric data compression encoder” be configured to compress data “at a higher data compression rate” than the “second asymmetric data compression encoder.” Ex. 1001 at Cl. 1[B]. And the Petition defines “data compression rate” as “the execution or algorithmic speed of a compression encoder.” Pet. 20. It further notes that “it is the throughput of the asymmetric data compression encoder measured by the amount of input data that it can compress per unit of time at a given compression ratio.” Pet. at 21.

47. Therefore, according to Petitioners’ definition of “data compression rate,” Claim 1 requires “a first asymmetric data compression encoder” that is

configured to compress more input data per unit of time at a given compression ratio than a “second asymmetric data compression encoder.”

48. The requirement that the “first asymmetric data compression encoder” is “configured to compress . . . at a higher data compression rate than a second asymmetric data compression encoder” means that the relationship between the first and second encoders’ compression rates cannot arise by chance or as a side effect of some other design choice. In other words, a POSITA would understand the claim’s recitation of “configured” to require that the “first encoder” must compress at a higher rate than the “second encoder” because it is designed to do so.

49. The ‘477 patent’s specification supports that understanding, as it uses “configured to” to convey a purposeful design as opposed to a side effect or accidental arrangement.

50. For instance, the specification describes design features that can more efficiently use space on a disk, followed by the statement: “In this way, a system can be configured to achieve greater speed, while not sacrificing disk space.” Ex. 1001 at 18:26-41.

51. The specification also describes a “programmable logic device” being “configured for its environment.” *Id.* at 16:37-40. A POSITA would understand that a “programmable” device is not “configured for its environment” on accident,

but rather is intentionally programmed to operate in a specific and consistent manner with its environment in mind.

52. In both examples the “configuring” is an intentional design choice through programmed logic rather than a chance occurrence.

53. And the design is for the specific purpose for which the “system” or “programmable logic device” is “configured,” i.e., to “achieve greater speed” or be programmed “for its environment.” The configuring is not the side effect of a design choice with some other purpose.

54. A person of ordinary skill would also understand that the usage of “configured to” cannot be met by an accidental difference in compression rates or a difference in compression rates arising as a side effect of some other choice because the invention relies on the predictable relationship between the compression rates of the two recited encoders. The invention would not work if the relationship were reversed.

55. The specification describes switching from an encoder having a relatively slow compression rate to one having a “faster rate of compression” when the “throughput falls below a predetermined threshold” “so as to increase the throughput.” Ex. 1001 at 8:12-18. If the configuration of the encoders were reversed, the opposite would occur: the system would switch from the relatively

fast encoder to the relatively slow encoder, which would reduce the throughput and exacerbate the bottleneck at the encoder that the invention seeks to remedy.

56. It is thus my opinion that the predictable arrangement of the encoders is crucial. A difference in two encoders' compression rates that is not specifically planned would not suffice for the "first asymmetric data compression encoder" and the "second asymmetric data compression encoder" to serve their purposes.

57. I therefore conclude that limitation 1[B] has the following requirements: (1) "a first asymmetric data compression encoder" that is (2) designed to (3) compress more input data per unit of time than (4) "a second asymmetric data compression encoder."

VII. Petitioners' Obviousness Theory As To Imai

58. As explained below, it is my opinion that Imai does not teach the elements of limitation 1[B].

A. Obviousness Based on Probable Differences in Compression Rate

59. I understand that the Petition alleges that limitation 1[B] is obvious because, if Imai were to use at least two encoders, it is likely that one of them would be faster than another. Pet. 21 ("A POSITA would have understood that it is only a remote possibility that any two different asymmetric data compression encoders would have the same execution speed, and therefore the obvious result of including two or more different asymmetric compression encoders is that one

encoder would have a higher data compression rate than another encoder.”). I disagree with that reasoning.

60. As explained above, limitation 1[B] requires purposeful design with respect to the encoders’ compression rates. Therefore, any system that includes two encoders with compression rates that vary by chance would not have a first encoder that is “configured to compress” at a higher data compression rate than a second encoder as required by limitation 1[B].

61. Thus, the Petition’s statement that either of Imai’s encoders could compress at a faster rate than the other encoder demonstrates that Imai does not disclose Claim 1. Under the meaning of the ’477 patent’s usage of “configured to,” a statement that either encoder could be faster than the other is also a statement that neither is “configured to” be faster than the other.

62. In my opinion, the possibility that Imai might have one encoder that operates at a higher compression rate than another, but may also operate with the relationship reversed, cannot teach a “first asymmetric data compression encoder” that is “configured to compress . . . at a higher data compression rate than a second asymmetric data compression encoder.”

63. For the reasons stated above, it is my opinion that the Petition does not show that Claim 1 is obvious because it does not show any teaching of a first encoder that is configured to compress at a higher rate than a second encoder.

B. Imai's Purported References to Compression Rate

64. I disagree with the Petition's statement that a POSITA "would have appreciated from Imai's various teachings that the different asymmetric data compression encoders have different data compression rates, with some encoders having higher rates than others." Pet. 22. As I explain below, the portions of Imai that the Petition cites as disclosures regarding compression rates actually refer to other features of encoders. Indeed, the Petition does not point to any teaching in Imai regarding the speed of compression measured by input data compressed per unit of time.

65. For instance, the Petition cites to Imai's use of the term "compression rate," but Imai does not use the term in the way the '477 patent does.

66. The Petition states that Imai "compares and contrasts different asymmetric data compression encoders in terms of their 'compression rate,' and identifies several asymmetric data compression algorithms that 'provide[] a high compression rate,' referring to MPEG layer 3 and ATRAC 2 as 'example[s].'" Pet. 21 (citing Ex. 1005 at [0068]). But the cited sentence reads, "Furthermore, example of the coding method, which provides a relatively less bit rate of the resulting coded data (i.e., which provides a high compression rate), are MPEG layer 3 and ATRAC 2." Ex. 1005 at [0068].

67. Imai's reference to "a relatively less bit rate" makes clear that Imai's use of "compression rate" refers to the compression ratio, or the degree of compression. Because the *degree* of compression is high, the amount of data that is output from the encoder is low, and thus it provides "a relatively less bit rate of the resulting coded data." Imai is using the term to describe how much the data was compressed, rather than the speed at which it was compressed, as the Petition indicates that Claim 1 uses the term.

68. I therefore agree with Dr. Storer's deposition testimony that Imai does not use "compression rate" in the same sense as Claim 1 uses the term. Ex. 2003 at 114:14-115:4. In my opinion Imai is clearly using "compression rate" to mean compression ratio and he is not using it to refer at all to the speed of compression. In other words, Imai is not using compression rate in the same sense as in Claim 1.

69. Thus, the cited passage does not pertain to "compression rate" as the Petition defines the term or as Claim 1 uses it.

70. The Petition also argues that ATRAC is "a relatively faster compression algorithm" and that "Imai teaches including asymmetric compression encoders that have different execution speeds." Pet. 21. I note that the only evidence the Petition points to is Imai's statement that ATRAC "requires a not so large amount of computation for decoding." *Id.* (quoting Ex. 1005 at [0068]).

71. Imai's reference to the "amount of computation for decoding" is not a teaching about "compression rate," or the speed of encoding. Imai is describing the computation necessary for "decoding," and the Petition defines "compression rate" as the "algorithmic speed of a compression encoder," rather than the speed of a decoder. A description of the computational requirements of a decoder does not describe the speed of an encoder.

72. Indeed, it would not be possible to determine or infer the speed of an encoder even if one knew the speed of a decoder. The relationship between encoding speed and decoding speed is inexact, and it varies depending on characteristics of hardware implementation and which encoding and decoding algorithms are used.

73. Based on Imai's reference to the amount of computation required for decoding ATRAC, the Petition concludes that "Imai teaches using an ATRAC encoder and explains how it is a relatively faster compression algorithm" and that "Imai teaches including asymmetric compression encoders that have different execution speeds." Pet. 21. Both conclusions are incorrect for the reasons stated above. The cited language from Imai does not say that ATRAC is relatively fast at encoding than any other algorithm, and it does not describe the execution speed of any encoder.

74. The Petition also states, “Imai explains that ATRAC 2 can encode at various compression rates (e.g., ‘64 Kbps, 32K bps, 24 Kbps’).” Pet. 22 (quoting Ex. 1005 at [0069]). Under the Petition’s definition of “compression rate,” that is a misinterpretation of Imai. Imai states “Therefore, here, for example, all the encoders 531 to 53N perform encoding with ATRAC 2, while data rates of coded data outputted from the encoders are 64 Kbps, 32 Kbps, 24 Kbps, . . . , respectively.” Ex. 1005 at [0069].

75. A person of ordinary skill would understand that the numbers preceding “Kbps” are bitrates. Those bitrates describe the rates at which data is output from the encoder. They do not describe the “compression rate,” of any encoder, which the Petition states is measured by the “amount of input data that [the encoder] can compress per unit of time.” Pet. 21. As explained above, the rate at which data is output from an encoder is not the encoder’s compression rate.

76. Thus, I agree with Dr. Storer’s deposition testimony that Imai’s reference to “64 Kbps, 32K bps, 24 Kbps” describes output bitrates. Ex. 2003 at 105:4-106:13.

77. Accordingly, it is my opinion that all of the examples from Imai that the Petition cites as references to compression rate in fact describe something else, such as output rates, compression ratio, or computational requirements for decoding.

78. It is also my opinion that, even if Imai did teach that its different encoders have different data compression rates, such a teaching would not disclose limitation 1[B]. As I explained above, a person of ordinary skill would understand that limitation 1[B] requires more than encoders with different or varying compression rates.

C. The Petition’s Suggested Modification to Imai

79. I also disagree with the Petition’s statement that a POSITA would have included “encoders having higher and lower data compression rates” because the POSITA “would have recognized that adjusting the output rate of the compression encoder would impact the throughput of the compression encoder, particularly if the compression ratio of the encoder is fixed.” Pet. 22-23.

80. I start by addressing the teaching from Imai that the Petition cites in support when it states that Imai recognizes that the “transmission rate of a communication channel . . . ‘varies due to the amount of traffic’” and thus “Imai selects a ‘coding method which can provide the coded data having a bit rate not higher than the detected transmission rate.’” Pet. 22. (citing Ex. 1005 at [0145]). The quoted teaching from Imai describes lowering the encoder’s output bitrate to accommodate a slow network. As the Petition recognizes, that allows Imai to transmit the data in real time. *Id.* (“Imai explains that the transmission rate of a communication channel between the server and client ‘varies due to the amount of

traffic’ being sent across the channel, and that this can impact the ability of the client to reproduce the transmitted signals in real-time.”); *see also* Ex. 1005 at [001] (summarizing the invention as used for “encoding and transmitting time series digital signals such as audio signals, and receiving and decoding the digital signals to reproduce them in real time on the receiving side.”).

81. However, Imai does not teach lowering the output bitrate by lowering the speed of compression, or modifying the speed of compression in any way. Instead, the cited teaching from Imai describes reducing the output bitrate by compressing the data more, not by compressing it faster or slower.

82. As Imai explains, because the data encoded at a lower output bit rate is more compressed, the encoding method that “provides a relatively small (low) bit rate . . . reproduces an audio signal with relatively poor reproducibility” and the method “which provides a relatively large (high) bit rate . . . can reproduce an audio signal with relatively good reproducibility.” Ex. 1005 at [0067]. Imai thus increases the compression ratio at the expense of audio quality.

83. Increasing the compression ratio reduces the output bitrate to one that can be transmitted by the network in real time, or in Imai’s words, so that the “coded data ha[s] a bit rate not higher than the detected transmission rate.” Ex. 1005 at [0145].

84. Therefore, it is my opinion that Imai's teaching does not suggest modifying the speed of compression, as the Petition suggests.

85. That is especially so if the compression ratio of the encoder is fixed (as the Petition suggests it would be) because Imai's solution depends on changing the compression ratio. Pet. 22-23.

86. The Petition thus does not point to evidence that Imai teaches lowering the output bitrate of an encoder by modifying the speed of compression, as Claim 1 requires.

87. And in fact, Imai does not teach lowering the output bitrate of an encoder by modifying its compression rate, much less doing so to address a slow network.

88. It is also my opinion that a POSITA would not modify Imai as the Petition suggests because the Petition's approach of modifying the speed of compression would be either ineffectual or counterproductive in addressing Imai's concerns.

89. I agree with the Petition that Imai is addressing a situation in which the speed of the network creates a bottleneck in the system such that the audio may not be reproduceable in real time. Pet. at 22 ("Imai explains that the transmission rate of a communication channel between the server and client 'varies due to the amount of traffic' being sent across the channel, and that this can impact the ability

of the client to reproduce the transmitted signals in real-time.”) (citing Ex. 1005 at [0145]).

90. Imai’s concern is that “if the transmission rate of the network 2 is reduced down smaller than the data rate of the coded data, transmission of the coded data becomes so late that audio signals cannot be reproduced in real time.” Ex. 1005 at [0145].

91. In such a situation, lowering the output bitrate of the encoder by slowing the encoder while keeping the compression ratio fixed would exacerbate the problem that Imai is concerned with: that the data cannot be “reproduced in real time.” 1005 at [0145].

92. In order to lower the output bitrate by modifying the compression rate of an encoder, a POSITA would need to lower the encoder’s compression rate so that it could not encode as much input data per unit of time. But if the system is operating at real time before the encoder is slowed, lowering the amount of input data that can be processed will cause the system to operate at slower than real time, and output data at slower than real time.

93. For instance, Dr. Storer offers the following illustration of lowering the compression speed of an encoder: “[A] 32 kbps encoder could be created using a 64 kbps encoder that runs at half its normal execution speed. It would follow that the 64kbps encoder would have a higher data compression rate than the 32 kbps

encoder.” Ex. 1003 at ¶ 141. As explained below, modifying an encoder in that way would make it useless for real time encoding.

94. If an encoder could output data at 64 kbps when operating at real time, then each 64 kilobits of data would represent one second of audio (or video) input. If the compression ratio of the encoder were 2:1, then each second of audio or video input data would consist of 128 kilobits prior to encoding. If that encoder were modified to run at half the compression rate, it would produce 32 kbps of output data at the same 2:1 compression ratio. But, because the compression ratio has not changed, it still would still take 64 kilobits of output data to encode the 128 kilobits of input data that represents each second of audio or video input. Thus the 32 kilobits output each second would represent only half a second of audio or video. The result is that it would take two hours to watch a one-hour video, or six minutes to listen to a three-minute song.

95. Thus, a modification that slowed the compression rate without increasing the compression ratio, as the Petition suggests, would prevent the audio or video signal from being reproduceable in real time. Pet. 22-23.

96. Because the data could not be reproduced in real time, it would prevent the system from being used for its intended purpose and would not address Imai’s concerns.

97. Using an encoder with a higher compression rate would also be ineffective in addressing Imai's concerns.

98. That is so because the network is already too slow to transmit the existing output bitrate, and increasing the speed of the encoder could only increase the output bitrate further. A POSITA would recognize that there would be no point in increasing the output bitrate beyond what the network can transmit.

99. Thus, I agree with Dr. Storer that increasing the speed of the encoder is pointless if the communication channel is the bottleneck in the system. Ex. 2003 at 81:11-13; *see also id.* at 85:22-86:1.

100. It is thus my opinion that the Petition does not offer any reason why a POSITA would solve the problem of a slow network by varying the compression rate of an encoder as opposed to its compression ratio.

101. In contrast to the situation Imai describes, in which the network is the bottleneck in the system of data transmission, intentionally modifying the compression rate of the encoder is only useful if the encoder is the bottleneck in the system. Where the encoder's speed is such that its maximum output rate is slower than the other aspects of the system (such as the network or the decoder) can handle, speeding the encoder can remove that bottleneck and increase the system's throughput.

102. But the Petition does not point to any teaching from Imai regarding the situation in which the encoder is the bottleneck in the system.

103. As explained above, the Petition's motivation relies on a problem that its solution cannot address, a slow network.

104. It is thus my opinion that the Petition does not explain how Imai suggests configuring the system such that "a first asymmetric data compression encoder . . . [would] compress data blocks containing video or image data at a higher data compression rate than a second asymmetric data compression encoder."

105. It is also my opinion that Imai contains no such teaching.

106. I also note that the Petition does not argue that the solution to a slow network disclosed in Imai (increasing the degree of compression) teaches limitation 1[B]. That is evident from the Petition's statement that a POSITA would be motivated "particularly if the compression ratio of the encoder is fixed." If the compression ratio of the encoder is fixed, Imai's solution of increasing the compression ratio is inapplicable.

107. It is also my opinion that such an argument would be incorrect. Imai's solution of increasing the compression ratio could not disclose limitation 1[B] because a design choice to increase the compression ratio is not made because of an encoder's compression rate.

108. Even if a choice to include multiple encoders because of their varying compression ratios were to result in a system with encoders with varying compression rates, the system would not practice limitation 1[B] because the difference in compression rates would be only a side effect of the choice to include encoders with different compression ratios. There would be no design choice with the specific purpose of having encoders with different compression rates.

109. I also note that the Petition does not allege that a POSITA would configure Imai's system to increase throughput by taking both compression rates and compression ratios into account when selecting an encoder.

110. Moreover, such a modification would be beyond the skill of a person of ordinary skill in the art. The tradeoffs between compression rate and compression ratio would be sufficiently complex that a person of ordinary skill in the art would not have a reasonable expectation of success in improving the system with such a modification.

111. Thus, Imai's desire to increase the compression ratio of the system would not motivate a person of ordinary skill to "configure" the system in accordance with limitation 1[B].

VIII. Petitioner's Obviousness Theory as to Pauls

112. For the reasons discussed below, I also disagree with the Petition that Pauls teaches limitation 1[B].

A. Pauls's Purported References to Compression Rate

113. The Petition points to two teachings in Pauls as examples of teachings regarding compression rates, but those teachings in fact pertain to other features of encoders, and not their compression rates.

114. The Petition first quotes Pauls's statement that "[e]ach of the aforementioned encoding algorithms have associated different levels or percentages of compression." Pet. 39 (quoting Ex. 1007 at [0010]). That teaching is a reference to compression ratio and does not disclose compression rate in the sense that Claim 1 uses the term, i.e., compression speed. "The specific phrases "different levels" and "percentages of compression" in Pauls make it clear to a POSITA that they refer to compression ratios and not speed of compression. Specifically, "percentage of compression" gives a number analogous to a compression ratio. For example, a compression ratio of 2:1 might alternatively be referred to as a 50% compression.

115. That it is referring to compression ratio is also clear from context. The preceding sentences refer to "reducing the amount of data to be transmitted." Ex. 1007 at [0010]. The data to be transmitted is "reduc[ed]" because the degree of compression is higher.

116. The Petition also relies on the rate at which the encoders "render" video as teachings regarding compression rate. Pet. 39 ("For example, FIG. 5

teaches that H.263 renders video at a bit rate of 8–24 Kbps, MPEG renders video at a bit rate of 1.5 Mbps, and MPEG2 renders video at a bit rate of 2.0 Mbps.”). Pauls’s Figure 5 actually discloses output bitrates; it does not describe compression rates.

117. That is clear from Pauls’s description of Figure 5, which explicitly states that it depicts “encoding algorithms and the bit rate of the data after encoding (or compression).” Ex. 1007 at [0024].

118. Thus, I agree with Dr. Storer that Figure 5 discloses the rates at which data is output from the encoder. Ex. 2003 at 154:10-15.

119. Pauls’s description of output bitrates does not disclose compression rates under the Petition’s definition because it does not disclose “the amount of input data [an encoder] can compress per unit of time.”

120. It is thus my opinion that the Petition points to no part of Pauls that discloses, teaches, or mentions the compression rate of any encoder.

121. Indeed, Pauls does not mention compression rates at all.

B. Obviousness Based on Probable Differences in Compression Rate

122. I also disagree with the Petition’s theory that Pauls meets limitation 1[B] through chance differences in compression rates. Pet. 40 (“POSITA would have understood that it is only a remote possibility that any two different asymmetric data compression encoders would have the same execution speed, and

therefore the obvious result of including two or more different asymmetric compression encoders is that one encoder would have a higher data compression rate than another encoder.”).

123. As explained above, Claim 1[B]’s “configured to” requirement cannot be met by happenstance. It requires deliberate configuration with respect to the compression rates of the first and second “asymmetric data compression encoder[s].”

124. As explained above with respect to Imai, the Petition’s argument that Pauls arrives at the limitation by chance admits that Pauls does not disclose limitation 1[B].

125. Thus, it is my opinion that the Petition points to no disclosure from Pauls indicating that the system is “configured to,” or with the purpose of, having one encoder compress more quickly than another.

126. Indeed, the Petition points to no mention of encoding speed, or the scenario in which the encoder becomes a bottleneck in data transmission.

IX. Petitioner’s Obviousness Theory as to the Combination of Imai and Pauls

127. The Petition states that a POSITA would incorporate the video encoders mentioned in Pauls into Imai’s system. Pet. 53 (“A POSITA would thus have been motivated to combine the systems of Imai and Pauls to utilize the

numerous video and image data compression encoders of Pauls to enable video compression in Imai's system."). It also suggests that a POSITA would modify Pauls to incorporate "Imai's detailed teachings regarding determining the bandwidth of a communications channel to Pauls' system that selects from multiple video data compression encoders to fine-tune Pauls' video transmission system." *Id.*

128. In my opinion, however, the Petition does not explain why a POSITA would make either change.

129. For instance, it does not offer a motivation for why a POSITA would modify Pauls at all.

130. With regard to Imai, the Petition notes Imai's statement that it could be modified for video encoding Pet. 53 ("As Imai explicitly applies its teachings to video encoding, a POSITA would logically look towards other prior art references involving data encoding and video encoding techniques to create a video encoding and transmission system. One such prior art reference is Pauls, which includes extensive teachings specific to video.>").

131. And it states that Pauls and Imai share certain similarities. Pet. 52 ("Indeed, both references are used for the same purpose: encoding data at a server for transmission to a client over a distributed network such as the Internet."); *id.* ("They both teach encoding the data using encoding methods that achieve data

compression using asymmetric techniques.”); *id.* (“Also, both references choose an encoding method based upon the type of data being transmitted.”); *id.* (“Further, both teach choosing the encoding method based upon a throughout of the communications channel connecting the client.”); *id.* (“Imai and Pauls discuss implementing their inventions on known computer systems.”).

132. It further states that a POSITA would include the encoders from Pauls because the POSITA “would have a reasonable expectation of success . . . given that audio and video compression technologies were well known” and doing so would be “simple” and “would have predictable results.” Pet. 53; *see also id.* at 54 (“A POSITA would have found it obvious to incorporate Pauls’ videos-specific compression encoders into Imai using her ordinary skill because a POSITA at the time of the alleged invention would have known how to make use of off-the-shelf implementations of standards-based video encoders and could use those encoders within Imai’s multi-compressor system.”).

133. But none of the reasons suggested in the Petition indicate why a POSITA would make the Petition’s modification to Imai: including the encoders Pauls mentions.

134. A POSITA would not add an encoder to Imai’s system merely because that encoder was mentioned in Pauls, even if the POSITA were to conclude that the two systems share some similarities.

135. And a POSITA would not add any particular video encoder to Imai's system merely because Imai mentions that its approach could be applied to video.

136. Nor would a POSITA add any encoder simply because doing so would be easy, simple, or achievable.

137. In other words, a POSITA would not incorporate the encoders mentioned in Pauls simply because the POSITA could or because the POSITA was aware of the possibility.

138. Rather, a POSITA would make a careful choice regarding the costs and benefits of including a particular encoder. The POSITA would choose to include an encoder only if the POSITA determined that it would improve the system because the costs outweigh the benefits. In doing so, the POSITA would necessarily consider the likely application of the system and the various downsides of including each additional encoder.

139. Thus, it is my opinion that the reasons offered by the Petition would not lead a POSITA to make the suggested modification.

X. Petitioner's Obviousness Theory as to the Combination of Imai, Pauls, and Chao

140. I understand that the Petition also suggests a POSITA would configure the combined system of Imai and Pauls to use an arithmetic algorithm, whether by configuring it to use the "arithmetic mode" of an algorithm mentioned

in Pauls or by combining it with Chao. Pet. 60 (“A POSITA would have known of arithmetic data compression encoders . . . and known that such encoders could be used to complement or as a substitute to other well-known asymmetric encoders used in Imai and Pauls.”); *id.* at 61 (“Pauls teaches asymmetric data encoders that have optional arithmetic coding modes”); *id.* at 63 (“[I]t would have been obvious to substitute Chao’s video encoder for Pauls’ H.263 video encoder”).

141. I first note that configuring the combined system of Imai and Pauls to use an arithmetic algorithm would require a modification to the prior art because neither Imai or Pauls teach using the arithmetic mode of any algorithm.

142. I understand that the Petition alleges a POSITA would configure the system to use an arithmetic algorithm because of certain benefits of arithmetic encoding. Pet. 59-62.

143. However, as I note above, a POSITA would also weigh the costs of a design choice when deciding how to configure a system. In particular, a POSITA would consider the tradeoffs inherent in using arithmetic algorithms, which the Petition does not address.

144. For instance, the documents the Petition relies on to describe the benefits of arithmetic algorithms also explain that it entails costs in the form of reduced speed.

145. For example, the specification of the ‘477 patent states that arithmetic encoding “is the slowest to execute.” Ex. 1001 at 5:11-13.

146. And Mark Nelson’s book on data compression (which the Petition relies on) states that “[Arithmetic coding’s] [r]untime performance is significantly slower than Huffman coding, however, due to the computational burden imposed on the encoder and decoder.” Ex. 1018 at 39.

147. Chao provides another example: it states that the choice whether to use “either Arithmetic, Run Length, or Huffman, of [sic] Huffman and Run Length combined” depends on “the amount of compression desired against the invested time required to get that level of compression.” Ex. 1016 at 54.

148. In the case of H.263, using the arithmetic mode also has the downside of reduced compatibility. The H.263 specification notes that its arithmetic option “does not apply to certain types of pictures” and cannot be “used in combination with certain other modes.” Ex. 1020 at 38-39.

149. A person of ordinary skill would consider the above costs of arithmetic encoding before making any modification to the system.

150. But the Petition does not address any of the costs of arithmetic encoding or weigh those costs against the potential benefits. Thus, the Petition cannot show that a POSITA would in fact modify the art to use an arithmetic algorithm.

151. I also understand that the Petition relies on Pauls's disclosure of JPEG as an "arithmetic data compression algorithm" that would be used by one of the encoders. Pet. 59, 60. However, the Petition does not explain why a POSITA would use JPEG in a video data compression encoder.

152. Neither Pauls nor Imai disclose a "video data compression encoder" using JPEG, and in fact, JPEG is not a video standard. Indeed, the JPEG standard, a copy of which is submitted along with this declaration as Exhibit 2004, does not even mention video encoding or motion. Ex. 2004.

153. It is thus my opinion that the Petition does not make clear why a POSITA would choose to use JPEG in a "video data compression encoder."

XI. Conclusion

154. In signing this declaration, I understand that the Declaration will be filed as evidence in contested cases before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time allotted for cross examination.

155. I 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 '477 Patent.

Executed on May 20, 2019 in San Diego, California.

Respectfully submitted,

A handwritten signature in black ink, reading "Kenneth A. Zeger". The signature is written in a cursive, flowing style with a large initial 'K' and a long, sweeping tail on the 'Z'.

Kenneth A. Zeger, Ph.D.

EXHIBIT A

Kenneth A. Zeger

- Professor and consultant -

Personal Data

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Academic Degrees

Ph.D (ECE): University of California, Santa Barbara (1990)
M.A. (Mathematics): University of California, Santa Barbara (1989)
S.M. (EECS): Massachusetts Institute of Technology (1984)
S.B. (EECS): Massachusetts Institute of Technology (1984)

Faculty Positions

University of California, San Diego	- Professor of Electrical Engineering (1998-present) - Associate Professor of Electrical Engineering (1996-1998)
University of Illinois, Urbana-Champaign	- Associate Professor of Electrical Engineering (1995-1996) - Assistant Professor of Electrical Engineering (1992-1995)
University of Hawaii	- Assistant Professor of Electrical Engineering (1990-1992)

Honors and Awards

- IEEE Fellow (2000)
- NSF Presidential Young Investigator Award (1991)
- United States Mathematical Olympiad (1980)

Consulting Experience

Clients:

- Automatic Data Processing Co.
- Hewlett-Packard Laboratories
- U.S. Department of Defense
- MITRE Co.
- Nokia Telecommunications Inc.
- Prominent Communications Inc. (Chair of Technical Advisory Board)
- ViaSat Inc.
- Xerox Co. Palo Alto Research Center
- Zeger-Abrams Inc.
- Zunda LLC (President)
- Expert Witness in numerous patent infringement and trade secret litigations.

Topics:

- Image, fax, video, vision, television coding.
- Speech coding and recognition, audio coding, telephony.
- Electronic hardware devices: cell phones, printers, cameras, TV, computers, dongles, etc.
- Protocols, networks, Internet, security, GPS.
- Digital and wireless communications.
- Error correcting codes.
- Communication protocols.
- Software: C, C++, C#, BASIC, Lisp, Fortran, Cobol, Algol, Pascal, Assembler, TMS320, Java, DSP, Verilog, HTML, JavaScript, Perl, Visual Basic, VHDL.
- National security topics.

Professional Activities

- Board of Governors of IEEE Information Theory Society (1998-2000, 2005-2007, and 2008-2010)
- Associate Editor At-Large of *IEEE Transactions on Information Theory* (1995-1998).
- Steering Committee member of Fourth Workshop on Network Coding, Theory, and Applications (2007).
- Co-organizer of: Third Workshop on Network Coding, Theory, and Applications, San Diego (2007).
- Co-organizer of NSF Workshop on Joint Source-Channel Coding, San Diego, California. (1999)
- Co-organizer of IEEE Information Theory Workshop, San Diego, California. (1998)
- Co-organizer of Allerton Conference on Communication, Control, and Computing (1995)
- Co-organizer of IEEE Communication Theory Workshop, Ojai, California. (1990)
- International Advisory Committee of International Symposium on Spread Spectrum Techniques and Applications (ISSTA) (Taichung, Taiwan 2010)
- Program Committee of Information Theory Workshop (ITW) (Jerusalem, Israel, 2015)
- Program Committee member of International Symposium on Network Coding (NetCod) (Sydney, Australia, 2015)
- Program Committee member of International Symposium on Network Coding (NetCod) (Beijing, China, 2011)
- Program Committee member of Workshop on Network Coding, Theory, and Applications (NetCod) (Lausanne, Switzerland, 2009)
- Program Committee member of Workshop on Network Coding, Theory, and Applications (NetCod) (Hong Kong, 2008)
- Program Committee member of Workshop on Network Coding, Theory, and Applications (NetCod) (Boston, 2006)
- Program Committee member of International Symposium on Information Theory (ISIT) (Toronto, Canada 2008)
- Program Committee member of International Symposium on Information Theory (ISIT) (Adelaide, Australia 2005)
- Program Committee member of International Conference on Image Processing (ICIP) (Atlanta, Georgia, September 2006).
- Program Committee member of International Conference on Image Processing (ICIP) (Genova, Italy, 2005)
- Program Committee member of International Conference on Image Processing (ICIP) (Singapore 2004)
- Program Committee member of International Conference on Image Processing (ICIP) (Barcelona, Spain, 2003)
- Program Committee member of International Symposium on Information Theory and its Applications (Monterey, California 2016)
- Program Committee member of International Symposium on Information Theory and its Applications (Melbourne, Australia 2014)

May 17, 2019

- Program Committee member of International Symposium on Information Theory and its Applications (Honolulu, Hawaii 2012)
- Program Committee member of International Symposium on Information Theory and its Applications (Taichung, Taiwan 2010)
- Program Committee member of International Symposium on Information Theory and its Applications (Auckland, New Zealand 2008)
- Program Committee member of International Symposium on Information Theory and its Applications (Soeul, Korea 2006)
- Program Committee member of International Symposium on Information Theory and its Applications (Xian, China, 2002)
- Program Committee member of International Symposium on Information Theory and its Applications (Hawaii, 2000)
- Program Committee member of Data Compression Conference (Salt Lake City, Utah, 1996-2007)
- Plenary speaker at Nottingham Trent Univ. Workshop on Prob., Theory, & Appl. (England, 1998)
- Plenary speaker at IEEE Communication Theory Workshop (Destin, Florida, 1996)
- IEEE Communication Theory Technical Committee
- IEEE Signal Processing and Communications Electronics Technical Committee
- Started U.S.-Hungary Research Exchange Program
- MIT Educational Council (1985-present)

Research Interests

Source/Channel Coding, Image/Speech Compression, Networking, Statistical Learning and Pattern Matching, Information Theory, Graph and Complexity Theory, Combinatorial Monoid & Group Theory

Teaching Experience (g = grad, u = undergrad)

Calculus (u)

Probability (u)

Signals and Systems (u)

Circuits and Systems (u)

Information Theory (g)

Source Coding (g)

Random Processes (g)

Publications of Kenneth Zeger

Journal Papers:

1. **Kenneth Zeger and Allen Gersho**, “Zero-Redundancy Channel Coding in Vector Quantisation”, *IEE Electronics Letters*, vol. 23, no. 12, pp. 654-656, June 1987.
2. **Kenneth Zeger and Allen Gersho**, “A Stochastic Relaxation Algorithm for Improved Vector Quantiser Design”, *IEE Electronics Letters*, vol. 25, no. 14, pp. 896-898, July 1989.
3. **Kenneth Zeger and Allen Gersho**, “Pseudo-Gray Coding”, *IEEE Transactions on Communications*, vol. 38, no. 12, pp. 2147-2158, December 1990.
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5. **Kenneth Zeger**, “Corrections to ‘Gradient Algorithms for Designing Predictive Vector Quantizers’ ”, *IEEE Transactions on Signal Processing*, vol. 39, no. 3, pp. 764-765, March 1991.
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8. **Kris Popat and Kenneth Zeger**, “Robust Quantization of Memoryless Sources using Dispersive FIR Filters”, *IEEE Transactions on Communications*, vol. 40, no. 11, pp. 1670-1674, November 1992.
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10. **Tamás Linder, Christian Schlegel, and Kenneth Zeger**, “Corrected Proof of de Buda’s Theorem”, *IEEE Transactions on Information Theory*, vol. 39, no. 5, pp. 1735-1737, September 1993.
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15. **Kenneth Zeger and Vic Manzella**, “Asymptotic Bounds on Optimal Noisy Channel Quantization Via Random Coding”, *IEEE Transactions on Information Theory*, vol. 40, no. 6, pp. 1926-1938, November 1994.
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23. **P. Greg Sherwood and Kenneth Zeger**, “Progressive Image Coding on Noisy Channels”, *IEEE Signal Processing Letters*, vol. 4, no. 7, pp. 189-191, July 1997.
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35. **András György, Tamás Linder, and Kenneth Zeger**, “On the Rate-Distortion Function of Random Vectors and Stationary Sources with Mixed Distributions”, *IEEE Transactions on Information Theory*, vol. 45, no. 6, pp. 2110-2115, September 1999.
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94. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Unachievability of Network Coding Capacity”, *First Workshop on Network Coding, Theory, and Applications (NETCOD)*, Riva del Garda, Italy (invited), April 2005.
95. **Jillian Cannons, Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Network Routing Capacity”, *IEEE International Symposium on Information Theory (ISIT)*, Adelaide, Australia, pp. 11-13, September 2005.

96. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Insufficiency of Linear Network Codes”, *IEEE International Symposium on Information Theory (ISIT)*, Adelaide, Australia, pp. 264-267, September 2005.
97. **Randall Dougherty and Kenneth Zeger**, “Nonreversibility of Multiple Unicast Networks”, *Allerton Conference on Communication, Control, and Computing*, Allerton Park, Illinois (invited), September 2005.
98. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “The Vámos Network”, *Second Workshop on Network Coding, Theory, and Applications (NETCOD)*, Boston, Massachusetts, April 2006.
99. **Rathinakumar Appuswamy, Massimo Franceschetti, and Kenneth Zeger** “Sufficiency of Linear Codes for Broadcast-Mode Multicast Networks”, *IEEE International Symposium on Information Theory (ISIT)*, Seattle, Washington, July 2006.
100. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Six New Non-Shannon Information Inequalities”, *IEEE International Symposium on Information Theory (ISIT)*, Seattle, Washington, July 2006.
101. **Zsolt Kukorelly and Kenneth Zeger** “Automated Theorem Proving for Hexagonal Run Length Constrained Capacity Computation”, *IEEE International Symposium on Information Theory (ISIT)*, Seattle, Washington, July 2006.
102. **Jillian Cannons and Kenneth Zeger**, “Network Coding Capacity with a Limited Number of Coding Nodes”, *Allerton Conference on Communication, Control, and Computing*, Allerton Park, Illinois (invited), September 2006.
103. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Matroidal Networks”, *Allerton Conference on Communication, Control, and Computing*, Allerton Park, Illinois (invited), September 2007.
104. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Linear Network Codes and Systems of Polynomial Equations”, *IEEE International Symposium on Information Theory (ISIT)*, Toronto, Canada, July 2008.
105. **Rathinakumar Appuswamy, Massimo Franceschetti, Nikhil Karamchandani, and Kenneth Zeger** “Network Coding for Computing”, *Allerton Conference on Communication, Control, and Computing*, Allerton Park, Illinois (invited), September 2008.
106. **Jillian Cannons, Laurence Milstein, and Kenneth Zeger**, “Wireless Relay Placement”, *IEEE Radio and Wireless Symposium (RWS)*, San Diego, California (invited), January 2009.
107. **Rathinakumar Appuswamy, Massimo Franceschetti, Nikhil Karamchandani, and Kenneth Zeger**, “Network Computing Capacity for the Reverse Butterfly Network”, *IEEE International Symposium on Information Theory (ISIT)*, Seoul, Korea, June 2009.

108. **Kenneth Zeger**, “Network Coding and Computing”, *The 5th Western Canadian Summer School on Communications and Information Theory*, Banff, Alberta, Canada, August 2010 (invited plenary talk).
109. **Rathinakumar Appuswamy, Massimo Franceschetti, Nikhil Karamchandani, and Kenneth Zeger**, “Network Computing and Linear Codes”, *Information Theory and its Applications Workshop (ITA)*, San Diego, California, February 2011 (poster session).
110. **Rathinakumar Appuswamy, Massimo Franceschetti, Nikhil Karamchandani, and Kenneth Zeger**, “Linear Coding for Network Computing”, *IEEE International Symposium on Information Theory (ISIT)*, St. Petersburg, Russia, July-August 2011.
111. **Randall Dougherty, Christopher Freiling, and Kenneth Zeger**, “Achievable Rate Regions for Linear Network Coding”, *Information Theory and its Applications Workshop (ITA)*, San Diego, California, February 2012.
112. **Randall Dougherty, Eric Freiling, and Kenneth Zeger**, “Characteristic-Dependent Linear Rank Inequalities and Network Coding Applications”, *IEEE International Symposium on Information Theory (ISIT)*, Honolulu, Hawaii, June-July 2014.
113. **Joseph Connelly and Kenneth Zeger**, “A Class of Non-Linearly Solvable Networks”, *IEEE International Symposium on Information Theory (ISIT)*, Barcelona, Spain, June-July 2016.