UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Charter Communications, Inc.,
Petitioner

v.

Adaptive Spectrum and Signal Alignment, Inc.
Patent Owner

Case No. IPR2024-01379

U.S. Patent No. 7,809,996 B2

Filing Date: August 4, 2008
Issue Date: October 5, 2010

Title: ADAPTIVE FEC CODEWORD MANAGEMENT

DECLARATION OF DR. JAMES MARTIN

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I, James Martin, declare as follows:

1. My name is James Martin. I am an independent consultant and a Professor of Computer Science at Clemson University in Clemson, South Carolina.

2. I have prepared this report as an expert witness retained by Charter Communications, Inc. In this report I give my opinion as to the validity of claim 20 of U.S. Patent No. 7,809,996 (the "'996 Patent").

3. This report contains statements of my opinions formed as of the present date and the reasoning for those opinions. As this case progresses, I may offer additional opinions based on my review of materials, opinions, and/or testimony of other expert witnesses. I make this declaration based upon my personal knowledge and, if called upon to testify, I would competently testify thereto.

I. BACKGROUND AND QUALIFICATIONS

A. Relevant Experience and Qualifications

4. Below, I have summarized my educational background, career history, publications, and other relevant qualifications. My full curriculum vitae is attached as **Appendix A** to this declaration.

5. I divide my background summary into two parts. The first part summarizes my education and relevant work experiences prior to August 2002 when I left the corporate world and entered the academic world. The second part

summarizes the academic research and consulting engagements which are relevant for this Declaration. Please refer to my CV for further details. I point out that I contributed to the DOCSIS CableLabs standards as well as to the IEEE 802.16 WiMAX standards.

6. I received a B.S. degree in Electrical Engineering from the University of Illinois (Champaign/Urbana) in 1983. My focus was wireless communications. I received an MS in Computer Science from Arizona State University (Tempe, AZ) in 1989. I received a Ph.D. from North Carolina State University (Raleigh, NC) in Electrical Engineering in 1999. My dissertation research involved TCP congestion control. I invented the TCP variant referred to as delay-based TCP congestion control. Aspects of this work, along with aspects of my academic research discussed below, have been foundational to the Cable Industry's relatively recent adoption of delay-based Active Queue Management (AQM) methods such as CoDel and PIE.

7. My industry employment includes 6 years at Motorola, 2 years at a startup (FileNet), 10 years at IBM, and 2 years at Gartner. At Motorola, I worked on chip set design and embedded system design for military satellite communications (the DAMA program to be specific). At IBM, I worked on R&D topics related to Systems Network Architecture (SNA) networking system. While

at IBM, my work generated 3 patents in the 2001-2005 timeframe. At Gartner, I was a telecommunications consultant based out of Raleigh NC. I was also an Adjunct Faculty at NCSU. During this time period, I developed a simulation model of the DOCSIS 1.1 protocols.

8. In August of 2002, I joined Clemson University as an Assistant Professor in the Computer Science Department. Much of my research during the 2002-2015 time period explored resource allocation strategies for DOCSIS-based cable access systems. The 2015 publication in IEEE Communications Magazine "DOCSIS 3.1: Scaling broadband cable to Gigabit Speeds", which I co-authored with leading Industry technical leaders, identified open problems in DOCSIS. Two problems we identified include: 1) channel aware packet scheduling taking into account bonded channels and channel profiles; and 2) channel and spectrum analysis/monitoring with Proactive Network Management, and specifically, how it should be used to autonomically adapt the network based on spectrum issues.

9. The DOCSIS lineage originates from the 'Aloha with reservations' protocol. Academic and industry research in ATM over wireless, which again cemented the duality between DOCSIS cable and wireless, led to the IEEE 802.16 standards (WiMAX). In the 2012 timeframe, I switched my main research focus to wireless. From 2012 through present, my wireless research evolved from WiMAX,

to 802.11 and now to 3GPP 5G/6G. The majority of my ideas and research in wireless involves methods for monitoring and characterizing channels. I have numerous papers that present ideas I have developed related to wireless system optimization and spectrum sharing.

1. Compensation

10. For my efforts in connection with preparing this declaration, I have been compensated at the rate of $400 per hour. My compensation is not contingent on the results of this, or any other, proceeding relating to the ’996 Patent.

2. Materials and Information Considered

11. I have considered a variety of information from various sources in forming the opinions contained in this declaration. I have reviewed and considered each of the exhibits listed below in forming my opinions:

Exhibit No.	Description of Document
1001	U.S. Patent No. 7,809,996 B2 to John M. Cioffi (Application filed August 4, 2008, issued October 5, 2010)
1003	U.S. Patent No. 5,699,365 to Jeffrey T. Klayman, et al. (Application filed March 27, 1996, issued December 16, 1997)
1004	U.S. Patent No. 6,477,669 B1 to Anil K. Agarwal, et al. (PCT Application filed July 15, 1998, issued November 5, 2002)
1005	U.S. Patent No. 6,546,509 B2 to Thomas J. J. Starr (Application filed June 19, 2001, issued April 8, 2003)

Exhibit No.	Description of Document
1006	*Adaptive Spectrum and Signal Alignment, Inc. v. Charter Communications, Inc., et al.*, No. 2:24-cv-00124, Complaint (D.I. 1)
1007	'996 Patent File History
1010	E.R. Berlekamp, R.E. Peile, S.P. Pope, "The Application of Error Control to Communications," IEEE Communications Magazine, Vol. 25, No. 4, pp. 44-57 (April 1987)
1011	Claim Listing
1012	J.S. Engel, "Digital Transmission in the Presence of Impulsive Noise," (Apr. 4, 1965), *available at* https://ieeexplore.ieee.org/abstract/document/6769876
1013	U.S. Patent No. 6,654,410 to Marcos C. Tzannes (Application filed January 16, 2002, issued November 25, 2003)
1014	U.S. Patent No. 6,184,942 to Chandrakant B. Patel, et al. (Application filed August 16, 1999, issued February 6, 2001)
1015	U.S. Patent No. 5,886,989 to Allan Evans, et al. (Application filed June 10, 1996, issued March 23, 1999)
1016	U.S. Patent No. 5,659,578 to Siavash M. Alamouti, et al. (Application filed November 23, 1994, issued August 19, 1997)
1017	U.S. Patent No. 6,016,313 to Robert B. Foster, Jr., et al. (Application filed November 7, 1996, issued January 18, 2000)
1018	U.S. Patent No. 5,392,299 to Don S. Rhines, et al. (Application filed January 15, 1992, issued February 21, 1995)
1019	U.S. Patent No. 6,665,308 to Selim Shlomo Rakib, et al. (Application filed September 17, 1998, issued December 16, 2003)

II. STATEMENT OF LEGAL PRINCIPLES

12. I am not an attorney. In forming my opinions in this declaration, I applied relevant legal principles provided and explained to me by counsel, which are summarized below. The below legal principles represent my understanding of the law that I have applied in forming my opinions in this declaration.

A. Claim Construction

13. I have been informed by counsel that a purpose of claim construction is to determine what a person of ordinary skill in the art would have understood the claim terms to mean. I further understand that claim terms are generally given their ordinary and customary meaning, which is how a person of ordinary skill in the art at the time of invention (a "POSITA") would have understood the claim terms. The time of the invention is the effective filing date of the patent application. Also, a person of ordinary skill in the art is deemed to read a claim term within the context of the claim and within the context of the entire patent, including the specification. I am informed that the patent specification may be highly relevant to the claim construction and has been described as the single best guide to the meaning of a disputed claim term. The patent specification usually provides the best context for understanding the meaning of terms that do not have a customary meaning within the art. I understand that the "plain and ordinary meaning" or *Phillips* standard is applicable in these proceedings.

14. I am also informed that other claims within the patent can provide information as to a claim term meaning. Claim terms are normally used consistently throughout the patent, thus, the usage of a term in one claim can shed light on the meaning of that same term in other claims. I understand that differences among claims can also provide guidance to determine the meaning of claim terms.

15. I am further informed that the prosecution history of the patent can inform the meaning of claim language. The prosecution history helps explain how the inventors understood their invention and whether the invention was limited during prosecution, narrowing the claim scope. Extrinsic evidence, such as expert testimony, may also be consulted when properly construing claim terms.

16. I discuss issues of claim construction specific to the ’996 Patent in Part VI.

B. Obviousness

17. I have been informed by counsel that under 35 U.S.C. § 103 (pre-AIA, before March 16, 2013), a patent claim may be rendered invalid as obvious if, when the invention was made, the subject matter of the claim, considered as a whole, would have been obvious to a person of ordinary skill in the art. I have also been advised by counsel that this pre-AIA rule applies to the claims of the ’996 Patent because it was filed prior to March 16, 2013.

18. Counsel has advised me that the following factors should be considered when analyzing obviousness: (1) the scope and content of the prior art; (2) the differences between the prior art and the claims; and (3) the level of ordinary skill in the pertinent art. I understand further factors ("secondary considerations") may indicate non-obviousness. These factors include: commercial success, unexpected results, long felt but unresolved need, industry acclaim, simultaneous invention, copying by others, skepticism by experts in the field, and failure of others. I also understand that these secondary considerations should share a nexus with the claimed invention.

19. I understand that a POSITA is assumed to have knowledge of all prior art. A POSITA can combine different prior art references based on the teachings of those references, the general knowledge present in the art, or their common sense. I further understand that a motivation to combine references may be implicit in the prior art, and there is no requirement that there be an actual or explicit teaching to combine two references. Counsel has explained that one may take into account inferences and creative steps that a person of ordinary skill in the art would employ to combine the known elements in the prior art in the manner claimed by the challenged patent. I understand that one should avoid hindsight bias and *ex post*

reasoning when performing an obviousness analysis; however, this does not mean a POSITA must ignore common sense.

20. I am informed that neither the particular motivation for the patent nor the stated purpose of the patentee is controlling when determining obviousness. The main inquiry relates to the objective reach of the claims and if those claims extend to something obvious. If so, the entire patent claim is invalid.

21. I understand a patent may be found invalid by obviousness if, at the time of invention, there was a known problem for which there was an obvious solution encompassed by the patent's claims. I further understand a motivation to combine various prior art references to solve such a problem may come from a variety of sources, including market demand, academic papers, or scientific literature. I am informed that a need or problem within the field at the time of invention may also provide a reason to combine prior art references and render a patent claim obvious. Familiar items may have obvious uses beyond their primary purpose and a POSITA would be able to fit the teachings of multiple prior art references together like the pieces of a puzzle. I understand that a POSITA is also a person of at least ordinary creativity. Additionally, when there is a design need or market pressure to solve a problem with a finite number of identified, predictable solutions, a POSITA has good reason to pursue the known options within his or her

technical abilities. If these finite number of predictable solutions lead to the anticipated success, I understand that the invention is likely the product of ordinary skill and common sense, and not any sort of innovation. I am informed that the fact that a combination was obvious to try may also show that it was obvious and invalid. I understand that if a patent claims a combination of familiar elements according to known methods, that combination is likely to be obvious when it does nothing more than yield predictable results. Thus, if a POSITA can implement a predictable variation, a claimed invention is likely obvious. I understand that combining embodiments disclosed near each other within a prior art reference would not ordinarily require a great leap of inventiveness.

22. Counsel has also advised me that obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. I understand obviousness may be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior art. I have been advised by counsel that a claimed invention may be obvious if some teaching, suggestion, or motivation exists that would have led a person of ordinary skill in the art to combine the invalidating references. Additionally, I am informed that this suggestion or motivation may come from within the knowledge of a POSITA, or from sources such as explicit statements

in the prior art, but such explicit statements are not required. Alternatively, any need or problem known in the field at the time and addressed by the patent may provide a reason for combining elements of the prior art. I am advised by counsel that when there is a design need or market pressure, and there are a finite number of predictable solutions, a person of ordinary skill may be motivated to apply common sense and his or her skill to combine the known options to solve the problem.

23. Counsel has advised me that the following are examples of approaches and rationales that may be considered in determining whether a piece of prior art could have been combined with other prior art or with other information within the knowledge of a person having ordinary skill in the art:

- some teaching, motivation, or suggestion in the prior art that would have led a person of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention;
- known work in one field of endeavor may prompt variations of it for use in the same, or different, field based on design incentives or other market forces if the variations would have been predictable to a POSITA;

- combining prior art elements according to known methods to yield predictable results;
- applying a known technique to a known device, method, or product ready for improvement to yield predictable results;
- applying a technique or approach that would have been "obvious to try" (choosing from a finite number of identified, predictable solutions with a reasonable expectation of success);
- simple substitution of one known element for another to obtain predictable results; or
- use of a known technique to improve similar products, devices, or methods in the same way.

III. RELEVANT TECHNOLOGICAL BACKGROUND

24. The '996 Patent describes an idea for managing adaptive forward error correction (FEC) codewords targeting broadband access systems based on ADSL type 1 and 2 access technology. The main ideas contained in the patent can readily be applied to any data communication technology, including but not limited to access technologies involving satellite, DOCSIS-based HFC cable, dial-up Public Switched Telephony Networks (PSTN), ATM, Frame Relay, or MPLS systems.

25. The related background to the ’996 Patent dates back to early satellite systems used by the U.S. military and other federal agencies. The concepts of Error Correction Codes (ECC), Forward Error Correction (FEC), and data Interleaving have been fundamental to data communications since the 1940s. Ex. 1010. Applying these principles to all manner of access technologies was well-established by 2003.

26. The goal of this brief introductory background section is to provide a technical framework that will allow me to accurately describe the ideas described by ’996 Patent and the references I have selected and to efficiently and clearly explain why I think the patent is invalid.

A. Error Coding over Communications Channels

27. Computers communicate by sending and receiving signals carrying data across a data link. When two computers, such as Node 1 (N1) and Node 2 (N2), illustrated below, are directly connected by a link which operates on a specific physical medium, the nodes can communicate.

Link

Node 1 ---------- Node 2

Specifically, a component within N1 above the link layer can send a message to a peer component at N2. Channel errors can occur, however, while N1 is transmitting the link frame containing the message. This could be due to interference on the

channel, noise conditions, or other factors contributing to the unreliability of the transmission. If a damaged frame arrives at N2, it might detect that one or more bit errors exist thereby requiring the frame to be dropped. A more extreme level of impairment might prevent N2's physical layer receiver from receiving any portion of a frame or from even knowing a transmission was attempted.

28. In order for the link to provide reliable transport, it should support one or more methods for error detection and error recovery. To improve transmission performance, experts in this field have turned to coding theory, dating back to 1948. Ex. 1010 at 44. Error codes, such as CRC or checksum, are the most common method to detect if an arriving frame was damaged. If an entire frame is lost, then a form of Automatic Request for Retransmission (ARQ) is required in order for the link layer to recover the frame. While ARQ protocols can adapt the link to operate across a range of lossy link conditions, they add complexity to the link and potentially significant latency to transmissions.

29. ARQ is one type of error correction coding (ECC). The idea of ECC is to proactively add to the message a controlled amount of redundant data. Depending on how much (e.g., how many octets) of the frame are in error, and on the amount of redundant data provided (e.g., the strength of the coding), the erroneous data can potentially be fixed, allowing the frame to be successfully received. If the extent of

the damage to a frame exceeds the capabilities of the ECC, the frame will be dropped. All forms of ECC must navigate the conflict that exists with coding: increasing the coding strength will decrease the efficiency of communications over the link. The additional, redundant data effectively reduces the capacity of the link and increases the time it takes for a transmission to occur.

B. Forward Error Correction and Interleaving

30. Prior to 1980s, coding saw limited usage. It required custom, expensive circuity. By the late 1980s, low cost, high performing coding chip sets were available. Low-cost microprocessors allowed systems to leverage adaptive coding schemes. In 1987, "[e]rror control [was] an area of increasing importance to communications" and various error control techniques were being used to optimize performance over transmission channels. Ex. 1010 at 44. Over time, a preeminent approach to error control was through the use of forward error correction (FEC). As explained in 1987:

> The underlying tenet of FEC (in a communications system) is to take user data, add some redundancy, and transmit both the user data and the redundant data. At the receiver, the possibly corrupted signal is processed by the decoder which utilizes the redundancy to extract correct data. An analogy may be made to a person speaking slowly and repetitiously over a noisy phone line, adding more redundancy for the listener to process into the correct message.

Id. at 46. In 1960, a type of FEC codes, Reed-Solomon codes, were first published and evolved throughout the 1970s and 1980s. *Id.* at 45. Reed-Solomon codes remain in use today as a common type of FEC in digital communications systems.

31. At a basic level, FEC coding attempts to improve data transmission reliability by including error-correcting code, which is redundant information to data already being transmitted, to aid in allowing the receiver to detect when errors during transmission occur. Prior to data transmission, an encoder adds the extra bits of data (the redundant data) to the original data based on a specific encoding algorithm, such as Reed-Solomon. Then, the data and redundant data is transmitted to a receiver where it is received and decoded. During transmission, the channel may have been impacted by noise, interference, or other errors. The decoder at the receiver will look to the redundant data to determine if errors can be detected that occurred during the transmission.

32. FEC operates in real-time such that the receiver can correct any errors immediately upon detection based on the redundant bits of data that were transmitted. This allows the system to continuously adapt to ongoing transmission errors as they happen. This was seen as an improvement in some ways over other error correction methodologies (such as the ARQ protocols I discussed above) because it reduces the need for retransmission. Because retransmission in FEC is not

always necessary, this avoids the overall delays and amount of throughput, resulting in a more efficient communications system.

33. Along with FEC coding, by the 1980s, many systems utilized interleaving to optimize the decoding process. Data interleaving is used to improve error correction and can be utilized alongside FEC coding to increase the overall effectiveness of the system. Interleaving is most often used to address burst errors—which commonly occur on noisy communication channels—and provides a way to spread out those errors so FEC algorithms can more easily correct them. Interleaving changes the order of transmit data from the scheduled order so more important portions of data are not sent contiguously to reduce the probability that all important data will be in error. If used in coordination with FEC coding, interleaving can increase the effectiveness of coding regardless of the specific form of coding used. Because interleaving involves rearranging and spreading out data, however, it inherently introduces latency into a transmission.

34. FEC coding and/or interleaving methods can be employed in a variety of communications systems, including radio frequency systems, wireless systems (Wi-Fi, LTE, mobility systems like 3GPP, and WiMAX), satellite systems, DSL, DOCSIS, digital broadcasting, broadband, and cable systems as well as within storage systems.

C. Adaptive Forward Error Correction and Interleaving in the '996 Patent

35. The '996 Patent presents an approach to adapting error control procedures primarily for DSL links based on the ISO G.992.1 and G.992.5. These standards require ADSL links to jointly use Reed-Solomon block coding with appropriate interleaving to meet service levels that can mitigate specified channel error rates while maintaining maximum transmission latencies. The standards provide a number of "profiles" specifying coding and interleaving details. An operator statically selects the profile to be used in a DSL deployment. The '996 Patent describes a method for dynamically adjusting the profiles used (with further levels of granular control) based on current channel conditions.

36. The '996 Patent identifies the following functional components:

- A transmitter: This component receives user data to be sent over a communications link, and at least a R/S FEC encoder, an interleaver, a modulator and circuitry to transmit the frame over the channel. The transmitter has the control interface that accepts (and understands) feedback information as to how to modify the Tx side settings involved in error correction control. The patent language implies this could be either specific control instructions to adapt the interleave depth and

coding strength, or a measure fully describing the updated Codework Composition Ratio (CCR).

- A receiver: This component processes the received signal from the channel, demodulates the received symbols producing received data, and de-interleaves/decodes to produce the original user data. If the received signal was negatively impacted by channel conditions, the data might not be received, or it might be received in error. In the former case, the inbound frame is dropped (or possibly never detected). If the frame is received with errors, the de-interleaving and reverse FEC potentially allows the user data to be correctly received.
- An adaptation controller: This component acquires Measured Transmission Error Values (MEVs), has knowledge of the Target Transmission Error Values (TEVs), and has the means to compute an adaptation action (i.e., a specific set of interleaver and coding updates). More specifically, the controller:
    - Includes a means to acquire the MEV sample, to process the feedback, and to determine a possible adaptation to the transmission process;

- Has a means to convey to the transmitter adaptation updates; and
- Has a means to convey to the receiver the updates (i.e., to ensure the updates are synchronized).

IV. THE '996 PATENT

37. I understand that the '996 Patent issued on October 5, 2010 from an application that was filed on August 4, 2008. Ex. 1001. I further understand that the '996 Patent is a division of Application No. 10/795,593 which was filed on March 8, 2004, and the '996 Patent claims priority to Provisional Application No. 60/527,853 which was filed on December 7, 2003. *Id.* I also understand that Petitioner is challenging the validity of claim 20 of the '996 Patent in the Petition for *Inter Partes* Review to which this declaration will be attached. That claim is reproduced in Exhibit 1011. In rendering my opinions, I have considered all claims of the '996 Patent, the '996 Patent specification, and the '996 Patent prosecution history.

A. Overview of the '996 Patent

38. The '996 Patent relates to adaptive FEC coding used in a transmission system. Ex. 1001 at Abstract. The '996 Patent explains:

> [T]he system preferably measures the desired transmission error value. This MEV of the system is analyzed, which may include comparing the MEV to a TEV. The CCR can then be adjusted in response to the MEVs deviation from the TEV. . . . While such a system is of particular importance with regard to digital subscriber lines, those skilled in the art will appreciate that it is applicable to any system that incorporates codeword-type data structures and interleaving, especially where it is desirable to avoid increasing latency when improving error correction.

Id. at 13:65 – 14:10. The invention purports to "allow[] for adjustments to the transmission error rate of a communications system using data codewords, without affecting the latency of data transmission through the system between a transmitter and a receiver." *Id.* at 5:41-44.

39. Figure 4 of the '996 Patent depicts the method carried out by the disclosed system:

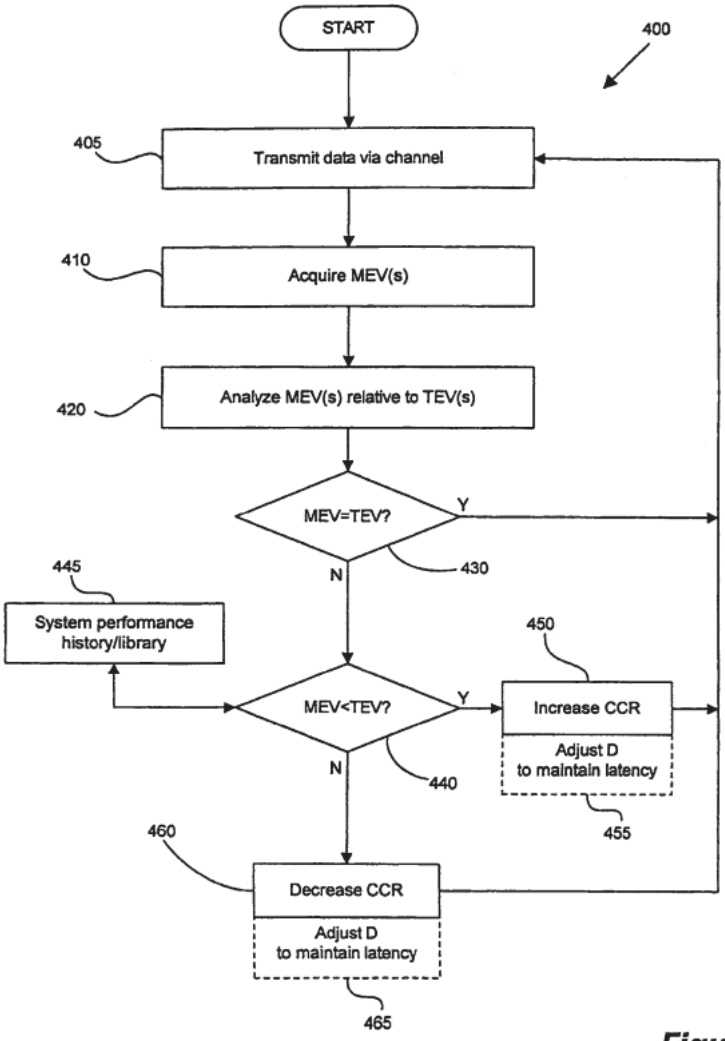


Figure 4

Id. at Fig. 4.

40. FEC techniques were well-known in the art at the time of the '996 Patent. The specification, in fact, acknowledges that "forward error correction (FEC) employing Reed-Solomon encoding . . . is well-known to those skilled in the art." *Id.* at 1:65-67. Additionally, the specification discusses interleaving as "a coding technique commonly used to increase the performance of transmission systems by

decreasing errors in the system." *Id.* at 1:44-49. Interleaving FEC codewords "introduces a transmission delay (or 'latency'), which can be a significant drawback in DSL systems." *Id.* at 2:48-50. Although "providers generally strive to minimize latency through their systems, [they] still tolerate it to gain the benefits of interleaving and [to] offset adverse error effects." *Id.* at 2:57-60. Accordingly, "it is desirable to minimize the interleaving necessary to achieve desired performance." *Id*. at 2:60-62.

41. The '996 Patent discloses that prior art systems have used adaptive interleaving, which alters the amount of interleaving used by such prior art systems. *Id.* at 2:63-65. "Adaptive interleavers are known to those skilled in the art." *Id.* at 2:65-66. However, adaptively increasing the interleave depth can sometimes "lead to a disproportionately large increase in latency" (*id.* at 3:15-17) and cause systems to "violate standards relating to prescribed latencies" (*id*. at 3:9-11). According to the '996 Patent, "[e]arlier systems have ignored adaptive codeword generation and adjustment and, instead, have focused only on programming the D parameter alone in the interleaver." *Id*. at 8:8-14.

42. The '996 Patent purports to improve upon these prior art systems and methods, by using "adaptive programming" of other known coding parameters, besides only interleave depth, to avoid the transmission delay related to increasing

that parameter. *Id.* at 2:41-47, 3:47-50 (explaining that "having to go to a higher latency as a result of adaptive interleaving and the like can mean a substantial increase in transmission delay"). The specification asserts that "maintaining a fixed latency delay for interleaving of data in an ADSL system, while adaptively adjusting the system to meet one or more error rate requirements would likewise constitute a significant advancement in the art." *Id.* at 3:56-59. Accordingly, the '996 Patent teaches, *inter alia*, adaptively adjusting the codeword composition of FEC codewords in a communications system. *Id*. at 3:63-64.

43. The '996 Patent also teaches the use of a controller in the disclosed transmission system "to monitor, analyze and adjust the various values used in adaptively managing FEC coding." *Id.* at 4:7-9. Specifically, the controller "measures error rate performance of the system . . . to determine whether adjustment of the CCR is beneficial and how best to implement such an adjustment." *Id.* at 14:44-47. As explained in the '996 Patent, CCR (i.e., codeword composition ratio) corresponds to "any quantity or value" that "represents the relation between the payload and parity bytes in the applicable FEC coding scheme." *Id.* at 9:18-21. The controller may adjust CCR by adjusting specific parameters within the system. *Id.* at 4:3-9 (discussing adjusting the N, K, and/or R parameters in ADSL1 systems or INP or maximum interleaving delay parameters in ADSL2 systems).

44. The '996 Patent specification states that the controller may be "a dynamic spectrum manager or spectrum management center" or may simply be "a computer or computer system". *Id.* at 12:64-65, 13:45-46.

45. The controller includes means for: (1) "acquiring a measured transmission error value (MEV)"; (2) "analyzing the MEV relative to a target transmission error value (TEV)"; and (3) "generating one or more control signals . . . used to adjust the CCR". *Id.* at 4:21-29, 16:55-59. The '996 Patent explains that the above-described collecting and calculating means "preferably comprises a monitor for measuring, collecting, and/or calculating one or more of the transmission error values . . . as is known to those skilled in the art." *Id.* at 16:60-63. The controller and means are depicted in Figure 5:

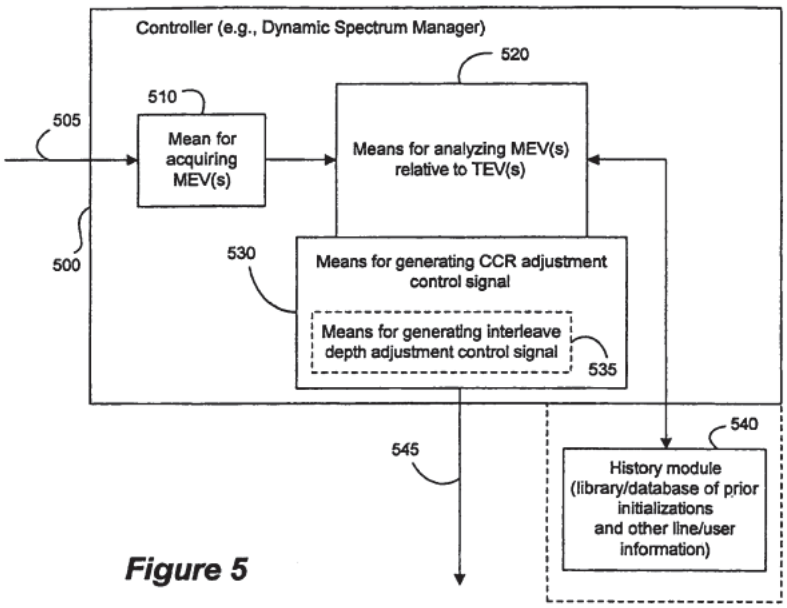


Figure 5

Id. at Fig. 5.

46. The "acquiring" means determines the MEVs which correspond to error rates in transmission. According to the '996 Patent, this can be done by, for example, "directly measuring a characteristic of the communication system, collecting a value from an element management system, or computing the MEV from collected data." *Id.* at 9:28-34. Additionally, the MEVs may correspond to the bit error rate, "errored seconds, errored minutes, the number of code violations over a fixed period of time, the signal-to-noise ratio measured at the receiver, the TCP/IP (or other protocol) throughput at a higher level, and/or a combination of these values." *Id.* at 9:35-41.

47. The '996 Patent teaches that the "acquiring" means preferably includes a "transmission error value monitor" to acquire the MEV and also to generate "a signal representative of that MEV, as is known to those skilled in the art." *Id.* at 13:10-13. This may include "an input signal" which is "representative of the value being sought." *Id.* at 13:13-15. The patent teaches the input signal "can take many forms and be based in whole or in part on the BER, errored seconds, etc. . . . can be analog or digital and linear or non-linear . . . [or] binary such that the input signal 643 is greater than or less than one or more threshold values based upon the MEV(s)." *Id.* at 17:11-19.

48. The "analyzing" means then analyzes each MEV relative to a TEV to see if they are equal or sufficiently different. *Id.* at 9:44-59. If the values are equal, the transmission system continues to transmit data using the same CCR. *Id.* at 9:46-49. If "sufficiently different," the system adjusts the CCR. *Id.* at 9:54-10:5. The means may take historical data into account when performing this analysis. *Id.* at 9:56-58. The "generating" means may be part of the same unit as the "analyzing" means or could be separate. *Id.* at 13:62-64.

49. While the specification specifically discusses its invention in the context of DSL (including ADSL1 and ADSL2) systems, it clarifies that "the invention is not limited to any particular system" and "can be used in any data transmission system that uses codeword-type data structures." *Id.* at 6:49-54. Additionally, the '996 Patent purports to invent an apparatus that performs the above-described operations which "may be specially constructed for the required purposes" or "may be a general purpose computer selectively activated or reconfigured by a computer program stored in the computer." *Id.* at 19:24-27.

B. '996 Patent Prosecution History

50. I understand that the '996 Patent issued from U.S. Patent Application No. 12/185,729 (the "'729 Application") which is a divisional of U.S. Patent Application No. 10/795,593, now U.S. Patent No. 7,428,669 (the "'669 Patent").

The ’729 Application also claims priority to Provisional Application No. 60/527,853, filed on December 7, 2003. For purposes of this declaration, I have been asked to assume a priority date of December 7, 2003, but I make no opinion as to the propriety of that priority date regarding the ’996 Patent.

51. Based on the file history, I understand the ’729 Application was filed on August 4, 2008. Ex. 1007. The application was published on April 2, 2009. *Id.* at 399. On April 27, 2010, the Examiner issued a Non-Final Rejection of the ’729 Application. *Id.* at 59-64. The Examiner rejected all claims of the ’729 Application on the ground of non-statutory double patenting over claims 1-31 of the ’669 Patent. *Id.* at 61-62. The Examiner explained that “although the claims are not identical, they are not patentably distinct from each other because the scope of the claimed subject matter in claims 1-20 of the instant application is broader than the scope of the claimed subject matter in claims 1-31” of the ’669 Patent. *Id.* at 61-62.

52. I understand that on May 7, 2010, the applicant submitted a terminal disclaimer with respect to the ’669 Patent to overcome the Examiner’s Non-Final Rejection. *Id.* at 44-52. The terminal disclaimer was approved by the Examiner. *Id.* at 43. On June 9, 2010, the Examiner issued a Notice of Allowance of claims 1-20 of the ’729 Application. *Id.* at 27-33. The ’996 Patent issued on October 5, 2010. *Id.* at 13.

C. The Challenged Claim

53. This Declaration addresses claim 20 (the "Challenged Claim"). Independent claim 20 is an apparatus claim. It recites:

> 20. A transmission system comprising:
>
> a transmission channel to carry data between a transmitter and a receiver/decoder, each communicatively interfaced with the transmission channel;
>
> a transmission error value monitor communicatively interfaced with the receiver/decoder to periodically monitor for transmission error values indicative of impulse noise events on the transmission channel, wherein the transmission error values are periodically monitored after training and initialization on the receiver/decoder, the transmission error values being selected from a group comprising: a bit error rate, errored seconds, errored minutes, code violations over a fixed period of time, Signal-to-Noise Ratio (SNR) measured at the receiver/decoder, and Transmission Control Protocol and Internet Protocol (TCP/IP) throughput, and wherein the transmission error vale monitor to further generate an input signal based on the transmission error values monitored; and
>
> a controller coupled with the transmitter to receive the input signal from the transmission error value monitor and to further generate a retransmission overhead control signal for the transmitter in response to the input signal.

54. I address each of the limitations of claim 20 further in my detailed analysis in Part VIII below.

V. LEVEL OF ORDINARY SKILL IN THE ART

55. In determining the characteristics of a person of ordinary skill in the art of the field of the '996 Patent at the time of the claimed invention (a "POSITA")[1], I considered several factors, including various prior art techniques relating to FEC coding in transmission systems, the types of problems that such techniques gave rise to, and the ease and rapidity with which innovations were made. Additionally, I considered the sophistication of the technologies involved, educational background of those in the field, and experience of those in the field at the time of invention. I also considered the level of education necessary to understand the '996 Patent and its claimed invention. Finally, I considered the relevant time period along with engineers in the field of transmission and communication systems, including DSL, cable, and internet fields.

56. Based on the above, I have concluded that a POSITA in the field of art of the '996 Patent would have had a bachelor's degree in electrical engineering, or an equivalent subject, with at least two years of experience in the field of DSL, cable, or wireless communication systems. A person with less formal education, but more relevant practical experience, may also meet this standard, as may a person with

[1] I considered the level of ordinary skill in the art as of December 7, 2003, the assumed priority date of the '996 Patent, as explained more fully above in Part IV.B.

more formal education but less relevant practical experience. Such a person would have been capable of understanding the '996 Patent and the prior art references discussed below. Based on my own education, training, and professional experience in the field of the claimed invention, I am familiar with the level and abilities of a POSITA at the time of the claimed invention. Additionally, I meet at least the minimum qualifications to be a person having ordinary skill in the art at the time of the claimed invention of the '996 Patent. My opinions herein would not change if a slightly different definition of a POSITA were adopted.

VI. CLAIM CONSTRUCTION FOR THE '996 PATENT

57. In my analysis of the '996 Patent's claim terms and the prior art in this declaration, unless otherwise indicated, I have applied the plain and ordinary meaning of the claim terms in light of the specification and '996 Patent prosecution history to a person of ordinary skill in the art.

58. I understand that the Board may decide to construe certain terms of the Challenged Claim. Regardless of any likely construction that is ultimately applied, however, the Grounds included in the Petition are sufficient to invalidate the claim.

59. I understand that the Petitioner may take a different approach to claim construction in other proceedings, but for purposes of the Petition I understand that the Petitioner believes no construction is necessary.

60. I have not yet formed, and do not offer, any opinion on the indefiniteness of any claims, including claim 20, of the '996 Patent.

VII. SUMMARY OF THE PRIOR ART

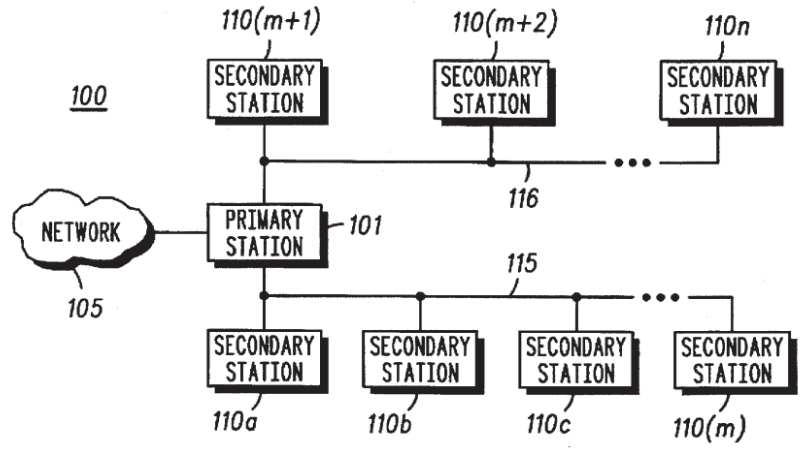
A. Klayman (Ex. 1003)

61. U.S. Patent No. 5,699,365 to Jeffrey T. Klayman, John A. Perreault, Katherine Unger, and Stephen Schroeder is an issued patent entitled "Apparatus and Method for Adaptive Forward Error Correction in Data Communications" ("Klayman"). Ex. 1003. Klayman was filed on March 27, 1996 and issued on December 16, 1997. It is prior art to the '996 Patent under 35 U.S.C. §§ 102(a), (b), and (e) (pre-AIA).

62. Klayman discloses an apparatus and method "for adaptive forward error correction in a data communications system". *Id.* at Abstract. The system "provides such adaptive and flexible error correction capability, providing sufficient error correction for accurate data reception, and also providing for overhead minimization for increased data throughput." *Id.* at 2:54-58. One purported benefit of Klayman's disclosed invention is that it dynamically responds to "changing and variable communications channel conditions, such as changes in noise conditions and error rates." *Id.* at 2:60-62.

63. The communications system taught by Klayman is depicted in Figure 1 below:

FIG. 1



Id. at Fig. 1. As shown in Figure 1, Klayman teaches primary and secondary stations, communicatively interfaced over communications medium 114. *Id.* at Fig. 1, 2:65 – 3:3. The primary and secondary stations are also communicatively coupled to processors, as well as a master controller, as shown in Figure 2, depicting a primary station:

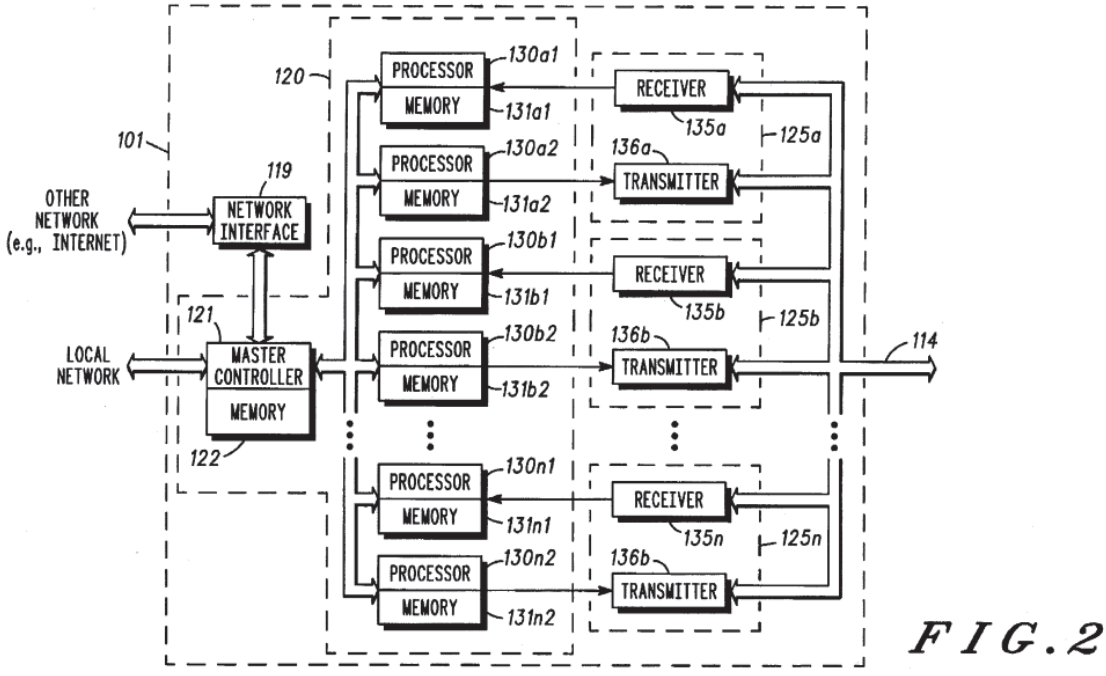
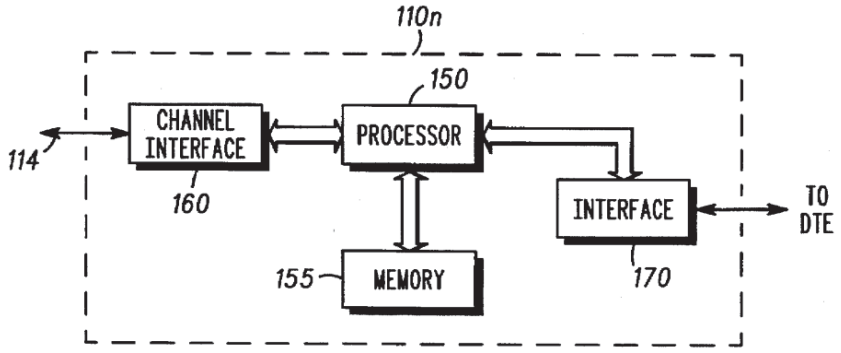


FIG. 2

Id. at Fig. 2. And, as seen in Figure 3, a secondary station comprises a channel interface 160 and processor 150:

FIG. 3



Id. at Fig. 3.

64. Regarding the operation of its disclosed communication system, Klayman teaches:

> The transmitting unit, such as the processor 150 and channel interface 160 of a secondary station 110_n, generates the error correcting code from the user data, and appends the encoded data onto the user data during transmission. The receiver unit, such as receiver 135, and processor 130_{n2} of the primary station 101, uses the encoded data to detect received errors and to correct detected errors.

Id. at 5:22-28. Upon receipt of encoded data with forward error correction coding, the primary station monitors channel parameters (e.g., bit error rates) to determine whether the degree of forward error correction being utilized should be revised. *Id.* at 7:60-66. If so, Klayman teaches transmitting a revised forward error correcting parameter back to a secondary station. *Id.* at 8:30-42. Klayman also discloses that this process is repeated. *Id.* at 8:42-47.

B. Agarwal (Ex. 1004)

65. U.S. Patent No. 6,477,669 to Anil K. Agarwal and Dattakumar M. Chitre is an issued patent entitled "Method and Apparatus for Adaptive Control of Forward Error Correction Codes" ("Agarwal"). Ex. 1004. It was filed as a PCT Application on July 15, 1998—which published as WO99/04338 on January 28, 1999—and issued on November 5, 2002. Agarwal qualifies as prior art under 35 U.S.C. §§ 102(a), (b), and (e) (pre-AIA).

66. Agarwal discloses adaptive forward error correction in a satellite or wireless transmission system. *Id.* at Abstract, Figs. 1A-1B, 5:12-14. Agarwal specifically explains that the steps of its disclosed "method for control of a forward error correction code" include: (1) "calculating a byte error rate associated with the communication signals, received by the first terminal"; (2) "determining a forward error correction code length based on the byte error rate"; and (3) "transmitting the forward error correction code length to the second terminal". *Id.* at Abstract.

67. While the forward error correction codes taught by Agarwal are "[a]dvantageously . . . associated with ATM-based formatted data," Agarwal explains that "one of ordinary skill in the related art would recognize that similar structures would be applicable to frame relay, ISDN and other cell- or packet-based transmissions systems." *Id.* at 5:9-11, 5:14-16. Agarwal teaches that "adaptive coding is employed in order to determine the proper amount of forward error-correction on a real-time basis in accordance with the number of bit errors detected in the received link." *Id.* at 6:1-4. Additionally, Agarwal's invention provides "an efficient use of transmission link bandwidth." *Id.* at 5:30-31.

68. The transmission system taught in Agarwal is depicted in Figure 1A, which shows interfaces 5 and 7:

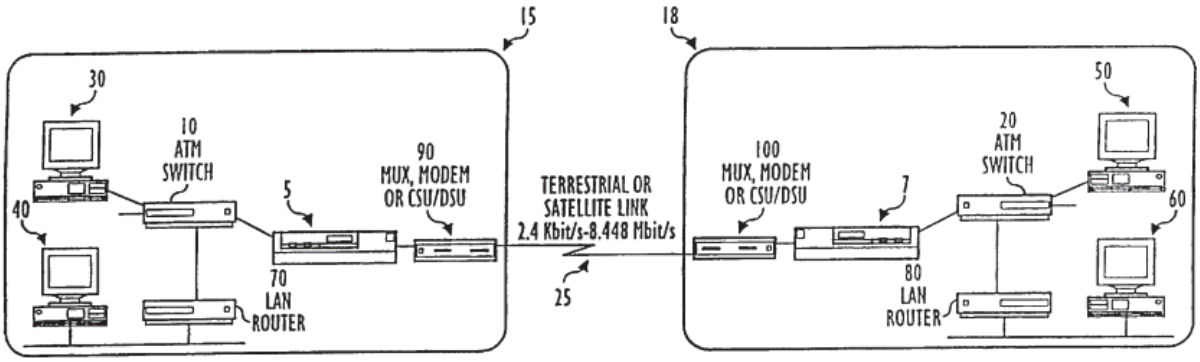


FIG. 1A

Id. at Fig. 1A. Agarwal teaches a primary interface that receives forward error correction encoded data and a remote interface that receives revised forward error correction code lengths based on determinations made at the primary interface regarding byte errors. *Id.* at 5:41-58.

69. Within this transmission system is an encoder 120 "which generates a forward error correction code (i.e. block code) that is included in each frame for error correction of that frame" and a decoder 135 "which decodes the forward error correction code of each frame in order to provide error correction for that frame." *Id.* at 5:44-47, 5:53-55. The encoder 120 and decoder 135 are shown in Figure 1B below, which shows part of the disclosed interfaces:

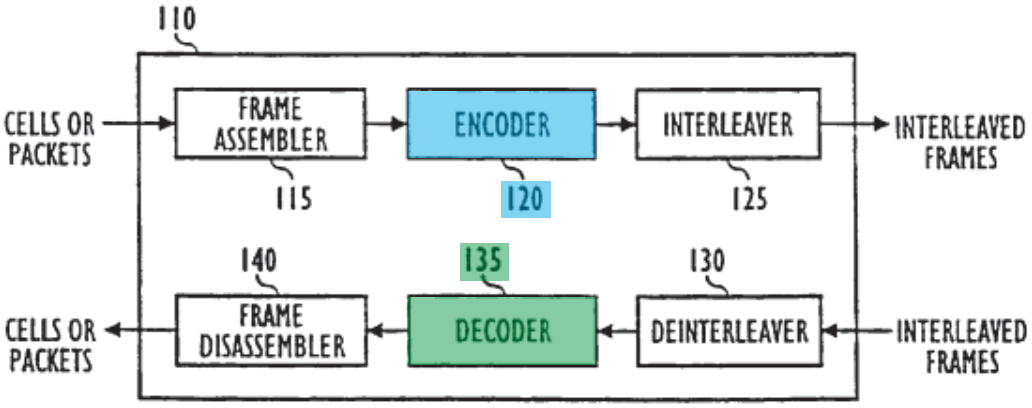


FIG. 1B

Id. at Fig. 1B (highlighted to identify the encoder 120 (in blue) and decoder 135 (in green)). The encoder and decoder, which are components of the remote and primary interfaces, are communicatively coupled to Microprocessor 1015 which enables them to carry out these disclosed operations. *Id.* at 12:1-59; *see also* Fig. 4 (depicting the communicative interface between Microprocessor 1015 and a Reed-Solomon Encoder 1030 and Decoder 1070).

C. Starr (Ex. 1005)

70. U.S. Patent No. 6,546,509 to Thomas J. J. Starr is an issued patent, entitled "Method and System for Adaptive Interleaving" ("Starr"). Ex. 1005. It was filed on June 19, 2001, published on February 7, 2002, and issued on April 8, 2003. Starr claims priority to U.S. Patent No. 6,272,652 (filed January 13, 2000) and U.S. Patent No. 6,067,646 (filed April 17, 1998). Starr is prior art to the '996 Patent under 35 U.S.C. §§ 102(a), (b), and (e) (pre-AIA).

71. Starr describes a method and system of adaptive interleaving by "monitoring performance parameters of a transmission system and controlling the adaptive interleaver in response to the performance parameters." *Id.* at Abstract, 2:18-20. Starr's disclosed invention includes a controller which can: (1) analyze input signals; (2) provide an adaptive interleave control signal; and (3) determining first and second performance parameters. *Id.* at 2:21-28. The disclosed "performance parameters" are preferably Signal-to-Noise ratio values, bit error rate (BER) values, and/or data rate values. *Id.*at 2:37-39.

72. As shown in Figure 3 below, in one example the disclosed system includes a controller, bit error rate monitor, adaptive interleaver, transmitter, transmission channel, and receiver/decoder:

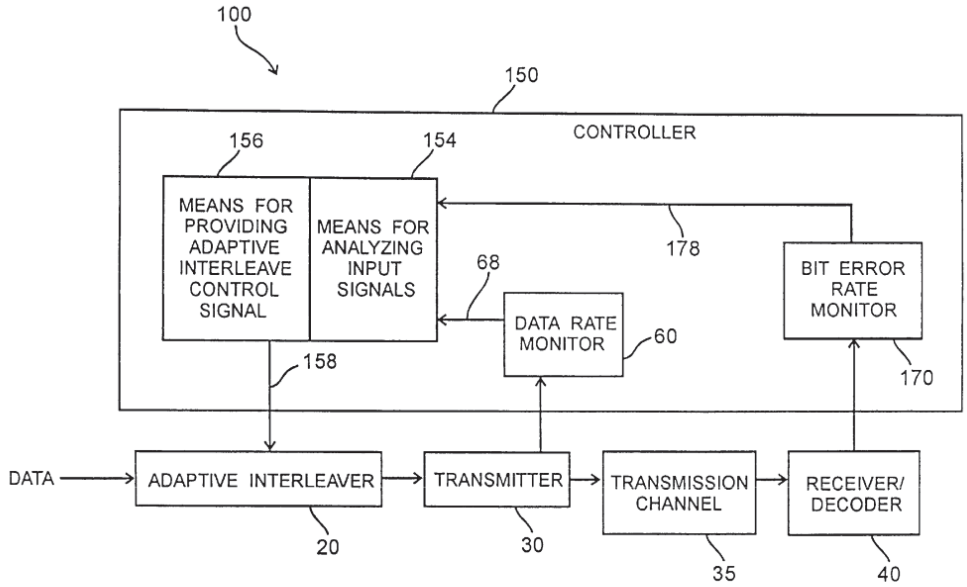


Fig. 3

Id. at Fig. 3. Starr explains that the "bit error rate monitor 172 generates a multiple bit adaptive interleave control signal 174 that preferably varies as a function of the BER." *Id.* at 8:1-3. Starr also teaches that although the disclosed system "is of particular importance with regard to digital subscriber lines," it is also "applicable to any system that incorporates interleaving." *Id.* at 2:50-53.

VIII. APPLICATION OF THE PRIOR ART TO THE CHALLENGED CLAIM

73. Based on my review and analysis of the materials cited herein, my opinions regarding the understanding of a POSITA, and my training and experience, it is my opinion that the Challenged Claim is rendered obvious by the Grounds presented in this declaration. The reasons for my conclusions are explained more fully below.

74. I have reviewed and analyzed the prior art references, including all materials listed in Part I.A.2 above. In my opinion, claim 20 of the '996 Patent is rendered obvious based on, at least, the following prior art:

Ground	'996 Patent Claims	Basis for Challenge	Application of Prior Art
1	20	35 U.S.C. § 103	Klayman in view of Starr
2	20	35 U.S.C. § 103	Agarwal in view of Starr

75. I am informed by counsel that each of the references cited in the above grounds qualifies as prior art to the Challenged Claim because each reference was filed and/or published before the priority date for the '996 Patent.

A. Ground 1: Analysis of Claim 20 Based on Klayman in view of Starr.

1. Overview of the Combination of Klayman and Starr

76. With respect to claim 20, Klayman teaches the recited transmission system comprising a transmission channel, transmitter, receiver/decoder, transmission error value monitor, transmission error values (e.g., bit error rate), and controller coupled with the transmitter. As is explained regarding limitation 20[b], Starr also teaches a transmission error value: signal to noise ratio, which is typically used to assess the impacts of channel interference on the received signal from any number of sources, including impulse noise on the channel. In my opinion, a POSITA would have been motivated to combine Klayman and Starr resulting in a transmission system that monitors both bit error rate and signal to noise ratio as transmission error values. Additionally, as is explained regarding limitations 20[e]-[f] below, it is my opinion that Klayman implicitly teaches the generation of input and control signals for the receiver and transmitter, respectively. However, to the extent the input signal and control signal are not explicitly taught by Klayman, in my opinion, a POSITA would have been motivated to combine Klayman's disclosed

communications system with the teachings of Starr which include a generated input signal based on monitored transmission error values and a generated control signal used to control the transmitter based on the input signal.

77. Prior to 2003, POSITAs were well-aware that signal-to-noise ratio could be determined when data is transmitted over a communications channel. Klayman, in fact, teaches "monitoring . . . noise levels (such as levels of impulse noise or ingress noise)". Ex. 1003 at 7:40-42. Starr explains that monitoring signal to noise ratio—by using a signal to noise ratio monitor—was "known to those skilled in the art." Ex. 1005 at 5:10-12.

78. Prior to 2003, POSITAs were also well-aware that signals could be used in an adaptive transmission system. Klayman, in fact, explicitly teaches the use of transmission signals in its disclosed system: "the communications channels in which a primary station, such as the primary station 101, transmits information, signals, or other data to a secondary station . . ." (Ex. 1003 at 3:23-26) and "the apparatus and method of the present invention provides a means for signaling and changing the forward error correction parameters (typically used on an upstream channel), based upon variable channel quality, such as variable noise or error levels" (*id.* at 6:65 – 7:3). Starr provides an example of the use of an input signal which is generated based on data rate, signal to noise ratio, and bit error rate. Ex. 1005 at 4:63 – 5:5, 5:27-29,

6:43-44. Additionally, Starr provides an example of the use of a control signal which is generated by a controller in response to an input signal. *Id.* at Fig. 3; 2:65-67. Starr explains that "[t]he adaptive interleaver preferably adjusts the interleave depth in response to the adaptive interleave control signal 58." *Id.*at 2:65-67. The means for generating the control signal and communicative coupling between that means and the adaptive interleaver and transmitter of Starr is depicted in Figure 3:

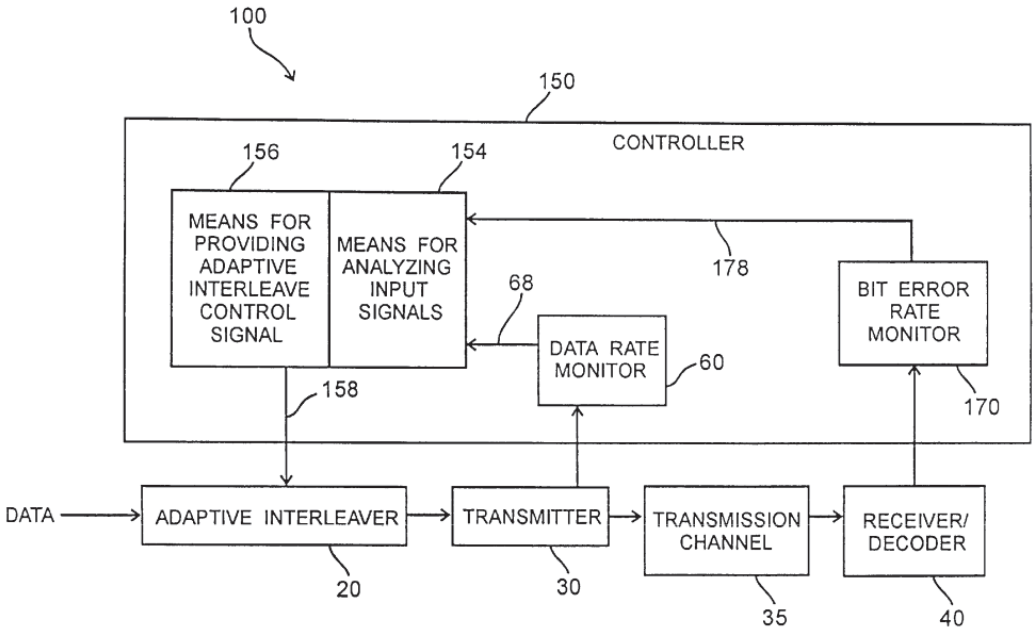


Fig. 3

Id. at Fig. 3.

79. As I set forth below, a POSITA would have been motivated to combine Klayman's system employing adaptive forward error correction coding in a communications system with Starr's teachings of a signal to noise ratio, an input signal corresponding to the detected errors, and a control signal utilized to instruct

the transmitter to adjust the forward error correction code value based on the receiver's transmission of a new forward error correction code length which itself is based on a calculated bit error rate and/or signal to noise ratio. For the reasons set forth below, a POSITA would have been motivated to combine Klayman and Starr and also have had a reasonable expectation of success in making this well-understood combination.

2. Motivation to Combine and Expectation of Success (Klayman in view of Starr)

80. Klayman and Starr are analogous art as they both relate to adaptively adjusting coding parameters in transmissions, including forward error correction codes. Specifically, Klayman discloses "a method for adaptive forward error correction in a data communication system." Ex. 1003 at Abstract. The disclosed system in Klayman includes communication channels, a controller, processors, a transmitter, a receiver, and a decoder. *Id.* at 2:63 – 3:3, 4:8-38, Figs. 1-2. While Klayman teaches that in a preferred embodiment, the communications system uses a "hybrid optical fiber and coaxial cable. In other embodiments, the communications media . . . may be coaxial cable, fiber optical cable, twisted pair wires, and so on, and may also include air, atmosphere or space for wireless and satellite communication." *Id.* at 3:2-8. Additionally, Klayman teaches that "the preferred embodiment utilizes a Reed-Solomon error correcting code forward error

correction" and discloses that "inclusion of different types of error correcting codes, such as . . . inclusion of interleaving (with a specified depth)" is anticipated. *Id.* at 5:55-58, 7:20-23.

81. Similarly, Starr discloses a system for "automatically controlling an adaptive interleaver in response to the performance parameters of a transmission system." Ex. 1005 at 2:19-20. The system of Starr, like Klayman, utilizes a transmitter, transmission channel, receiver/decoder, and a controller. *Id.* at 2:54-57. The receiver/decoder of Starr "can employ a Reed Solomon decoder or any other suitable error correcting decoder as known to those skilled in the art." *Id.* at 4:24-26. Starr teaches that its "system is of particular importance with regard to digital subscriber lines" but "those skilled in the art will appreciate that it is applicable to any system that incorporates interleaving," like the transmission system of Klayman. *Id.* at 2:50-53. Additionally, like Klayman, Starr teaches that its transmission channel "preferably comprises twisted-pair conductive wire" but could alternatively "comprise coaxial cable, optical fiber, free-space laser, radio or any other type of transmission media as known to those skilled in the art." *Id.* at 4:9-15.

82. In my opinion, these teachings of Starr and Klayman would have indicated to a POSITA that they are both transmission systems utilizing specific methods to monitor and adjust performance parameters and improve the quality of

transmissions. Both Klayman and Starr disclose communications systems with common engineering designs and were published during a period of time where these broadband access systems, such as DSL and HFC Cable, were going through rapid development and deployment. Both systems rely on adaptive methods to correct transmission errors within the system.

83. In my opinion, a POSITA would have been motivated to combine the teachings of Klayman and Starr for several reasons.

i. Monitoring SNR and generating an input and control signal in the Klayman system based on the teachings of Starr would have been using well-known prior art methods to yield predictable results.

84. Prior to December 2003, it was known to monitor signal to noise ratio over a transmission channel. As noted above, Starr itself states that signal to noise monitors were known in the art. Ex. 1005 at 5:10-12. Indeed, determining the signal to noise ratio of a data transmission was "readily measured" as early as 1965. Ex. 1012 at 1701 (also explaining that "[C]onditional error rates, in terms of the average number of bit errors per noise burst, as determined as functions of a signal-to-noise ratio."). It was also known, by at least 1965, that signal to noise ratio served as an indication of "[t]he impulse noise present on such a channel." *Id.* at 1702-1706.

85. Starr teaches a signal to noise ratio monitor 70 which "preferably comprises a monitor for determining the SNR as known to those skilled in the art."

Ex. 1005 at 5:10-13. Additionally, Starr explains: "SNR is preferably defined as the ratio of average signal power to average noise power." *Id.* at 5:13-15. Starr teaches that SNR is a preferred performance parameter in a transmission system. *Id.* at 2:37-39. In my opinion, a POSITA would have known signal to noise ratio could be monitored in a transmission system, such as by processor 130 of Klayman's system, as a method of measuring channel quality.

86. Additionally, prior to December 2003, it was well-known that controllers could generate and utilize signals to instruct a transmitter. For example, it was well-known to generate and transmit an input signal corresponding to measured error values in a data transmission within a system employing forward error correction coding and/or interleaving. Ex. 1005, Ex. 1014, Ex. 1015, Ex. 1016. Additionally, control signals were known to be used to change the coding parameters used by transmitters in adaptive transmission systems. Utilizing control signals for this purpose, such as the adaptive interleave control signal taught by Starr, were known and commonly used in transmission systems at least by the 1990s. Ex. 1005, Ex. 1017, Ex. 1018, Ex. 1019. In fact, the '996 Patent teaches:

> The FEC coder 612 preferably comprises means for receiving a multiple bit CCR adjustment control signal and means for adjusting the CCR in response to the CCR adjustment control signal, as will be known to those skilled in the art.

Ex. 1001 at 14:62-65. Accordingly, the '996 Patent itself acknowledges that utilizing a control signal to adjust CCR was known in the art at the time of invention.

87. Starr teaches a bit error rate monitor 170 which "generates an input signal 178 that varies as a function of the BER." Ex. 1005 at 6:43-44. Specifically, regarding the input signal, Starr discloses:

> [T]he input signal 178 can take more forms. The input signal 178 can be based in-whole or in-part on the BER. The input signal 178 can be analog or digital and linear or non-linear as known to those skilled in the art. Alternatively, the input signal 178 can be binary such that input signal 178 is greater than or less than a threshold value based upon the BER as known to those skilled in the art.

Id. at 6:45-52. This is nearly identical to the '996 Patent's disclosure of an input signal:

> [T]he input signal 643 can take many forms and can be based in whole or in part on the BER, errored seconds, etc. The input signal 643 can be analog or digital and linear or non-linear, as will be appreciated by those skilled in the art. Alternatively, the input signal 643 can be binary such that the input signal 643 is greater than or less than one or more threshold values based upon the MEV(s).

Ex. 1001 at 17:12-19. Starr explains that the "BER monitor 170 preferably determines the BER and continuously generates the input signal 178". Ex. 1005 at 6:52-53. Similarly, Starr teaches "signal to noise ratio monitor 70 preferably determines the SNR and generates an input signal 78 that varies as a function of the SNR." *Id.* at 5:27-29; *see also id.* at 5:29-37 (describing the input signal from the

signal to noise ratio monitor in similar terms to the input signal generated by the bit error rate monitor).

88. A POSITA would have had knowledge of other prior art systems utilizing input signals that correspond to transmission errors, like that taught by Starr. For example, U.S. Patent No. 6,184,942 to Chandrakant B. Patel, et al. ("Patel") teaches that "data recovered by symbol decoding are supplied as input signal to a data de-interleaver, and the de-interleaved data are supplied to a Reed-Solomon decoder." Ex. 1014 at 3:25-28. Similarly, U.S. Patent No. 5,886,989 to Allan Evans, et al. ("Evans") teaches a "digital demodulator [that] recovers the carrier and symbol timing of input signal and passes soft-decision demodulated data to the forward error correction decoder." Ex. 1015 at 36:63-66. And U.S. Patent No. 5,569,578 to Siavash M. Alamouti, et al. ("Alamouti") discloses a method wherein an "encoder receives a three-bit input signal which is to be encoded into a four-bit output signal". Ex. 1016 at 3:5-7. Like Starr, these exemplary references demonstrate that before 2003 it was known to generate and transmit an input signal within a communications system employing forward error correction coding to inform the decoder and/or encoder of relevant transmission error values.

89. With regard to a control signal, Starr teaches that a controller "generates an adaptive interleave control signal" in response to determined performance

parameters of the system based on a measured bit error rate or signal to noise ratio. Ex. 1005 at 2:54-67. Specifically, Starr explains that the control signal is generated by a bit error rate monitor or the signal to noise ratio monitor 70 and "preferably varies as a function of the BER [or SNR]." *Id.* at 7:46-46, 8:1-5. Once generated and transmitted, "[t]he adaptive interleave control signal 174 is preferably utilized by the adaptive interleaver 20 to control the interleave depth to generate an adaptively interleaved signal." *Id.* at 8:13-16; *see also id.* at 9:20-22 ("an adaptive interleave control signal . . . controls the adaptive interleaver 20 such that interleaving is implemented").

90. A POSITA would have had knowledge of other prior art systems relying on control signals, like that taught by Starr. For example, U.S. Patent No. 6,016,313 to Robert B. Foster, Jr., et al. ("Foster") teaches using different control signals in a centralized communication system transmitting data between nodes. Ex. 1017 at Abstract, 7:36-46. Foster explains:

> Link management information, such as control signals adjusting the aforementioned information density, and/or error correction information may be multiplexed as control information into the data stream communicated by the modem. For example, the control information may include multiplexed filtering and error correction information, such as forward error correction (FEC) data embedded in the data stream.

Id. at 7:36-43 (emphasis added). Additionally, U.S. Patent No. 5,392,299 to Don S. Rhines, et al. ("Rhines") teaches error correction in digital data transmissions over a media channel using interleaving. Ex. 1018 at Abstract. Rhines discloses "[t]he read/write function for the dual buffer interleave system is controlled by a read/write control signal on line 122 from address generators 124(a) and 124(b)." *Id.* at 13:40-43. Specifically, "the read/write control signal switches to cause the next sequence of code words to be stored in buffer 112(b) while the code words previously stored in buffer 112(a) are output in an interleaved fashion." *Id.* at 13:45-49.

91. U.S. Patent No. 6,665,308 to Selim Shlomo Rakib, et al. ("Rakib") discloses a communications system comprising a "transmitter with any encoder to receive downstream data, encode it" and a "remote unit receiver which has . . . a decoder to decode the received data." Ex. 1019 at 4:11-40. Rakib teaches:

> Fallback mode is implemented by a mode control signal on line 530 in FIG. 32 to the encoder circuit 526 (the connection to the CPU 405 is not shown). This mode control signal can command three modes: idle mode where the encoder pass the tribits adding only zeroes as the 4th bit; normal mode where 4th bits are added based upon the previous state for that timeslot during the last symbol time; and fallback mode where more redundant bits are added to each 4-bit group and correspondingly less payload data in [sic] included in each 4-bit group.

Id. at 67:21-30. Along with the mode control signal, Rakib also teaches a "switching control signal" which is used to "edit the contents of the buffer 548 to overlay the 4-bit groups of the access control symbols with the payload data on bus 507 so that the

media access control 4-bit groups go into the right addresses of the buffer 548 so as to get spread by the CDMA code assigned to the access channels." *Id.* at 74:31-38.

92. As taught by the prior art, a POSITA would have expected implementing a control signal in Klayman's communication system to predictably result in controlling the transmitting unit of the secondary station, including channel interface 160, of Klayman to adaptively adjust the forward error correction code degree and transmit future data "utilizing the revised degree of forward error correction indicated by the revised forward error correction parameter." Ex. 1003 at 10:16-19; *see also* Ex. 1005 at 8:13-16 (analogously teaching that the control signal results in controlling the interleave depth).

93. For at least these reasons, by December 2003, a POSITA would have known to monitor SNR and use input and control signals to instruct the transmitter to change the forward error correction code parameters for future transmissions. Thus, applying the teachings of Starr to the adaptive forward error correction coding system of Klayman would have simply been combining known prior art elements according to known methods. And, as explained above, a POSITA would have recognized that this combination would predictably result in the system's ability to monitor both bit error rate and SNR and instruct the transmitter's adaptive correction of error code parameters.

ii. Starr and Klayman expressly suggest utilizing their teachings on the same communication channels and in similar transmission systems.

94. Starr discloses that its teachings can be utilized in different forms of transmission systems. For example, Starr teaches its systems can utilize transmission channels comprising "twisted-pair conductive wire, . . . coaxial cable, optical fiber, free-space laser, radio or any other type of transmission media as known to those skilled in the art." Ex. 1005 at 4:9-15 (emphasis added). Like, Starr, Klayman explicitly teaches that its communications media may be "hybrid optical fiber and coaxial cable" or "coaxial cable, fiber optic cable, twisted pair wires, and so on." Ex. 1003 at 3:2-7 (emphasis added). Klayman also teaches that its invention "could also be used where dial-up or other lines are used as the upstream channel" and "dynamic adaptive forward error correction could be used to improve throughput over such a dedicated channel." *Id.* at 12:49-55.

95. Thus, a POSITA reading the teachings of Starr and Klayman would have recognized that Starr's disclosures, including monitoring SNR, are applicable to the system disclosed in Klayman. Moreover, Starr explains that the disclosed input and control signals are used "to control the interleave depth to generate an adaptively interleaved signal." Ex. 1005 at 8:13-16. Klayman similarly discloses that the

processor and transmitting unit use received information to transmit data "utilizing the revised degree of forward error correction". Ex. 1003 at 10:16-20.

96. Accordingly, it is my opinion that a POSITA would have been motivated to combine the teachings of Klayman and Starr to monitor SNR and utilize the input and control signals disclosed in Starr to instruct the secondary station of Klayman to revise the forward error correction parameter as needed corresponding to the received revised degree of forward error correction.

iii. It would have been obvious to try monitoring SNR in Klayman's system based on Klayman's teachings.

97. It is my opinion that it would have been obvious to try implementing Starr's teachings of monitoring SNR in Klayman's system.

98. Klayman explicitly teaches monitoring channel parameters including "noise levels (such as levels of impulse noise or ingress noise)". Ex. 1003 at 7:40-42. Additionally, as explained more fully below regarding claim limitation 20[b], a POSITA would have understood that processors 130 of Klayman include transmission error value monitors to monitor these channel parameters. *Id.* at 7:37-50. Accordingly, a POSITA would have been motivated to try monitoring parameters that are indicative of noise levels based on the teachings of a Klayman. In my opinion, POSITA would have been motivated to look to other references, like Starr, which teach the implementation of a signal to noise ratio monitor to monitor

SNR on a transmission channel which is indicative of noise events. Starr teaches monitoring both bit error rate and SNR on a transmission channel, thus, a POSITA would have found it obvious to try monitoring SNR—along with the already-monitored bit error rate—in Klayman's system.

iv. It would have been obvious to try implementing the input and control signal of Starr with the receiver, processor, and transmitter of Klayman.

99. It is my opinion that it would have been obvious to try the use of Starr's input and control signal in conjunction with the disclosed forward error correction coding system of Klayman to instruct the transmitter.

100. A POSITA would have understood that there are a limited number of predictable solutions to ensure that the transmitter utilizes the revised forward error correction code parameter received from the primary station for future transmissions. First, a POSITA would have understood that, after monitoring the transmission error values and determining whether a different forward error correction code is required, that information must be communicated to the encoder at the transmitter. Based on the teachings of Klayman—which explicitly calls for the use of transmission signals—a POSITA would have known to use an input signal to transmit the new forward error correction coding information based on monitored transmission error values (e.g., bit error rate or SNR).

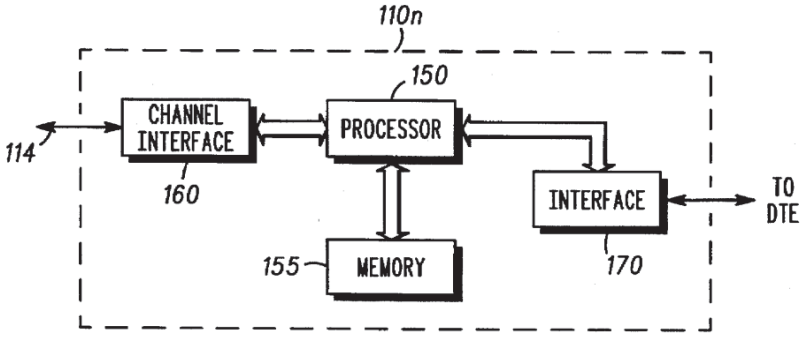
101. Second, regarding the control signal, a POSITA would have recognized that either: (1) a control signal must be sent to the transmitter to instruct it to utilize the revised forward error correction code parameter; or (2) the forward error correction coding must be performed entirely in the controller's memory such that a control signal is not needed. These two predictable options are exemplified in Starr which teaches:

> While the controller 50, 150 and adaptive interleaver 20 are preferably implemented as separate elements as shown in FIGS. 1 and 2, they can alternatively be implemented as a single element comprising software, hardware or a combination thereof as described herein and known to those skilled in the art.

Ex. 1005 at 7:31-36.

102. Given that using a control signal was well-known in the art and is one of two options to instruct the transmitter to adjust the new forward error correction code length, it would have been obvious for a POSITA to try implementing a control signal (like that disclosed in Starr) in Klayman's system. Klayman, for example, teaches that processor 150 is a separate element from channel interface 160 and memory 155, which work together to transmit forward error correction code parameters within the secondary station. Ex. 1003 at Fig. 3. Figure 3 of Klayman depicting the transmitting unit, including processor 150, memory 155, and channel interface 160 is reproduced below:

FIG. 3



Id. at Fig. 2. Klayman also explicitly teaches that "memory 155 may also be embodied or contained within the corresponding processor 150." *Id.* at 5:6-8. Thus, a POSITA looking at the disclosures of Klayman and explicit teachings of a control signal in Starr, would have found it obvious to implement a control signal in Klayman's system.

103. I also believe it would have been obvious for a POSITA to try different configurations—such as incorporating processor 150, memory 155, and channel interface 160 as a single element or as separate elements—to determine which configurations were more efficient, easier to assemble, or more effective. These configurations would be simple design choices to a POSITA.

104. As I explained below, a POSITA would have had a reasonable expectation of success in trying to use the input and control signals of Starr to instruct the transmitter disclosed in Klayman.

v. A POSITA would have expected to succeed in combining Starr's teachings of SNR and input and control signals with Klayman's communications system.

105. In my opinion, a POSITA would have expected success in implementing Starr's teachings of monitoring SNR within Klayman's system. Klayman teaches processor 130 within the primary station monitors channel parameters including bit error rates and noise levels. Ex. 1003 at 7:37-50, Fig. 4. Similarly, Starr teaches a bit error rate monitor and signal to noise ratio monitor within controller 50 which monitors bit error rate and signal to noise ratio. Ex. 1005 at Figs. 2, 3. A POSITA would have recognized that Klayman's processor 130—which already includes means to monitor noise levels—could successfully include the signal to noise ratio monitoring means of Starr to monitor SNR at the primary station. A POSITA would have no seen no technological hurdles in monitoring SNR with Klayman's processor 130.

106. In my opinion, a POSITA would have expected success in implementing the input and control signals of Starr in Klayman's system. Configuring the processor within the receiver to generate and transmit an input signal and configuring the processor at the transmitter to generate a control signal to accomplish the invention's stated purpose of adaptive forward error correction coding would have been easily accomplished. Klayman teaches that the receiver and

processor 130 communicate with the transmitting unit and processor 150. For example, Figure 1 of Klayman depicts the communicative coupling between the primary and secondary stations, each of which includes processors 130 and 150 as shown in Figures 2 and 3. Additionally, in Klayman, processor 150 is communicatively coupled to the transmitting unit. For example, Klayman explains that "the secondary station 110_n includes a processor (or processor arrangement) 150 . . . coupled to a memory 155" and coupled to a channel interface 160. Ex. 1003 at 4:12-15; *see also id.* at Fig. 3. Thus, the controller of Klayman's transmitting unit (i.e., processor 150) is already configured to communicate with the transmitter.

107. Klayman also teaches that its disclosed invention "provides a means for signaling and changing the forward error correction parameters." *Id.* at 6:65 – 7:1. Specifically, Klayman teaches that the channel interface 160 (within the transmitting unit of the secondary station) "performs functions . . . for data and other signal reception and transmission." *Id.* at 4:64 – 5:1. Configuring processor 130 at the receiver to generate an input signal and configuring processor 150 to send a control signal to the channel interface 160, instructing it to adjust the forward error correction code parameter based on the received revised forward error correction code degree from the primary station, would have been in-line with the teachings of Klayman and a POSITA would have expected success with this combination.

108. For all of these reasons, I conclude that a POSITA would have been motivated to combine Klayman and Starr and would have expected success in doing so.

3. Claim 20

109. Based on my review and for the reasons that follow, it is my opinion that claim 20 is obvious based on the teachings of Klayman alone and/or Klayman and Starr.

110. I have reproduced independent claim 20 below and divided up the limitations using bracketed notations to facilitate identification of the limitations in my analysis below.

20[pre] A transmission system comprising:

> [a] a transmission channel to carry data between a transmitter and a receiver/decoder, each communicatively interfaced with the transmission channel;
>
> [b] a transmission error value monitor communicatively interfaced with the receiver/decoder to periodically monitor for transmission error values indicative of impulse noise events on the transmission channel,
>
> [c] wherein the transmission error values are periodically monitored after training and initialization on the receiver/decoder,
>
> [d] the transmission error values being selected from a group comprising: a bit error rate, errored seconds, errored minutes, code violations over a fixed period of time, Signal-to-Noise Ratio

(SNR) measured at the receiver/decoder, and Transmission Control Protocol and Internet Protocol (TCP/IP) throughput,

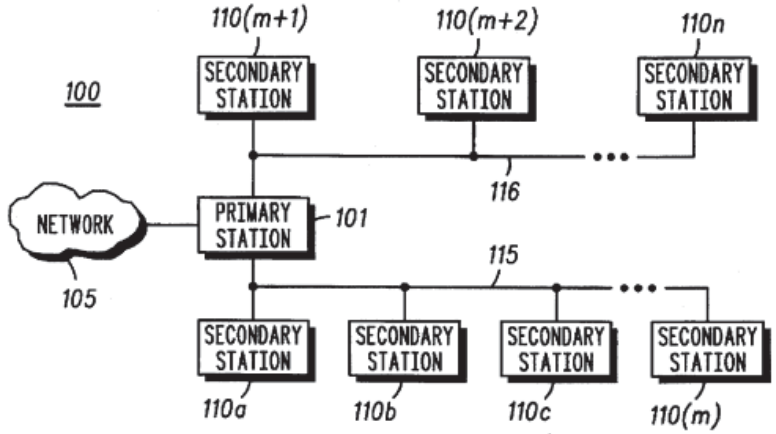
[e] and wherein the transmission error value monitor to further generate an input signal based on the transmission error values monitored; and

[f] a controller coupled with the transmitter to receive the input signal from the transmission error value monitor and to further generate a retransmission overhead control signal for the transmitter in response to the input signal.

i. Limitation 20[pre]: A transmission system comprising:

111. I understand that a preamble generally does not state a claim limitation. However, to the extent the preamble limits claim 20, it is my opinion that Klayman discloses a transmission system. Klayman teaches communications system 100, as shown in Figure 1:

FIG.1



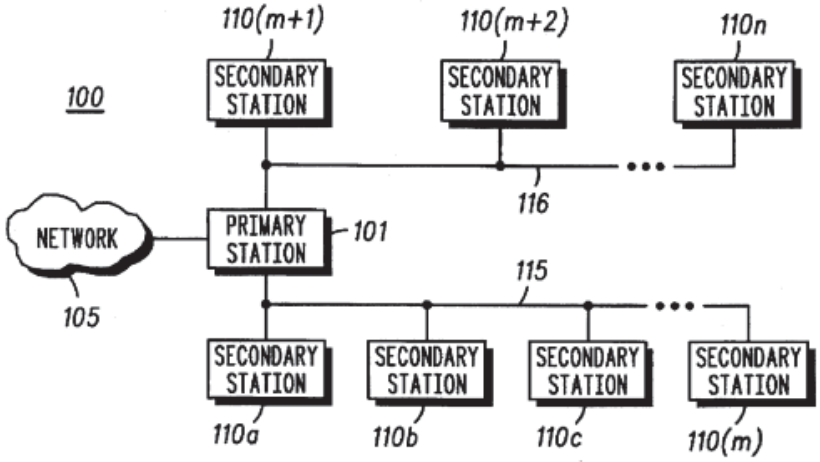
Ex. 1003 at Fig. 1. Specifically, Klayman discloses "apparatus 101 for adaptive forward error correction in a data communications system 100, the data communications system 100 having a communication medium (114, 115, or 116), with the communications medium having a plurality of communications channels." *Id.* at 10:56-59. In my opinion, a POSITA would have understood the disclosed communications system 100 to be a transmission system.

112. Accordingly, it is my opinion that Klayman teaches limitation 20[pre].

ii. Limitation 20[a]: a transmission channel to carry data between a transmitter and a receiver/decoder, each communicatively interfaced with the transmission channel;

113. In my opinion, Klayman teaches limitation 20[a]. Klayman teaches a plurality of communications channels (i.e., transmission channels), with which primary and secondary stations are communicatively interfaced to transmit data. As depicted in Figure 1 below, communications media 115 and 116 are communicatively interfaced with the primary station and each of the secondary stations, as well as with each other:

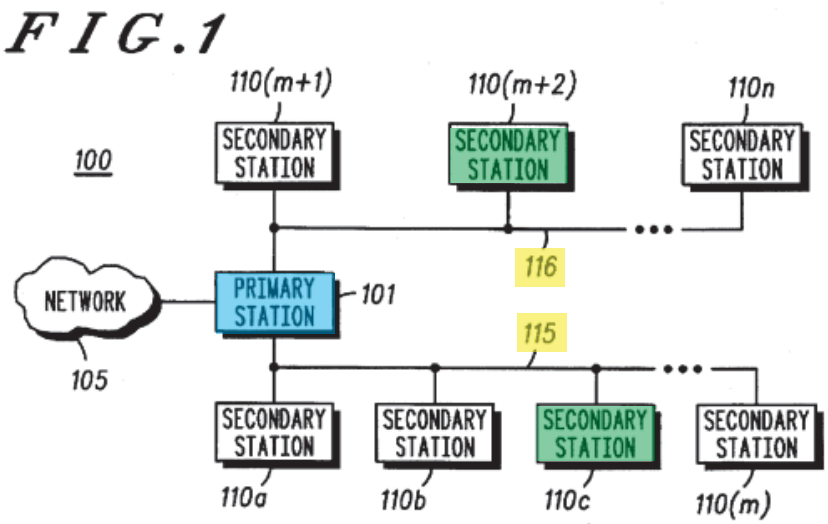
FIG. 1



Id. at Fig. 1; *see also* Figs. 2-3 (depicting communication medium 114 which is a communication channel that connects, and communicatively interfaces with, the primary and secondary stations). Thus, in Klayman's disclosed system, each transmission channel (i.e., each of communication media 114, 115, and 116) are communicatively interfaced with the primary station and each secondary station.

114. As depicted in Figure 1, and discussed above, Klayman teaches a communications system 100 that couples primary and secondary stations over communication medium 114. *Id.* at Fig. 1, 2:63 – 3:3, 3:20-28. Klayman discloses "the communications medium, such as communications media 115 and 116, has or supports of a plurality of communications channels" over which "primary station 101, transmits information, signals, or other data to a secondary station." *Id.* at 3:20-26. Figure 1 shows the primary and secondary stations communicatively interfaced

with communications media 115 and 116, which support the plurality of communications channels:



Id. at Fig. 1 (highlighted to identify primary station 101 (in blue), exemplary secondary stations (in green), and communications media 115 and 116 (in yellow)). The primary and secondary stations are also communicatively interfaced via communication medium 114 as depicted in Figures 2 and 3.

115. Klayman further discloses that "[t]he primary station includes a processor arrangement 120 which is connected to a plurality of channel interfaces . . . for communication over the communication medium 114." *Id.* at 3:50-53. Specifically, Klayman teaches:

> The apparatus 101 then comprises, first, a channel interface 125 coupleable to the communications medium 114 for transmission of encoded data on a first communications channel of the plurality of communications channels to form transmitted encoded data and for

> reception of encoded data on a second communications channels to form received encoded data . . .

Id. at 10:59-66. A POSITA would have understood that each of these communication channels are communicatively interfaced with the primary and secondary stations. Klayman explicitly discloses that the system "transmit[s] data on a communication channel" and "primary station 101, transmits information, signals, or other data to a secondary station." *Id.* at Fig. 5 (at steps 405, 420, and 425); 3:20-26. Thus, a POSITA would have recognized that Klayman teaches transmission channels over which the primary and secondary stations transmit data.

116. A POSITA would have also recognized that the primary station and channel interface 160 of the secondary station of Klayman correspond to receiver/decoder and transmitter, respectively. Klayman teaches a "transmitting unit, such as processor 150 and channel interface 160 of a secondary station 110" and a "receiver unit, such as receiver 135 and processor 130_{n2} of the primary station". *Id.* at 5:22-28. Klayman also teaches that "each of the receivers" may include a processor and a Reed-Solomon decoder "for decoding forward error correction and cyclic redundancy checks." *Id.* at 4:21-26. Therefore, the receivers also include decoders. As discussed above, the primary and secondary stations include processor arrangements and Klayman teaches that the processors are included within the primary station (processors 130) and within the secondary stations (processor 150).

Id. at Figs. 2, 3, 4:12-20 (processing arrangement 120, comprising processors 130, communicatively coupled to the receiving unit), 4:47-58 (processor 150 communicatively coupled to the transmitting unit, including channel interface 160). Processors 130 and processor 150 are communicatively interfaced via communications medium 114 as shown in Figures 2 and 3. *Id.* at Figs. 2-3. Even if processors 130 and 150 were not directly coupled to the same communication channel; though, a POSITA looking at Klayman's disclosed system would have understood that each processor within each primary and secondary station is communicatively interfaced via communications media 114, 115, and 116 within the system and can transmit signals to one another via those channels. Moreover, as shown in Figures 2 and 3 below, both the primary station, including receivers 135, (i.e., receiver/decoder) and channel interface 160 of the secondary station (i.e., transmitter) are communicatively interfaced with communications medium 114 (i.e., transmission channel):

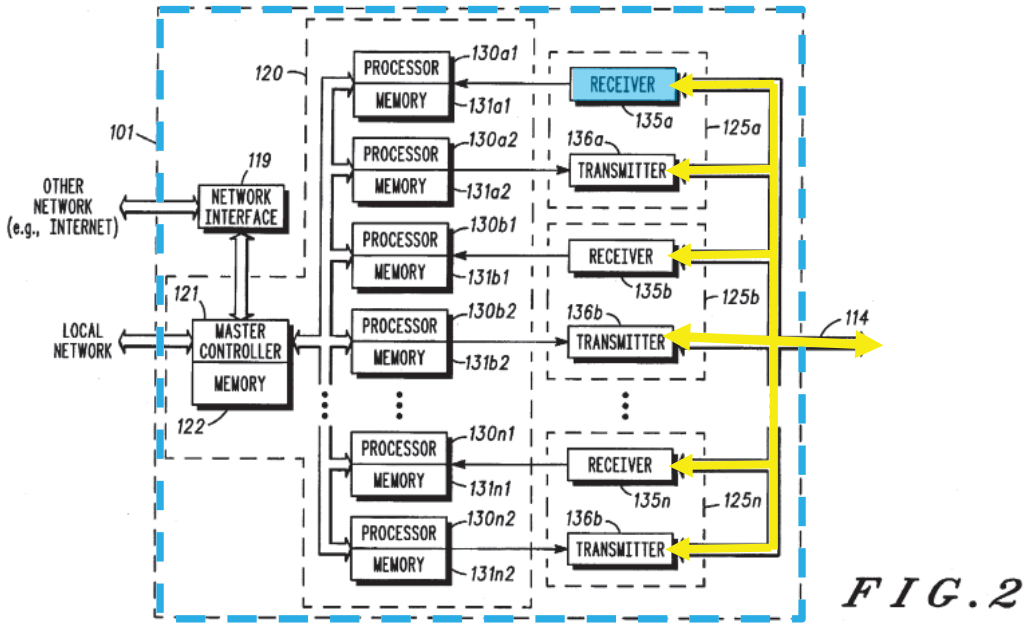
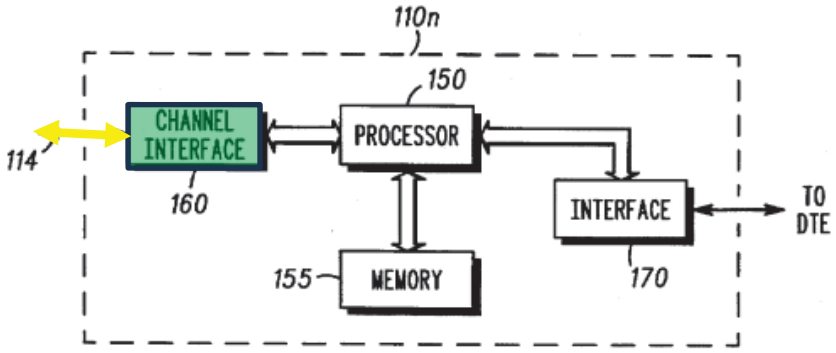


FIG. 2

FIG. 3



Id. at Fig. 2 (annotated to indicate primary station 101 with exemplary receiver 135a and communications medium 114), Fig. 3 (annotated to indicate channel interface 160 and communications medium 114).

117. Accordingly, it is my opinion that Klayman teaches limitation 20[a].

iii. Limitation 20[b]: a transmission error value monitor communicatively interfaced with the receiver/decoder to periodically monitor for transmission error values indicative of impulse noise events on the transmission channel,

118. In my opinion, Klayman teaches limitation 20[b]. Klayman teaches that the receiver (including decoders) is communicatively interfaced with each processor 130 which repeatedly monitors channel parameters (e.g., bit error rates) that are indicative of impulse noise events on the communications channel.

119. As explained immediately above regarding limitation 20[a], Klayman teaches that the primary station 101 includes receivers 135 which are each communicatively interfaced with a processor 130. Ex. 1003 at Fig. 2 (depicting the communicative connections between receivers 135 and procesors 130 within the primary station). Klayman also teaches that "[t]he receiving unit, such as receiver 135_n and processor 130_{n2} of the primary station 101, uses the encoded data to detect received errors." *Id.* at 5:26-29. Referring to Figure 4, Klayman explains that this is done at step 310 where "channel parameters are monitored . . . such as monitoring packet error rates, bit error rates, noise levels (such as levels of impulse noise or ingress noise), other interference, or other parameters or factors which could be correlated with channel quality, error rates, and a desired or necessary degree of error correction capability." *Id.* at 7:39-45. Figure 4 is reproduced below:

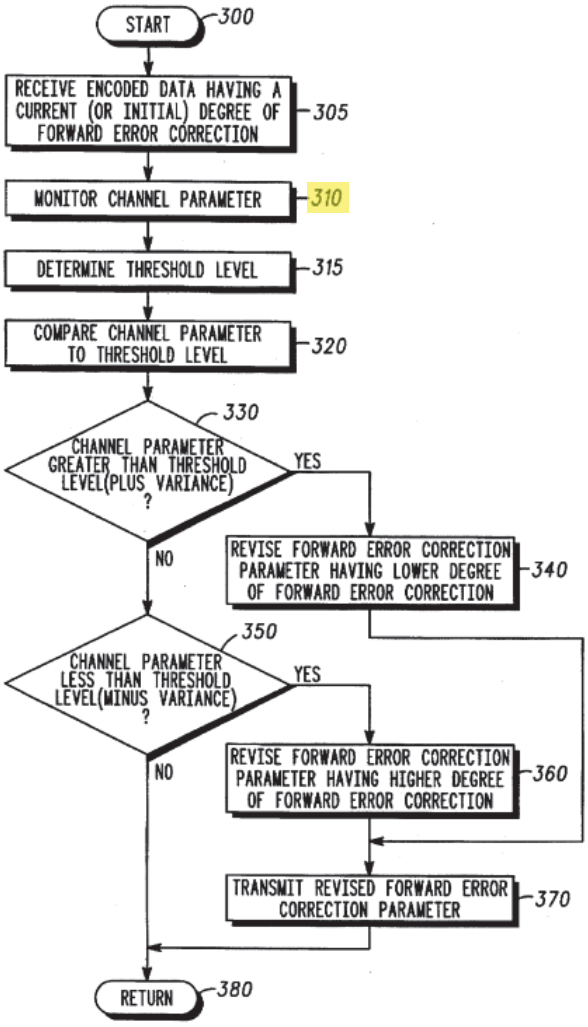


FIG. 4

Id. at Fig. 4 (highlighted to identify step 310). In my opinion, a POSITA reading Klayman would have understood that the primary station (through processors 130, as explained more fully below) detects errors by monitoring and comparing these parameters, as shown in Figure 4.

120. Klayman specifies that processor 130, which is within processor arrangement 120, performs the following functions:

> [T]he processor arrangement 120 responsive through a set of program instructions to monitor a channel parameter of the second communications channel to form a monitored parameter; the processor arrangement further responsive to compare the monitored parameter with a threshold level of the channel parameter; and when the monitored parameter is not within a variance (or tolerance level) of the threshold level, the processor arrangement is further responsive to change the first degree of forward error correction to a second degree of forward error correction…

Id. at 11:2-12. A POSITA would have understood that the processor 130—coupled with the receiver at the primary station—is performing the steps of Figure 4, including step 310, and monitoring the channel parameters (such as bit error rate) as described in Klayman. Accordingly, a POSITA would have recognized that processor 130 includes a transmission error value monitor.

121. Klayman also discloses periodic monitoring as the process taught in Figure 4 is repeated. Referring to Figure 4, Klayman teaches "this process may be repeated for each secondary device and over time . . . and it is also anticipated that different revised forward error correction parameters will be received by the different secondary stations and, over time, by the same secondary station." *Id.* at 10:20-26, claim 2 (reciting that the steps of the claimed method are repeated). A POSITA reading Klayman would have understood that, in order for "different revised forward error correction parameters" to be received by the secondary station (including the transmitter), the process of monitoring channel parameters at the

primary station would necessarily be repeated. In my opinion, this repeated process, done "over time", indicates that each processor 130 is periodically monitoring the parameters. Thus, Klayman teaches that the processor (i.e., transmission error value monitor) periodically monitors the channel parameters, including bit error rates (i.e., transmission error values).

122. Klayman also explains that the channel parameters, such as bit error rates, (i.e., transmission error values) indicate impulse noise events that have been detected on the communication channel (i.e., transmission channel). Klayman discloses that communication systems are "susceptible to interference from typical noise sources" and "the optimal error correcting methodology would utilize precisely enough error correction to compensate for the existing noise level." *Id.* at 5:15-16, 6:28-30. As such, a POSITA would have understood that Klayman's teaching of monitoring bit error rates would mean those bit error rates indicate an "existing noise level" or noise interference on the transmission channel. *Id.* In my opinion, a POSITA would have understood that these channel parameters, such as bit error rate, to be indicative of impulse noise events on the channel.

123. Accordingly, it is my opinion that Klayman teaches limitation 20[b].

124. Additionally, Starr teaches monitoring channel parameters, explicitly including both bit error rate (which Starr refers to as "BER") and signal to noise ratio

(SNR). Ex. 1005 at 2:37-39. As shown in Figure 2 below, Starr teaches a signal to noise ratio monitor 70 which determines SNR at the receiver/decoder:

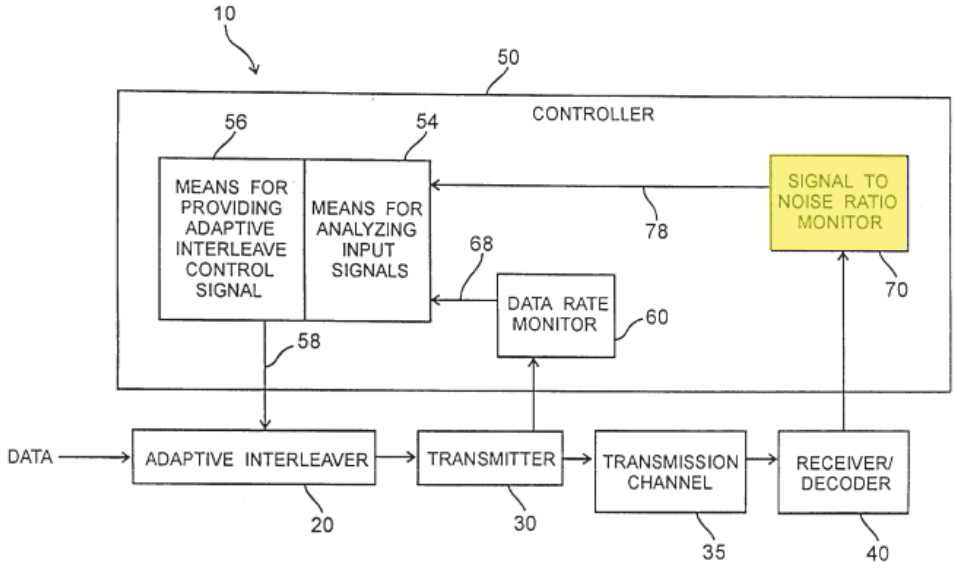


Fig. 2

Id. at Fig. 2 (highlighted to identify Signal to Noise Ratio Monitor 70 within Controller 50). Figure 7 further demonstrates Starr's teachings of determining the signal to noise ratio on the transmission channel:

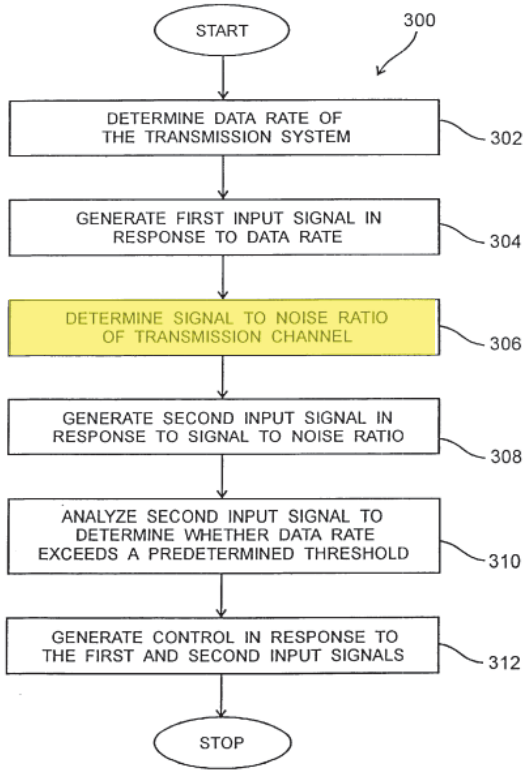


Fig. 7

Id. at Fig. 7 (highlighted to identify step 306); 5:27-29 (explaining the "signal to noise ratio monitor 70 preferably determines the SNR"). Regarding SNR and the signal to noise ratio monitor 70, Starr teaches:

> The signal to noise ratio monitor 70 preferably comprises a monitor for determining the SNR as known to those skilled in the art. The SNR monitor 70 is preferably coupled with the transmission channel 35 and the controller 50. SNR is preferably defined as the ratio of average signal power to average noise power. The signal power can be determined by measuring the maximum amplitude and phase deviation of all received data prior to demodulation. The noise power can be determined by measuring the amplitude and phase distance between adjacent points in the modulation constellation as known to those skilled in the art. Alternatively, the SNR can be determined through a

> variety of other techniques, and any suitable method of determining the SNR can be adapted for use in the presently preferred system.

Id. at 5:10-22. In my opinion, a POSITA would have understood that in the combined Klayman-Starr system, processor 130 of the primary station of Klayman, including a transmission error value monitor to monitor bit error rate, would also include a means to monitor SNR based on the teachings of Starr.

125. In my opinion, a POSITA would have recognized that the monitored SNR in Starr is indicative of impulse noise events on the transmission channel. For example, Starr explains that "[t]he capacity of the transmission channel 35 typically depends on factors including the following: . . . noise present in the transmission channel . . . ." *Id.* at 3:43-50. Starr then states: "While many of these factors are not directly measurable, their cumulative effect may be monitored by measuring one or both of the SNR and BER of the system." *Id.* at 3:50-53. A POSITA would have understood "noise present in the transmission channel" to include impulse noise events on the channel. Accordingly, in my opinion Starr's measured SNR (i.e., a transmission error value) is indicative of impulse noise events on the transmission channel.

126. As I explained in Part VIII.A.2, a POSITA would have been motivated to combine Klayman and Starr.

127. Accordingly, it is my opinion that Klayman in view of Starr renders obvious limitation 20[b]

iv. Limitation 20[c]: wherein the transmission error values are periodically monitored after training and initialization on the receiver/decoder,

128. In my opinion, Klayman teaches limitation 20[c]. As explained immediately above regarding limitation 20[b], Klayman discloses that transmission error values (i.e., bit error rate of Klayman and/or SNR of Starr) are periodically monitored (i.e., repeatedly monitored over time). Additionally, Klayman teaches that this periodic monitoring occurs after training and initialization on the primary station (i.e., the receiver/decoder).

129. Klayman teaches that "the receiving unit should know, prior to the receipt of actual data, what type of error correcting code is to be employed by the transmitting unit, for proper decoding and error correction." *Id.* at 5:29-33. This is "typically done by prior agreement (e.g., during initial set up or configuration of the communication system) or during a negotiation 'handshake' during establishment of the communications link." *Id.* at 5:33-36 (emphasis added). A POSITA would have understood this "initial set up or configuration" to correspond to initialization and training of the receiving unit and decoder. For example, as is described in U.S. Patent No. 6,654,410 to Marcos C. Tzannes, filed January 16, 2002, an "initialization

procedure," including "training signals . . . set between the transceivers" "must be completed" "to establish communication between the transceivers at the very onset". Ex. 1013 at 5:61-66. Therefore, the initial set up in Klayman that allows the primary and secondary stations to transmit data corresponds to initialization and training.

130. Klayman also explains: "In the preferred embodiment, the initial degree of forward error correction may be established during an initial registration process, when a secondary station establishes a communication link with a primary station." *Id.* at 7:23-27. Additionally, as shown in Figure 4, the monitoring process discussed with regard to limitation 20[b] above occurs after the primary station "receive[s] encoded data having a first or initial degree of forward error correction . . . in step 305." *Id.* at 7:11-13, Fig. 4 (at step 305). A POSITA would have recognized that the remaining steps of Figure 4 which are repeated, including monitoring channel parameters at 310, would occur only after this initial set up, registration process, and receipt of the initial degree of forward error correction at the primary station (i.e., training and initialization on the receiver/decoder).

131. In the combined Klayman-Starr system, a POSITA would have understood that the signal to noise ratio of Starr (i.e., transmission error value) would also be periodically monitored after training and initialization at the receiver/decoder

in the same way as the bit error rate of Klayman. I explain the rationale and motivation to combine Klayman and Starr in Part VIII.A.2 above.

132. Accordingly, it is my opinion that Klayman alone and/or Klayman in view of Starr teaches and/or renders obvious limitation 20[c].

v. Limitation 20[d]: the transmission error values being selected from a group comprising: a bit error rate, errored seconds, errored minutes, code violations over a fixed period of time, Signal-to-Noise Ratio (SNR) measured at the receiver/decoder, and Transmission Control Protocol and Internet Protocol (TCP/IP) throughput,

133. In my opinion, Klayman teaches limitation 20[d]. Klayman discloses that the monitored channel parameters (i.e., transmission error values) may be bit error rates that affect channel quality and error rates. *Id.* at 4:37-50.

134. As explained above, Klayman discloses that processor 130 (which a POSITA would have understood to include a transmission error value monitor) monitors channel parameters. Klayman also teaches that those parameters include monitoring "bit error rates". *Id.* at 7:40-42. Therefore, Klayman teaches that the transmission error values are bit error rates. *Id.*; *see also id.* at claim 4.

135. In the combined system of Klayman-Starr, the transmission error values also include signal to noise ratio. Ex. 1005 at 2:37-39, 5:10-26. Starr teaches monitoring both bit error rate, like Klayman, and signal to noise ratio. *Id.* Starr

further discloses that SNR is monitored at the receiver/decoder as shown in Figure 4:

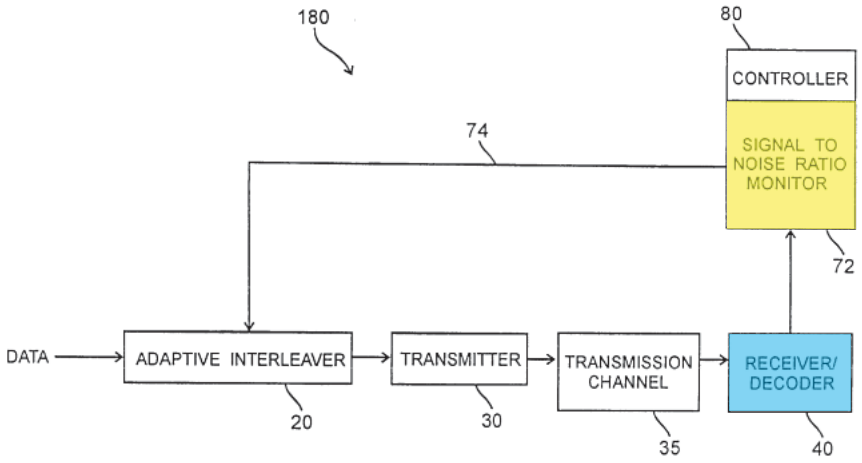


Fig. 4

Id. at Fig. 4 (highlighted to identify signal to noise ratio monitor 72 and receiver/decoder 40). A POSITA would have recognized that in the combined system of Klayman-Starr, SNR is being measured at the receiver/decoder by processor 130. I explain the rationale and motivation to combine Klayman and Starr in Part VIII.A.2 above.

136. Klayman also teaches that this monitoring occurs at the primary station (i.e., receiver/decoder). *Id.* at 7:37-45, Fig. 4. A POSITA reading Klayman would have understood that, although Klayman focuses its disclosure on the objective to improve upstream transmissions, both link directions are discussed. *Id.* at 3:45-50 ("The primary station 101 is coupled to a communication medium 114 for upstream

and downstream communication to one or more secondary stations (not illustrated)"). Therefore, a POSITA would have recognized that Klayman discloses channel parameters, including bit error rate and SNR in the combined Klayman-Starr system (i.e., transmission error values), which are measured at the receiver/decoder.

137. Accordingly, it is my opinion that Klayman renders obvious limitation 20[d].

vi. Limitation 20[e]: and wherein the transmission error value monitor to further generate an input signal based on the transmission error values monitored; and

138. In my opinion, Klayman teaches limitation 20[e]. As explained regarding limitation 20[b], Klayman discloses processor 130 within the primary station is communicatively interfaced with the receiver and decoder (also within the primary station) and includes a transmission error value monitor. *See also id.* at Fig. 2 (depicting the communicative interface between the processors 130 and receivers 135). Klayman also discloses that the primary station (including processor 130) transmits a revised forward error correction parameter back to the secondary station based on the monitored channel parameters, such as bit error rate (i.e., a transmission error value). A POSITA would have understood the transmission of this revised forward error correction parameter to be an input signal.

139. As explained regarding limitation 20[b] above, processor 130 performs steps 310-370 of Figure 4. *See also id.* at 11:2-15 (explaining that the processing arrangement uses program instructions to monitor channel parameters, compare those monitored parameters to a threshold level, and change the degree of forward error correction based on that comparison). Additionally, as explained regarding limitation 20[b] above, a POSITA would have recognized that processor 130, communicatively interfaced with the receiver and decoder in the primary station, to include a transmission error value monitor. Thus, a POSITA would have understood processor 130 (i.e., transmission error value monitor) to perform step 370: "transmit revised forward error correction parameter." *Id.* at Fig. 4.

140. Prior to this transmission of a revised forward error correction parameter, Klayman teaches:

> [D]epending on the choice of channel parameter employed, such as noise levels or error rates, the comparative steps 330 and 350 may be reversed or modified. For example, if the selected channel parameter is an error rate, such that if the threshold error rate level with a selected tolerance is exceeded in step 330, then a revised forward error correcting parameter is selected which has a higher degree of forward error correction capability in step 340, with corresponding modifications of step 350 and 360. Following steps 340 and 360, the revised forward error correction parameter is transmitted, step 370, for example, to a particular secondary station...

Id. at 8:30-42 (emphasis added). A POSITA reading Klayman would have understood that after the processor monitors channel parameters and compares them

to a threshold value, processor 130 generates an input signal based on those monitor values when it transmits the revised forward error correction parameters to the secondary station. Klayman explicitly states that, for transmission and reception of the revised forward error correction parameter, "the preferred embodiment utilizes signaling." *Id.* at 9:64 – 10:2. Klayman further teaches that "signaling may be performed at any layer in a communication protocol, including the physical layer, the network layer, or in a software download (from a primary station 101 to a secondary station 110_n)." *Id.* at 10:4-7; *see also id.* at 6:66 – 7:3 (describing "a means for signaling and changing the forward error correction parameters"). Additionally, part of Klayman's disclosed invention is transmitting the forward error correction revision parameter "in a link layer protocol message." *Id.* at claim 16. A POSITA would have, therefore, recognized that, although not explicitly referred to as an "input signal", the transmission of the revised forward error correction parameter is an input signal. In my opinion, a POSITA would have known that the system would use an input signal, which is received by the secondary station, as the transmission of the revised parameter sent from the primary station.

141. Accordingly, it is my opinion that Klayman teaches limitation 20[e].

142. To the extent Klayman does not explicitly teach an "input signal," Starr explicitly teaches that the above-described transmission involves an input signal.

Starr teaches that a "bit error rate monitor 170 preferably generates an input signal 178 that varies as a function of the BER." Ex. 1005 at 6:43-44. Specifically, Starr discloses that the bit error rate monitor, like Klayman's transmission error value monitor (or processor 130) both "determines the BER and continuously generates the input signal 178." *Id.* at 6:52-53. Similarly, "[t]he SNR monitor 70 preferably determines the SNR and continuously generates the input signal 78." *Id.* at 5:36-37.

143. Regarding the disclosed input signal, Starr explicitly teaches:

> The input signal 68 can take more forms. The input signal 68 can be based in-whole or in-part on the data rate. The input signal 68 can be analog or digital and linear or non-linear as known to those skilled in the art. Alternatively, the input signal 68 can be binary such that input signal 68 is greater than or less than a threshold value based upon the data rate as known to those skilled in the art.

Id. at 4:65 – 5:5; *see also id.* at 5:29-37, 6:45-53 (describing input signal 78 relating to BER and input signal 178 relating to SNR in very similar terms). This is nearly identical to the '996 Patent's description of an input signal:

> Means 642 preferably generates an input signal 643 that varies as a function of the MEV(s). Alternatively, the input signal 643 can take many forms and can be based in whole or in part on the BER, errored seconds, etc. The input signal 643 can be analog or digital and linear or non-linear, as will be appreciated by those skilled in the art. Alternatively, the input signal 643 can be binary such that the input signal 643 is greater than or less than one or more threshold values based upon the MEV(s). Means 642 may continuously generate the input signal 643, if desired.

Ex. 1001 at 17:11-20.

144. In the combined system of Klayman and Starr, then, a POSITA would have understood that when processor 130 transmits a revised forward error correction parameter to the transmitter at step 370, that step would include generating an input signal indicative of that revised forward error correction parameter which varies as a function of the monitored transmission error value (i.e., bit error rate or SNR). I explain the rationale and motivation to combine Klayman and Starr in Part VIII.A.2 above.

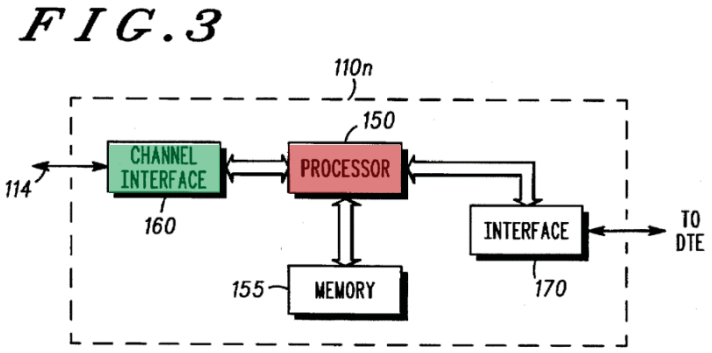
145. Accordingly, it is my opinion that Klayman alone and/or Klayman in view of Starr renders obvious limitation 20[e].

vii. Limitation 20[f]: a controller coupled with the transmitter to receive the input signal from the transmission error value monitor and to further generate a retransmission overhead control signal of the transmitter in response to the input signal.

146. In my opinion, Klayman discloses limitation 20[f]. Klayman teaches processor 150 (i.e., controller) coupled with the secondary station, including channel interface 160, which receives the transmission of a revised forward error correction parameter (i.e., input signal) from the primary station. Klayman also discloses that the transmitter (channel interface 160) transmits encoded data based on the received revised forward error correction parameter. A POSITA would have understood that

processor 150 necessarily generates a retransmission overhead control signal to instruct the transmitter to act accordingly.

147. As explained immediately above regarding limitation 20[e], processor 130 coupled to the receiver at the primary station includes a transmission error value monitor that transmits a revised forward error correction parameter (i.e., an input signal) to the secondary station. Klayman also teaches processor 150 coupled to channel interface 160 within the secondary station which receives this input signal. As shown in Figure 3, channel interface 160, memory 155, and interface 170 are all communicatively coupled to processor 150:



Id. at Fig. 3 (highlighted to indicate processor 150 (in red) and channel interface 160 (in green)). A POSITA would have known that processor 150 is a controller, based on the plain and ordinary meaning of that term.[2] Klayman teaches that processor 150

[2] A POSITA would have understood that numerous components within Klayman's disclosed system correspond to a controller. For example, the master controller within the primary station is communicatively interfaced with the secondary

is part of the transmitting unit: "The transmitting unit, such as the processor 150 and channel interface 160 of a secondary station". *Id.* at 5:22-24.

148. Additionally, Klayman teaches that the transmitting unit of the secondary station, including processor 150, receives the transmitted input signal from processor 130 (i.e., transmission error value monitor) coupled to the receiving unit. As shown in Figure 5, processor 150, coupled to the transmitting unit, "monitor[s] communication channel for reception of a forward error correction revision parameter." *Id.* at Fig. 5 (step 410). Klayman also teaches that "a revised degree of forward error correction is received in step 415." *Id.* at 10:16-17. As with Figure 4, and for the same reasons as explained above, a POSITA would have understood that processor 150 at the secondary station carries out the steps of Figure 5. *See also id.* at 11:44-60 (explaining the processor is "responsive to monitor the second communications channel for reception of a forward error correction revision parameter."); *see also id.* at 5:22-26 ("The transmitting unit, such as the processor 150 and channel interface 160 of a secondary station 110_n, generates the error correction code from the user data, and appends the encoded data onto the user data during transmission.").

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station and, for the same reasons discussed regarding processor 150, could constitute a controller.

149. If a revised forward error correction parameter is received at the secondary station, processor 150 (i.e., controller) coupled to channel interface 160 (i.e., transmitter) determines whether the revised parameter indicates a revised degree of correction and, if so, channel interface 160 transmits encoded data with that revised degree of forward error correction. *Id.* at 11:49-60. A POSITA would have understood that, in between these two steps, the processor would necessarily generate a control signal to send to channel interface 160 and instruct it to transmit encoded data with the revised forward error correction parameter. Klayman explains that channel interface 160 at the secondary station performs forward error correction and encoding. *Id.* at 4:58 – 5:1.

150. A POSITA would have further understood this control signal to constitute a retransmission overhead control signal. In my opinion, a POSITA would have understood that a retransmission overhead control signal may include an instruction to send another transmission with less overhead based on a revised forward error correction parameter. As taught by Klayman, "a greater or higher degree of forward error correction capability is selected to decrease the overhead associated with retransmission of an entire data packet due to excessive errors, when such greater error correction capability is necessary because the channel parameter indicates more errors needing correction." *Id.* at 8:24-30. Thus, a POSITA reading

Klayman would recognize that an instruction (i.e., control signal) regarding the revise forward error correction parameter done to "decrease the overhead associated with retransmission of an entire data packet" is a retransmission overhead control signal. Additionally, in my opinion, the generation of a retransmission overhead control signal to adjust the forward error correction code parameters would have been obvious to a POSITA.

151. Accordingly, it is my opinion that Klayman alone renders obvious limitation 20[f].

152. To the extent Klayman does not explicitly teach the generation of a retransmission overhead control signal, in my opinion Klayman in view of Starr renders obvious limitation 20[f]. Starr explicitly teaches "The controller 50 provides an adaptive interleave control signal 58 (step 312) in response to the input signals 68, 78." Ex. 1005 at 8:50-52.

153. As shown in Figure 1, Starr teaches a controller including "means for providing adaptive interleave control signal":

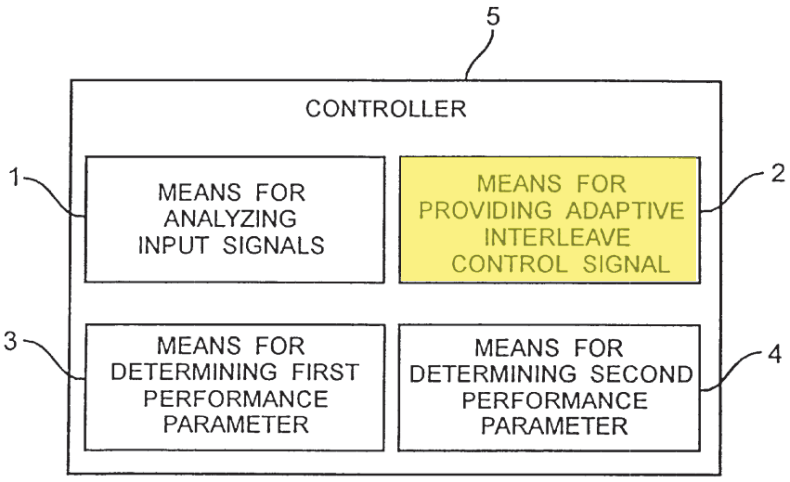


Fig. 1

Id. at Fig. 1 (highlighted). Similarly, Figure 3 depicts the connection between the means for providing the control signal with the adaptive interleaver, which is communicatively coupled to the transmitter:

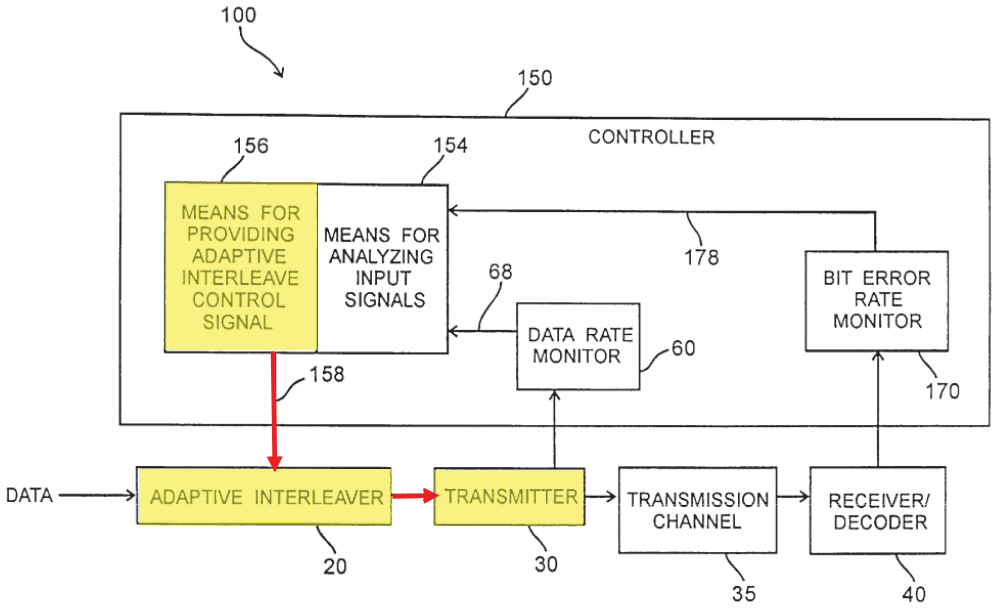


Fig. 3

Id. at Fig. 3 (highlighted to show the means for providing the control signal 156, adaptive interleaver 20, and transmitter 30, and communicative coupling between them).

154. Starr discloses that the controller can "generate an adaptive interleave control signal . . . that controls the adaptive interleaver" and "causes the adaptive interleaver 20 to implement an interleave depth that is proportional to the SNR, BER, data rate or combination thereof." *Id.* at 9:18-25. Also, Starr specifically teaches that the control signal "can be based in-whole or in-part on the BER." *Id.* at 7:66-8:5. Similarly, Starr teaches that the control signal "can be based in-whole or in-part on the SNR." *Id.* at 7:46-48.

155. Thus, Starr teaches that the controller generates a control signal which controls the adaptive interleaver (i.e., transmitter in Starr) to implement a new interleave depth proportional to the BER. In the combined system of Klayman-Starr, it would have been obvious to a POSITA to use the control signal taught by Starr such that processor 130 of Klayman would generate a control signal to send to channel interface 160 and instruct it to transmit encoded data with the revised forward error correction degree. A POSITA would have further understood this control signal to constitute a retransmission overhead control signal because, as explained above and taught by Klayman, "a greater or higher degree of forward error

correction capability is selected to decrease the overhead associated with retransmission of an entire data packet due to excessive errors, when such greater error correction capability is necessary because the channel parameter indicates more errors needing correction." Ex. 1003 at 8:24-30.

156. A POSITA would have been motivated to combine the teachings of Klayman and Starr for the reasons discussed in Part VIII.A.2 above.

157. Accordingly, it is my opinion that Klayman alone and/or Klayman in view of Starr renders obvious limitation 20[f].

158. For the foregoing reasons, it is my opinion that Klayman alone and/or Klayman in view of Starr teaches and/or renders obvious each limitation of claim 20.

B. Ground 2: Analysis of Claim 20 Based on Agarwal in view of Starr.

1. Overview of the Combination of Agarwal and Starr

159. With respect to claim 20, Agarwal teaches the recited transmission system comprising a transmission channel, transmitter, receiver/decoder, transmission error value monitor, transmission error values, and controller coupled with the transmitter. As explained in limitation 20[b] below, Agarwal teaches byte error rate which corresponds to a transmission error value. As explained in Ground 1, Starr also teaches a transmission error value in the form of signal to noise ratio

which is measured at the receiver/decoder. A POSITA would have been motivated to combine the teachings of Agarwal and Starr resulting in a system that monitors both byte error rate and signal to noise ratio.

160. As is explained regarding limitation 20[e]-[f] below, it is my opinion that Agarwal also implicitly teaches the generation of an input signal and retransmission overhead control signal for the transmitter in response to the input signal. However, to the extent these signals are not explicitly taught by Agarwal, in my opinion a POSITA would have been motivated to combine Agarwal's disclosed system with the teachings of Starr which include an input signal and generated control signal used to instruct the transmitter based on the input signal.

161. Prior to 2003, POSITAs were well-aware that signal-to-noise ratio could be determined when data is transmitted over a communications channel. Agarwal, in fact, teaches that communication channels are "inherently noisy". Ex. 1004 at 2:34-41. Starr explains that monitoring signal to noise ratio—by using a signal to noise ratio monitor—was "known to those skilled in the art." Ex. 1005 at 5:10-12.

162. Prior to 2003, POSITAs were also well-aware that input and control signals could be used in an adaptive transmission system. Starr provides an example of the use of an input signal which is generated based on data rate, signal to noise

ratio, and bit error rate. Ex. 1005 at 4:63 – 5:5, 5:27-29, 6:43-44. Additionally, Starr provides an example of the use of a control signal which is generated by a controller in response to an input signal. *Id.* at Fig. 3, 2:65-67. Starr explains that "[t]he adaptive interleaver preferably adjusts the interleave depth in response to the adaptive interleave control signal 58." *Id.*at 2:65-67. The means for generating the control signal and communicative coupling between that means and the adaptive interleaver and transmitter of Starr is depicted in Figure 3:

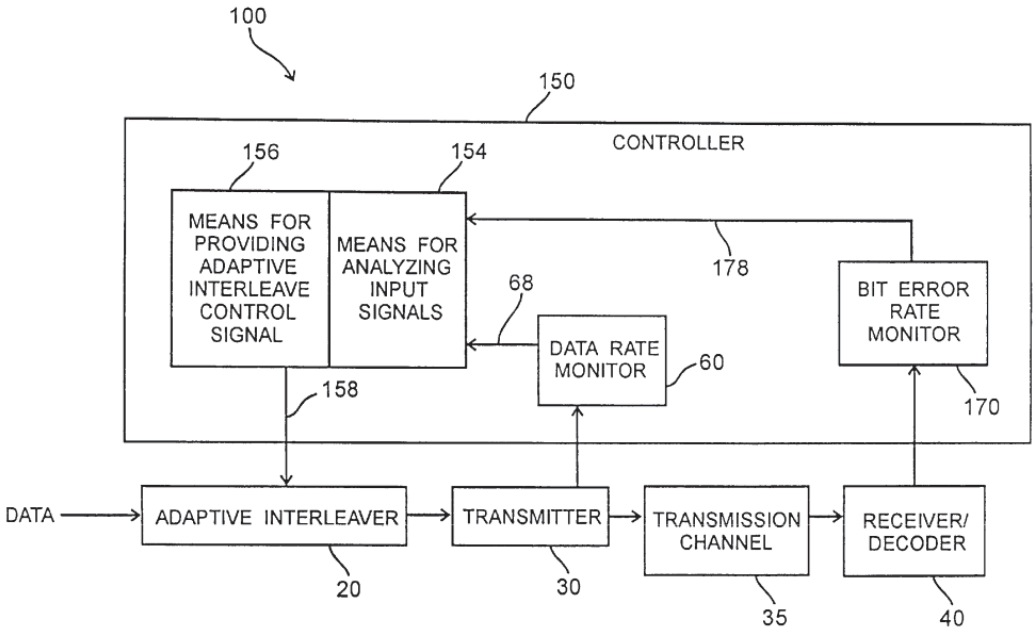


Fig. 3

Id. at Fig. 3.

163. As I set forth below, a POSITA would have been motivated to combine Agarwal's system employing adaptive forward error correction coding with Starr's teachings of monitoring signal to noise ratio (SNR) and generating an input and

control signal which instruct the transmitter to adjust the forward error correction code value based on the received new forward error correction code length which itself is based on byte error rate. For the reasons set forth below, a POSITA would have also had a reasonable expectation of success in making this well-understood combination.

2. Motivation to Combine and Expectation of Success (Agarwal in view of Starr)

164. I understand that Agarwal and Starr are considered to be analogous art as they both relate to adaptive correction of transmissions, including forward error correction codes and adaptive interleaving. Specifically, Agarwal discloses "a method for the adaptive control of forward error correction codes for transmission over communication channels." Ex. 1004 at 3:56-58. The disclosed system in Agarwal includes a controller (Microprocessor 1015), transmitter (remote interface), and receiver (primary/receiving interface) which include an encoder/decoder and interleaver/deinterleaver respectively. *Id.* at 5:41-58; *see also id.* at Fig. 4 (showing a Reed-Solomon decoder and encoder). While Agarwal teaches that its system is preferably associated with a wireless network, it explains that "the present invention is equally applicable with respect to terrestrial based communications." *Id.* at 5:1-10, 6:14-15.

165. Similarly, Starr discloses a system for "automatically controlling an adaptive interleaver in response to the performance parameters of a transmission system." Ex. 1005 at 2:19-20. The system of Starr, like Agarwal, utilizes an interleaver, transmitter, transmission channel, receiver/decoder, and a controller. *Id.* at 2:54-57. The receiver/decoder of Starr "can employ a Reed Solomon decoder or any other suitable error correcting decoder as known to those skilled in the art." *Id.* at 4:24-26. Starr teaches that its "system is of particular importance with regard to digital subscriber lines" but "those skilled in the art will appreciate that it is applicable to any system that incorporates interleaving." *Id.* at 2:50-53.

166. In my opinion, a POSITA would have been motivated to combine the teachings of Agarwal and Starr for several reasons.

i. Monitoring SNR and generating an input and control signal in the Agarwal system based on the teachings of Starr would have been using well-known prior art methods to yield predictable results.

167. Prior to December 2003, it was known to monitor signal to noise ratio over a transmission channel. As noted above, Starr itself states that signal to noise monitors were known in the art. Ex. 1005 at 5:10-12. Indeed, determining the signal to noise ratio of a data transmission was "readily measured" as early as 1965. Ex. 1012 at 1701 (also explaining that "[C]onditional error rates, in terms of the average number of bit errors per noise burst, as determined as functions of a signal-to-noise

ratio."). It was also known, by at least 1965, that signal to noise ratio served as an indication of "[t]he impulse noise present on such a channel." *Id.* at 1702-1706.

168. Starr teaches a signal to noise ratio monitor 70 which "preferably comprises a monitor for determining the SNR as known to those skilled in the art." Ex. 1005 at 5:10-13. Additionally, Starr explains: "SNR is preferably defined as the ratio of average signal power to average noise power." *Id.* at 5:13-15. Starr teaches that SNR is a preferred performance parameter in a transmission system. *Id.* at 2:37-39. In my opinion, a POSITA would have known signal to noise ratio could be monitored in a transmission system as a method of measuring channel quality.

169. Prior to December 2003, it was well-known that input and control signals could be generated to instruct a transmitter to change the applicable forward error correction code in adaptive transmission systems. Utilizing input and control signals for this purpose, such as the input signal and adaptive interleave control signal taught by Starr, were known and commonly used in transmission systems at least by the 1990s.

170. Starr teaches an input signal which is generated based on the bit error rate and SNR. Ex. 1005 at Figs. 7-8, 5:27-29, 6:43-45. A POSITA would have had knowledge of other prior art systems relying on input signals, like that taught by

Starr, as I explained in Part VIII.A.2 above, which I incorporate by reference. *See* Ex. 1014, Ex. 1015, Ex. 1016; *see also* Ex. 1005.

171. Starr also teaches that a controller "generates an adaptive interleave control signal" in response to determined performance parameters of the system. Ex. 1005 at 2:54-67. Specifically, Starr explains that the control signal is generated by a bit error rate monitor and "preferably varies as a function of the BER." *Id.* at 8:1-5; *see also id*. at 7:44-47 (teaching a control signal that varies and may be based in-whole or in-part on the SNR). Once generated and transmitted, "[t]he adaptive interleave control signal 174 is preferably utilized by the adaptive interleaver 20 to control the interleave depth to generate an adaptively interleaved signal." *Id.* at 8:13-16, at 9:20-22 ("an adaptive interleave control signal . . . controls the adaptive interleaver 20 such that interleaving is implemented"). A POSITA would have had knowledge of other prior art systems relying on control signals, like that taught by Starr, as I explained in Part VIII.A.2. above, which I incorporate by reference. *See* Ex. 1005, Ex. 1017, Ex. 1018, Ex. 1019.

172. As taught by the prior art, a POSITA would have expected implementing an input and control signal in Agarwal's transmission system to predictably result in instructing the remote interface of Agarwal to adaptively adjust the forward error correction code value "to include more or less coding bytes for all

subsequent frames which are transmitted from the remote interface." Ex. 1004 at 8:11-18; *see also* Ex. 1005 at 8:13-16 (similarly teaching that the control signal results in controlling the interleave depth).

173. For at least these reasons, by December 2003, a POSITA would have known to monitor SNR and use an input and control signal to instruct the transmitter to change the forward error correction code values for future transmissions. Thus, applying the teachings of these signals from Starr to the adaptive forward error correction coding system of Agarwal would have simply been combining known prior art elements according to known methods. And, as explained above, a POSITA would have recognized that this combination would predictably result in an instruction to the transmitter to adaptively correct error code values.

ii. Starr expressly suggests utilizing its teachings in other transmission systems, such as the wireless system disclosed by Agarwal.

174. Starr discloses that its teachings can be utilized in different forms of transmission systems. For example, Starr explains its disclosures are "applicable to any system that incorporates interleaving". Ex. 1005 at 2:50-53. Additionally, Starr teaches that its transmitter—which receives the input and control signals—"can comprise any transmitter for use with any form of transmission media as known to those skilled in the art." *Id.* at 3:32-34. Agarwal explicitly discloses interleaving in

conjunction with forward error correction coding. Ex. 1004 at Fig. 1B (showing both the remote and primary interfaces include an interleaver and deinterleaver and transmit or receive "interleaved frames").

175. Thus, a POSITA reading the teachings of Starr and Agarwal would have recognized that Starr's disclosures are applicable to the system disclosed in Agarwal. Moreover, Starr explains that the disclosed control signal is used "to control the interleave depth to generate an adaptively interleaved signal." Ex. 1005 8:13-16. Agarwal similarly discloses that the remote interface uses received information, which may include an input and control signal, to "change the frame format to include fewer or more coding bytes as necessary for all subsequently transmitted frames." Ex. 1004 at 6:9-12.

176. Accordingly, it is my opinion that a POSITA would have been motivated to combine the teachings of Agarwal and Starr to monitor SNR and utilize the input and control signals disclosed in Starr to instruct the remote interface of Agarwal to change the frame format as needed to correspond to the transmitted forward error correcting code length.

iii. It would have been obvious to try monitoring SNR in Agarwal's system based on Agarwal's teachings.

177. It is my opinion that it would have been obvious to try implementing Starr's teachings of monitoring SNR in Agarwal's system.

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178. Agarwal explicitly notes a correspondence between signal to noise ratio and link quality. Ex. 1004 at 10:66 – 11:1. Although Agarwal teaches monitoring byte errors and byte error rate to indicate link quality, a POSITA reading Agarwal would have found it obvious to try monitoring signal to noise ratio on data transmissions. Additionally, as explained more fully below regarding claim limitation 20[b], a POSITA would have understood that Microprocessor 1015 of Agarwal includes a transmission error value monitor to monitor byte error rate. *Id.* at Fig. 5. Accordingly, a POSITA would have been motivated, and found it obvious, to try monitoring SNR which is indicative of noise levels in Agarwal's system. In my opinion, POSITA would have been motivated to look to other references, like Starr, which teach the implementation of a signal to noise monitor to monitor SNR on a transmission channel. Starr teaches monitoring both bit error rate and SNR on a transmission channel, thus, a POSITA would have found it obvious to try monitoring SNR—along with the already-monitored byte error rate—in Agarwal's system.

iv. It would have been obvious to try implementing the input and control signals of Starr with the microprocessor and remote interface of Agarwal.

179. It is my opinion that it would have been obvious to try the use of Starr's control signal in conjunction with the disclosed forward error correction coding system of Agarwal to instruct the remote interface.

180. A POSITA would have understood that there are a limited number of predictable solutions to ensure that the transmitter utilizes the corrected forward error code length received from the primary interface for future transmissions. First, a POSITA would have understood that, after monitoring the transmission error values and determining whether a different forward error correction code length is required, that information must be communicated to the transmitter. Based on the teachings of Agarwal—which explicitly calls for the calculation of "a byte error rate associated with communication signals" (Ex. 1004 at Abstract)—a POSITA would have known to use an input signal to transmit the new forward error correction code length based on monitored byte error rate.

181. Second, regarding the control signal, a POSITA would have recognized that either: (1) a control signal must be sent to the transmitter to instruct it to utilize the new forward error correction code length; or (2) the forward error correction coding must be performed entirely in the controller's memory such that a control

signal is not needed. These two predictable options are exemplified in Starr which teaches:

> While the controller 50, 150 and adaptive interleaver 20 are preferably implemented as separate elements as shown in FIGS. 1 and 2, they can alternatively be implemented as a single element comprising software, hardware or a combination thereof as described herein and known to those skilled in the art.

Ex. 1005 at 7:31-35.

182. Given that using a control signal was well-known in the art and is one of two options to instruct the transmitter to respond to the new forward error correction code length, it would have been obvious for a POSITA to try implementing a control signal (like that disclosed in Starr) to Agarwal's system. Agarwal, for example, teaches that its controller (i.e., Microprocessor 1015) and its corresponding memory are separate from the disclosed primary and remote interfaces; thus, FEC coding is not occurring entirely within the controller's memory. Ex. 1004 at Fig. 4. Therefore, a POSITA looking at the disclosures of Agarwal and explicit teachings of a control signal in Starr would have found it obvious to implement a control signal in Agarwal's system.

183. As I explained below, a POSITA would have had a reasonable expectation of success in trying to monitor SNR and implement the input and control signal of Starr to instruct the remote interface disclosed in Agarwal.

v. A POSITA would have expected to succeed in combining Starr's SNR monitor and input and control signal with Agarwal's transmission system.

184. In my opinion, a POSITA would have expected success in implementing Starr's teachings of monitoring SNR within Agarwal's system. Agarwal teaches Microprocessor 1015 monitors byte errors and calculates byte error rate in data transmissions. Ex. 1004 at Figs. 4-5, 7:620-8:4. Similarly, Starr teaches a bit error rate monitor and signal to noise ratio monitor within controller 50 which monitors bit error rate and signal to noise ratio. Ex. 1005 at Figs. 2, 3. A POSITA would have recognized that Agarwal's Microprocessor 1015—which already includes means to monitor byte errors and calculate byte error rate—could successfully include the signal to noise ratio monitoring means of Starr to monitor SNR at the primary interface. A POSITA would have no seen no technological hurdles in monitoring SNR with Agarwal's Microprocessor 1015.

185. In my opinion, a POSITA would have also expected success in implementing the input and control signal of Starr in Agarwal's system. Configuring Microprocessor 1015 to generate and transmit an input and control signal to the remote interface to accomplish the invention's stated purpose of adaptive forward error correction coding would have been easily accomplished. Agarwal teaches that Microprocessor 1015 is coupled to the primary and remote interfaces and

"Interleaver RAM 1040 receives the output of the Reed-Solomon Encoder 1030 under the control of the Microprocessor 1015 in order to form an interleaved frame." Ex. 1004 at 12:12-15. Thus, the controller of Agarwal (i.e., Microprocessor 1015) is already configured to communicate with the remote interface.

186. Additionally, Agarwal already teaches the use of various "communication signals" including "signals" transmitted by the remote interface "including a forward error correction code having more or less forward error correction coding bytes in accordance with the information provided by the primary interface." *Id.* at 8:11-14. Configuring the primary interface, and Microprocessor 1015, to provide this information via an input signal is within the scope of the teachings of Agarwal and would have been obvious to a POSITA. Additionally, configuring the controller to send a control signal to the remote interface, instructing it to adjust its forward error correction code value based on the received length from the primary interface, would have been in-line with the teachings of Agarwal and a POSITA would have expected success with this combination.

187. For all of these reasons, I conclude that a POSITA would have been motivated to combine Agarwal and Starr and would have expected success in doing so.

3. Claim 20

188. Based on my review and for the reasons that follow, it is my opinion that claim 20 is obvious based on the teachings of Agarwal and Starr.

i. Limitation 20[pre]: A transmission system comprising:

189. I understand that a preamble generally does not state a claim limitation. However, to the extent the preamble limits claim 20, it is my opinion that Agarwal teaches a transmission system.

190. Agarwal discloses a "method for the adaptive control of a forward error correction code for transmission over a communication channel which connects the primary interface to a remote interface." Ex. 1004 at 3:66 – 4:3. The disclosed transmission system is shown in Figure 1A, below:

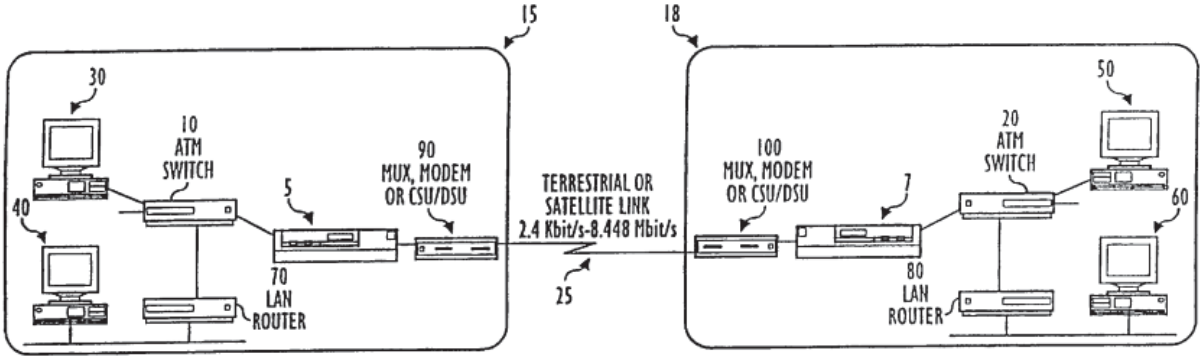


FIG. 1A

Id. at Fig. 1A.

191. Additionally, Agarwal teaches that its invention includes "an apparatus . . . provided in a primary interface for the adaptive control of a forward error correction code for transmission over a communication channel which connects the primary interface to a remote interface." *Id.* at 4:17-21. This apparatus is depicted in Figure 4 below:

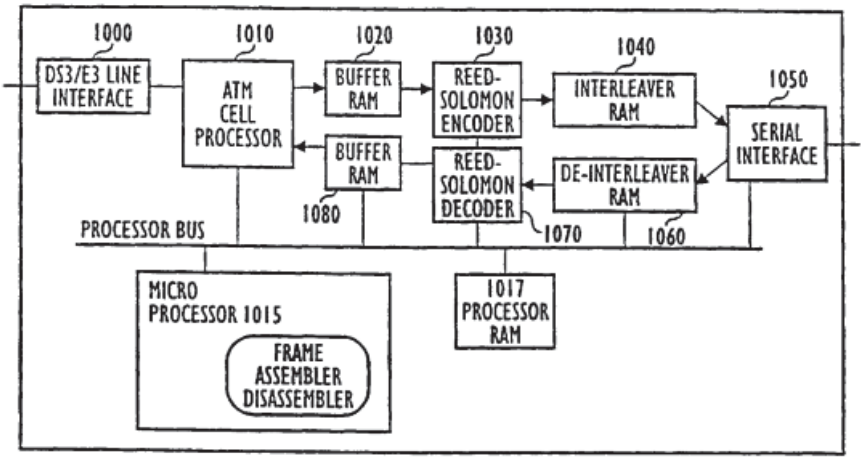


FIG. 4

Id. at Fig. 4.

192. Accordingly, it is my opinion that Agarwal teaches limitation 20[pre].

ii. Limitation 20[a]: a transmission channel to carry data between a transmitter and a receiver/decoder, each communicatively interfaced with the transmission channel;

193. In my opinion, Agarwal teaches a transmission channel which carries data between a transmitter and a receiver/decoder which are communicatively interfaced with the transmission channel.

194. As explained immediately above, Agarwal teaches that forward error correction codes are transmitted "over a communication channel which connects the primary interface to a remote interface." *Id.* at 4:2-3. Agarwal also explains that "the communication channel may be a satellite or wireless communication channel." *Id.* at 4:14-16; *see also id.* at 5:27-31 (describing "means of interconnecting standard ATM switches 10 and 20 over a terrestrial or satellite link 25"). In my opinion, a POSITA would have understood the "communication channel," and the "terrestrial or satellite link 25," disclosed in Agarwal to be "transmission channels."

195. Agarwal further teaches that the communication channel (i.e., transmission channel) carries data between a transmitter and receiver/decoder. Agarwal discloses two interfaces: "interfaces 5 and 7 which each provide a means of interconnecting standard ATM switches 10 and 20 over a terrestrial or satellite link 25 . . ." *Id.* at 5:27-32. These interfaces are referred to as "primary" and "remote" interfaces in Agarwal. *Id.* at 13:22-27, 7:62 – 8:4. Both interfaces "are identical" and operate in the same manner. *Id.* at 13:22-27.

196. In my opinion, a POSITA would have understood the remote interface corresponds to the claimed "transmitter." The remote interface:

> [I]ncludes a frame assembler 115 which forms the frames of a communication signal in accordance with a specific format, an encoder 120 which generates a forward error correction code (i.e. block code) that is included in each frame for error correction of that frame, and an

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> interleaver 125 which interleaves a group of individual frames in order to spread a burst of errors across each frame.

Id. at 5:41-49. These transmitting portions of the remote interface are shown in Figure 1B:

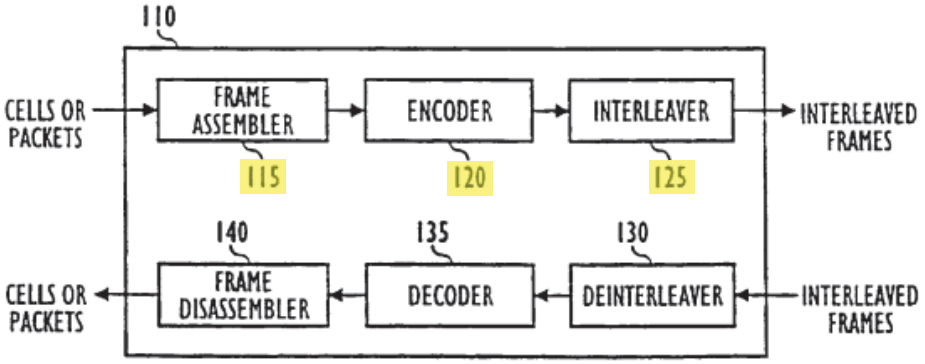


FIG. 1B

Id. at Fig. 1B (highlighted to indicate frame assembler 115, encoder 120, and interleaver 125).

197. Additionally, in my opinion, a POSITA would have understood the primary interface[3] to correspond to the claimed "receiver/decoder". As explained in Agarwal, the primary interface (which has identical functionality as the remote interface):

> [I]ncludes a deinterleaver 130 which deinterleaves an interleaved frame received across a transmission link in order to provide a group of individual frames, a decoder 135 which decodes the forward error

[3] Agarwal also refers to the primary interface as the "receiving interface" in certain embodiments. *Id.* at 7:62 – 8:4.

> correction code of each frame in order to provide error correction for that frame, and a frame disassembler 140 which disassembles a frame into its constituent parts, which may for example include ATM-based cells or packets of compressed ATM cells.

Id. at 5:50-58. These receiving and decoding portions of the remote interface are shown in Figure 1B:

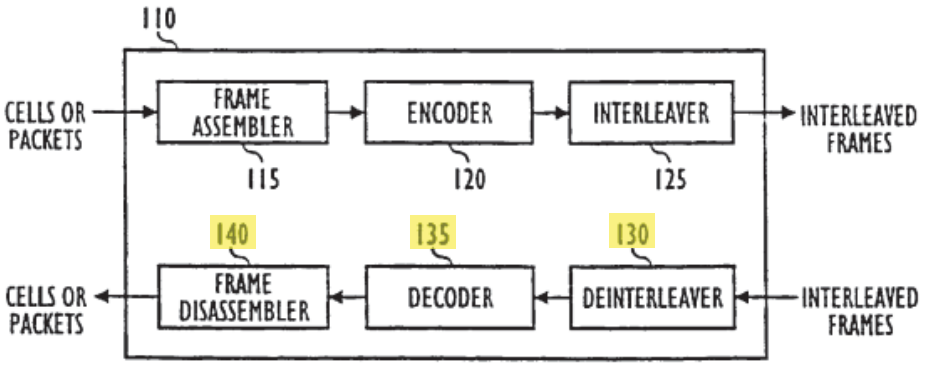


FIG. 1B

Id. at Fig. 1B (highlighted to indicate frame disassembler 140, decoder 135, and deinterleaver 130).

198. Agarwal also explicitly discloses a "decoder," "receiver," and "transmitter" within these interfaces. For example, as shown in Figure 1B above, portion 110 of each interface includes "decoder 135". *Id.* at Fig. 1B, 5:53-54. And Agarwal states that each interface, which includes both receiving and transmitting capabilities, "sets the forward error correction code value of its receiver and its transmitter to a maximum value" prior to synchronization. *Id.* at 8:28-30 (emphasis added).

199. The remote interface (i.e., transmitter) transmits data to the primary interface (i.e., receiver/decoder) over the communication channel (i.e., transmission channel). As shown in Figure 1B interleaved frames (corresponding to "data") are transmitted from the remote interface (i.e., transmitter) to the primary interface (i.e., receiver/decoder):

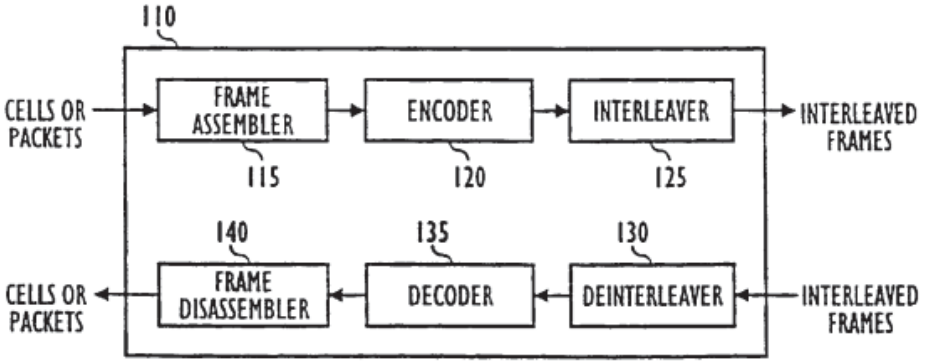


FIG. 1B

Id. at Fig. 1B. Agarwal explains that, when interleaving is utilized, "interleaving technique rearranges the order of the bytes in the interleaved frame and transmits each byte sequentially over a WAN link." *Id.* at 6:24-30 (emphasis added). A POSITA would have understood that these bytes are transmitted from the transmitter to the receiver/decoder and further understood the WAN link to be an exemplary communication channel, as disclosed in Agarwal. Agarwal further explains that the primary interface "receiv[es] bit stream" from the transmitter. *Id.* at 7:20-24; *see also*

id. at 13:22-27 (stating the interfaces process "received communication signals").

Specifically, Agarwal states:

> According to the inventive adaptive coding scheme, the quality of the incoming communication link is continuously measured at a receiving interface (e.g. ATM Link Accelerator), which will be referred to as the primary incoming bit stream transmitted from a remote interface. However, the measurement is not made until after the receiving interface becomes synchronized with the incoming bit stream transmitted from a remote interface. The measurement of the communication link quality is based on the number of byte errors corrected by a decoder which is included in the interface.

Id. at 7:62 – 8:4 (emphasis added). A POSITA would have understood these disclosures to mean that the transmission channel carries data between the transmitter and receiver/decoder taught by Agarwal.

200. Agarwal also teaches that both the "transmitter" and "receiver/decoder" are communicatively interfaced with the transmission channel. As shown in Figure 1A, "interfaces 5 and 7 [] each provide a means of interconnecting standard ATM switches 10 and 20 over a terrestrial or satellite link 25 . . ." *Id.* at 5:27-32; *see also id.* at 5:35-38 ("The interfaces 5 and 7 may connect to the terrestrial or satellite link 25 via modems 90 and 100 . . .").

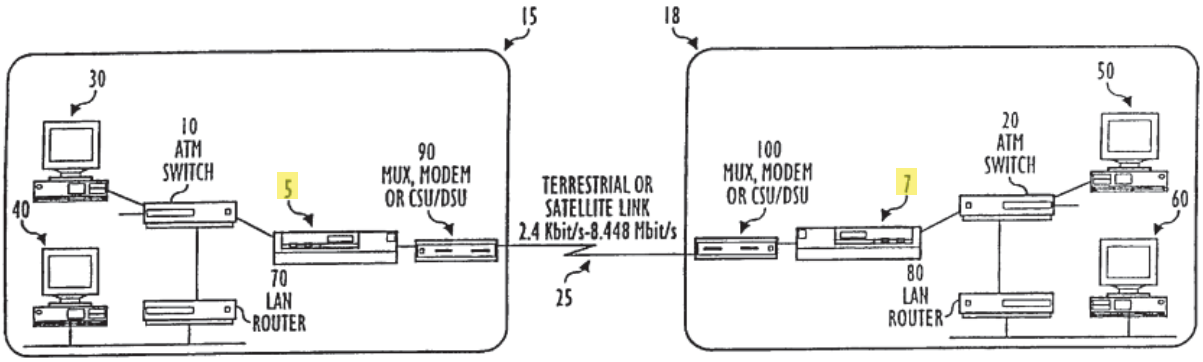


FIG. 1A

Id. at Fig. 1A (highlighted to indicate interfaces 5 and 7). A POSITA would have understood that, based on the teachings of Agarwal, the primary and remote interfaces (i.e., receiver/decoder and transmitter, respectively) are communicatively interfaced with the transmission channel.

201. Accordingly, it is my opinion that Agarwal teaches limitation 20[a].

iii. Limitation 20[b]: a transmission error value monitor communicatively interfaced with the receiver/decoder to periodically monitor for transmission error values indicative of impulse noise events on the transmission channel,

202. In my opinion, Agarwal teaches limitation 20[b]. Agarwal discloses the primary (or receiving) interface is communicatively coupled with a microprocessor which continuously measures byte errors to determine a byte error rate that is indicative of impulse noise events on the communication channel.

203. Agarwal explains that the "quality of the incoming communication link is continuously measured at a receiving interface (e.g. ATM Link Accelerator)" and

"[t]he measurement of the communication link quality is based on the number of byte errors corrected by a decoder which is included in the interface." *Id.* at 7:62 – 8:4. When the primary interface monitors byte errors it performs a calculation to determine the byte error rate based on the transmitted byte errors. *Id.* at 12:33-36, 12:47-50. Agarwal teaches that this is done through Microprocessor 1015 "which runs the algorithms associated with the inventive adaptive coding scheme" and "monitors the value of the coding field of every received frame whose frame number is 0." *Id.* at 12:33-36. Microprocessor 1015 also "will calculate a byte error rate associated with communication signals received by the primary interface via a communication channel." *Id.* at 12:47-50.

204. The byte error rate, calculated by the Microprocessor 1015 after interfacing with the primary interface, corresponds to a transmission error value. A POSITA would have recognized that Microprocessor 1015, therefore, includes a means comprising a transmission error value monitor to monitor byte errors and calculate the byte error rate. Microprocessor 1015 and the primary interface coordinate to monitor byte errors during transmissions and calculate a byte error rate (corresponding to a transmission error value).

205. A POSITA would have further understood that the Microprocessor 1015 is "communicatively interfaced" with the primary interface (i.e., receiver/decoder) as shown in Figure 4:

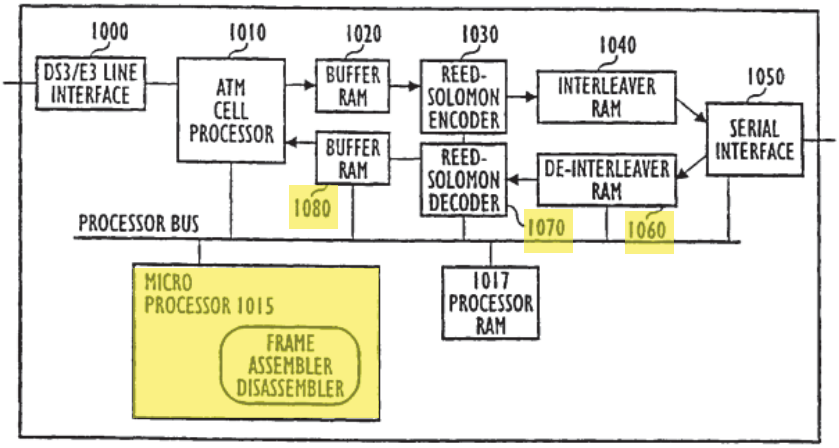


FIG. 4

Id. at Fig. 4 (highlighted to identify Microprocessor 1015 communicatively interfaced with the components of the primary interface, including Buffer RAM 1040, Reed-Solomon Decoder 1070, and De-Interleaver RAM 1060). Agarwal teaches that "Microprocessor 1015 controls the primary interface". *Id.* at 12:56-57. A POSITA would have recognized that Microprocessor 1015, including a transmission error value monitor, is thus communicatively interfaced with the primary interface (i.e., receiver/decoder).

206. Agarwal teaches that transmission errors are "continuously measured at a receiving interface" and "[t]he measurement of the communication link quality

is based on the number of byte errors corrected by a decoder." *Id.* at 7:62 – 8:4 (emphasis added). Additionally, Agarwal explains that byte error ratio is calculated "at a variable interval of, for example, one second." *Id.* at 8:56-57. Agarwal specifically teaches:

> Initially, the primary interface calculates the current bye error ratio (CURRBER) by dividing the total number of corrections made by the forward error correction decoder included in the primary interface during the computational interval (NERRORS) by a total number of bytes received during a computation interval (NBYTES).

Id. at 8:58-63. Additionally, claim 2 of Agarwal recites: "said step of calculating said byte error rate is performed at a predetermined interval based on said byte error rate." *Id.* at claim 2. Thus, the calculations of byte error rate are done periodically, at specific computation intervals.

207. The byte error rate in Agarwal is indicative of a noise event on the communication channel. Agarwal explains that the disclosed communication channels (for example, "wireless and satellite links") "are inherently noisy" and, therefore, there is a desire to "improve the bit error characteristics" of those channels. *Id.* at 2:35-39. To combat this noise, Agarwal teaches calculating the byte error rate to ultimately determine a revised forward error correction code length based on the byte error rate for future transmissions. *Id.* at Abstract. Agarwal details the calculations performed when the primary interface (i.e., receiver/decoder)

determines the byte error rate and BER based on the measured transmitted byte errors. *Id.* at 8:47-55 (explaining the BER "represents the byte error ratio associated with a communication link"), 9:19-10:6. In one embodiment of Agarwal, where forward error correction coding corresponds to Reed-Solomon coding, a table storing inverse BER values is utilized. *Id.* at 10:13-30, Fig. 3. Agarwal discloses that those BER values include a calculated decibel margin to maintain link quality when the level of noise on the transmission channel varies by a set amount. *Id.* at 10:59 – 11:2. Thus, a POSITA would have understood that the byte error rates (i.e., transmission error values) indicate an impulse noise event on the transmission channel.

208. Accordingly, it is my opinion that Agarwal teaches limitation 20[b].

209. Additionally, I explained Starr's teachings of monitoring signal to noise ratio (i.e., a transmission error value) in limitation 20[b] in Ground 1 above. I hereby incorporate my analysis and discussions of limitation 20[b] in Ground 1 by reference.

210. In the combined system of Agarwal and Starr, a POSITA would have understood that the transmission error value monitor of Microprocessor 1015 would monitor both byte error rate—as taught by Agarwal—and signal to noise ratio—as taught by Starr. The signal to noise ratio transmission error value is also indicative

of an impulse noise event on the transmission channel as I explained regarding limitation 20[b] in Ground 1 above. I explain the rationale and motivation to combine Agarwal and Starr in Part VIII.B.2 above.

211. Accordingly, it is my opinion that Agarwal alone and/or Agarwal in view of Starr teaches and/or renders obvious limitation 20[b].

iv. Limitation 20[c]: wherein the transmission error values are periodically monitored after training and initialization on the receiver/decoder,

212. In my opinion, Agarwal teaches limitation 20[c]. As explained above regarding limitation 20[b], Agarwal teaches that transmission error values are periodically monitored. Agarwal also teaches that the primary interface measures byte errors to periodically calculate the byte error rate after synchronization which occurs during training and initialization of the system, including the primary interface.

213. As explained above, Agarwal teaches that the primary (or receiving) interface, communicatively interfaced with Microprocessor 1015, measures byte errors and calculates the byte error rate to determine the quality of the communication link. *Id.* at 7:62 – 8:4. "However, the measurement is not made until after the receiving interface becomes synchronized with the incoming bit stream transmitted from a remote interface." *Id.* at 7:64 – 8:1 (emphasis added). Agarwal

teaches that this synchronization process is "need[ed]" to "ensure[] that no frames are lost during the changing of forward error correction codes." *Id.* at 8:22-27. Before synchronization occurs, the disclosed system "sets the forward error correction code value of its receiver and its transmitter to a maximum value which assumes worst case scenario (i.e. the communication signals are being transmitted during inclement whether [sic])." *Id.* at 8:28-33; *see also id.* at 7:21-25 ("If the receiving interface is not yet synchronized to its receiving bit stream, the coding field 268 is set to a predetermined value (e.g. 0xF).").

214. A POSITA would have understood that the synchronization process occurs as part of the training and initialization of the primary interface. For example, in communication systems with a transmitter and receiver, the first steps performed would be the initial boot of the system, initialization and completion of any system training, including synchronizing the transmitter and receiver such that data could be exchanged. *See, e.g.,* Ex. 1013 at Figs. 2-4, 5:61-66, 6:22-27, 7:8-26 (describing the typical initialization procedure where the "steady state communication link is only established after completion of the initialization steps" and when there is a loss of synchronization between transceivers, the system must complete initialization—including training—to allow for re-synchronization). A POSITA would have known that user data cannot be transmitted in the system prior to training and initialization,

nor prior to synchronization, as is taught by Agarwal. Thus, Agarwal discloses that the periodic monitoring of transmission error values—which explicitly occurs after synchronization—occurs after training and initialization of the receiver/decoder. Additionally, in my opinion, it would have been obvious to a POSITA to ensure initialization and training were complete prior to exchanging data and monitoring transmission errors in Agarwal's system.

215. In the combined Agarwal-Starr system, a POSITA would have recognized that monitoring SNR (as taught by Starr) would have occurred after training and initialization at the primary interface for the same reasons as explained immediately above. I explain the rationale and motivation to combine Agarwal and Starr in Part VIII.B.2 above.

216. Accordingly, it is my opinion that Agarwal alone and/or Agarwal in view of Starr renders obvious limitation 20[c].

v. Limitation 20[d]: the transmission error values being selected from a group comprising: a bit error rate, errored seconds, errored minutes, code violations over a fixed period of time, Signal-to-Noise Ratio (SNR) measured at the receiver/decoder, and Transmission Control Protocol and Internet Protocol (TCP/IP) throughput,

217. In my opinion, Agarwal teaches limitation 20[d]. Agarwal teaches that the transmission error values are byte error rates which correspond to a bit error rate.

As explained above, Agarwal discloses that its primary interface decoder measures byte errors to calculate the byte error rate. *Id.* at Fig. 5, 8:2-4. In addition, Agarwal teaches that "byte error rate" is calculated by Microprocessor 1015 as taught in Figure 5:

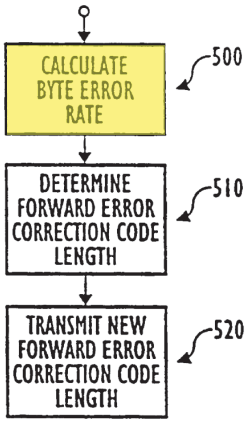


FIG. 5

Id. at Fig. 5 (highlighted to indicate that the first step of the disclosed method is calculating the "byte error rate"); *see also id.* at Abstract ("calculating a byte error rate associated with communication signals received by the first terminal"), 4:4-28 (same); *id.* at claims 1-3, 14.

218. A POSITA would have understood the byte error rate to correspond to a bit error rate. Agarwal itself acknowledges this correspondence as it states that its invention uses adaptive coding "to determine the proper amount of forward error-correction on a real-time basis in accordance with the number of bit errors detected in the receive link." *Id.* at 5:67 – 6:4 (emphasis added). Additionally, Agarwal

explains the relationship between the byte error ratio and bit error ratio: "The bit error ratio is approximately equal to BER divided by eight." *Id.* at 8:52-53. A POSITA would have known a similar conversion could be done to equate bit error rate to byte error rate. Additionally, a POSITA would have understood the relationship between bit error ratio and byte error ratio (i.e., division of eight) and would have considered the byte error rate of Agarwal to correspond to the bit error rate as claimed in the '996 Patent. A POSITA would have found it obvious to determine the bit error rate (as opposed to byte error rate) based on the teachings of Agarwal.

219. Accordingly, it is my opinion that Agarwal teaches and/or renders obvious limitation 20[d].

220. Additionally, as explained regarding limitation 20[b] above, Starr teaches a transmission error value of SNR. Ex. 1005 at 2:37-39, 5:10-26. Starr also explains that the signal to noise ratio monitor 72 is coupled to the receiver/decoder 40. *Id.* at Fig. 4. Similarly, Agarwal teaches that "the quality of the incoming communication link is continuously measured at the receiving interface". Ex. 1004 at 7:62-64 (emphasis added). Thus, a POSITA would have understood that in the combined Agarwal-Starr system, SNR is measured by Microprocessor 1015

(including a transmission error value monitor) at the receiver/decoder. I explain the rationale and motivation to combine Agarwal and Starr in Part VIII.B.2 above.

221. Accordingly, it is my opinion that Agarwal alone and/or Agarwal in view of Starr renders obvious limitation 20[d].

vi. Limitation 20[e]: and wherein the transmission error value monitor to further generate an input signal based on the transmission error values monitored; and

222. In my opinion, Agarwal teaches limitation 20[e]. Agarwal discloses that Microprocessor 1015 (which includes the transmission error value monitor) necessarily generates an input signal based on the measured byte errors and calculated byte error rate. This input signal is transmitted to the remote interface (i.e., transmitter).

223. Agarwal discloses:

> Once the measurement is complete, the primary interface calculates the appropriate amount of forward error correction coding for the measured communication link quality, Subsequently, the primary interface stores the calculated forward error correction code and transmits this information to the remote interface.

Id. at 8:5-10 (emphasis added). Agarwal further discloses "means for determining a forward error correction code length of the forward error correction code based on the byte error rate." *Id.* at 4:25-27; *see also* Fig. 3, 9:22-25 (showing the correlation between BER and forward error correction code length).

224. Agarwal specifies that the byte error rate is calculated by Microprocessor 1015 which determines the forward error correction code length based on that byte error rate. *Id.* at 12:47-55. The Microprocessor 1015 then "controls the primary interface to transmit the new forward error correction code length to the remote interface over the communication channel." *Id.* at 12:56-59. This step is depicted in Figure 5:

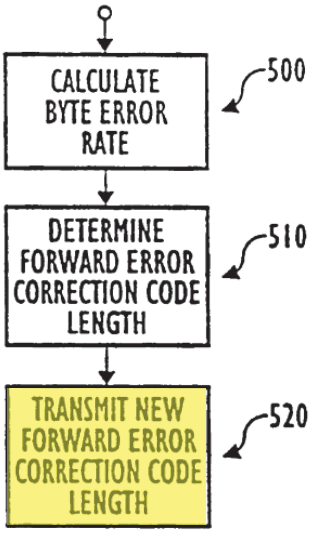


FIG. 5

Id. at Fig. 5 (highlighted to indicate step 520, transmission of a new forward error correction code length).

225. A POSITA would have understood that determining the forward error correction code length of the forward error correction code based on a byte error rate and transmitting the new forward error correction code length corresponds to

generating an input signal based on the transmission error values monitored. A POSITA would have further understood this is disclosed by Agarwal. Agarwal explains that the transmitted "forward error correction code" includes a transmission signal sent from the remote to the primary interface. *Id.* at 8:11-14. A POSITA would have likewise recognized that the primary interface's transmission of the forward error code correction length to constitute an input signal. Thus, the primary interface and Microprocessor 1015 (i.e., the transmission error value monitor) generates the transmission of the forward error correction code length (i.e., input signal) based on the byte error rate (i.e., transmission error values).

226. Although it is my opinion that Agarwal discloses this limitation, to the extent Agarwal does not explicitly teach an "input signal," the input signal is explicitly disclosed in Starr. I explained Starr's teachings of an input signal in limitation 20[e] in Ground 1 above. I hereby incorporate my analysis and discussions of limitation 20[e] in Ground 1 by reference.

227. In the combined system of Agarwal and Starr, a POSITA would have understood that when Microprocessor transmits a new forward error correction code length (at step 520 of Figure 5), that step would include generating an input signal indicative of that new forward error correction code length. Additionally, a POSITA would have understood that the input signal would be based on the byte error rate of

Agarwal or SNR of Starr (i.e., transmission error values). I explain the rationale and motivation to combine Agarwal and Starr in Part VIII.B.2 above.

228. Accordingly, it is my opinion that Agarwal alone and/or Agarwal in view of Starr renders obvious limitation 20[e].

vii. Limitation 20[f]: a controller coupled with the transmitter to receive the input signal from the transmission error value monitor and to further generate a retransmission overhead control signal of the transmitter in response to the input signal.

229. In my opinion, Agarwal discloses limitation 20[f]. Agarwal teaches a microprocessor (i.e., controller) coupled with the remote interface (i.e., transmitter) which receives the input signal from the primary interface. Additionally, Agarwal implicitly discloses that the Microprocessor 1015 generates a retransmission overhead control signal for the remote interface corresponding to the corrected forward error code length that the remote interface uses to adaptively generate the next forward error correction code.

230. Agarwal teaches that "the primary interface stores the calculated forward error correction code [length] and transmits this information to the remote interface." *Id.* at 8:8-10. Agarwal also explains that "the remote interface receives this information." *Id.* at 8:8-11. As explained above, the primary interface is coupled to the transmission error value monitor (in Microprocessor 1015) and the

transmission of the forward error correction code length corresponds to the input signal.

231. Agarwal also teaches Microprocessor 1015, which is a controller, is coupled with the transmitter (i.e., remote interface), as depicted in Figure 4[4]:

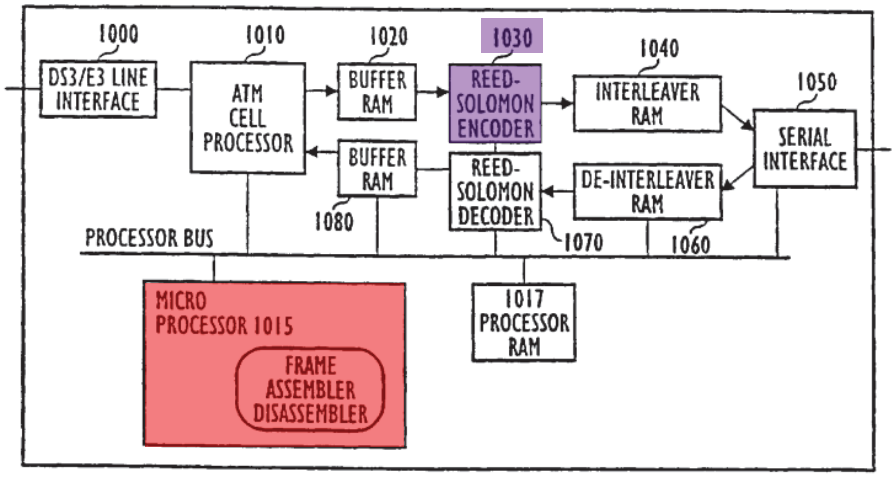


FIG. 4

Id. at Fig. 4 (highlighted to identify Microprocessor 1015 (in red) and Reed Solomon Encoder 1030 (in purple) which is part of the remote interface). Agarwal teaches that "the Reed-Solomon Encoder 1030 [is] under the control of the Microprocessor 1015". *Id.* at 12:13-14. Thus, a POSITA would have understood, based on the

[4] While Agarwal states the Figure 4 depicts an exemplary primary interface (*id.* at 11:51-53), Agarwal also explains that "the primary and remote interfaces are identical." *Id.* at 13:22-24. Thus, my discussion of Figure 4 and the corresponding disclosures regarding Microprocessor 1015 are framed in regard to the remote interface (i.e., transmitter).

disclosures of Agarwal that the Microprocessor 1015 (i.e., controller) is coupled to the transmitter, which includes the encoder.

232. Agarwal also teaches that "[a]fter the remote interface receives [the forward error correction code length transmission], it transmits signals including a forward error correction code having more or less forward error correction coding bytes in accordance with the information provided by the primary interface." *Id.* at 8:11-14. So, after the input signal is received by the transmitter, "the next frame having a number of 0 and all frames thereafter will be transmitted using the new Reed-Solomon code length." *Id.* at 12:56-59. Or, as Agarwal specifically explains in the same Reed-Solomon embodiment:

> An Interleaver RAM 1040 receives the output of the Reed-Solomon Encoder 1030 under the control of the Microprocessor 1015 in order to form an interleaved frame in the manner described above. Following the interleaving process, the interleaved frame is output by the Interleaver RAM 1040 to a Serial Interface 1050 for transmission to a receiving apparatus over a WAN via a modem, for example.

Id. at 12:12-17.

233. A POSITA would have known that a control signal is an instruction from the controller to the transmitter to change the forward error correction code value based on the new code length. A POSITA would have recognized that, in order for the transmitter to apply the new forward correction code length received from the primary interface and transmit signals corresponding to the new forward error

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correction code value, Microprocessor 1015 must instruct the transmitter (i.e., remote interface) to employ the new forward correction code length (i.e., from the received input signal). A POSITA would have understood this instruction to be a control signal. Moreover, this control signal is necessarily a retransmission overhead control signal as it instructs the transmitter to adjust the forward error correction coding to decrease the overhead associated with retransmission, as explained in Ground 1.

234. Accordingly, it is my opinion that Agarwal renders obvious limitation 20[f].

235. To the extent Agarwal does not explicitly disclose the retransmission overhead control signal, in my opinion, Agarwal in view of Starr renders obvious limitation 20[f]. Starr explicitly teaches "The controller 50 provides an adaptive interleave control signal 58 (step 312) in response to the input signals 68, 78." Ex. 1005 at 8:50-52.

236. As shown in Figure 1, Starr teaches a controller including "means for providing adaptive interleave control signal":

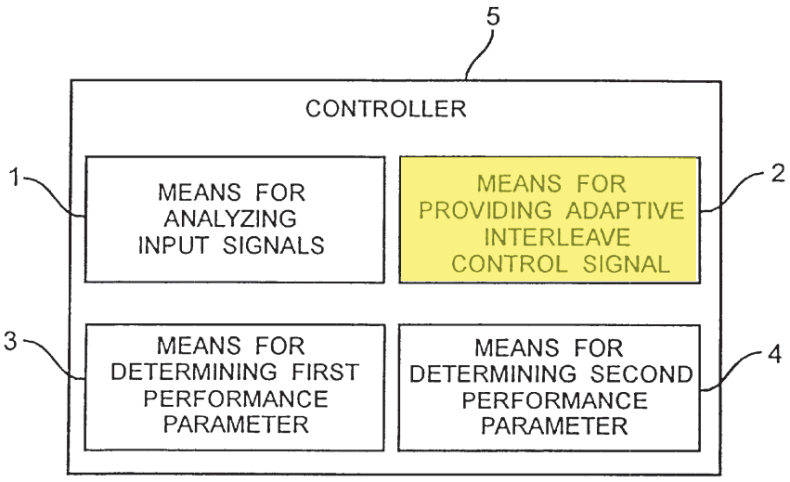


Fig. 1

Id. at Fig. 1 (highlighted). Similarly, Figure 3 depicts the connection between the means for providing the control signal with the adaptive interleaver, which is communicatively coupled to the transmitter:

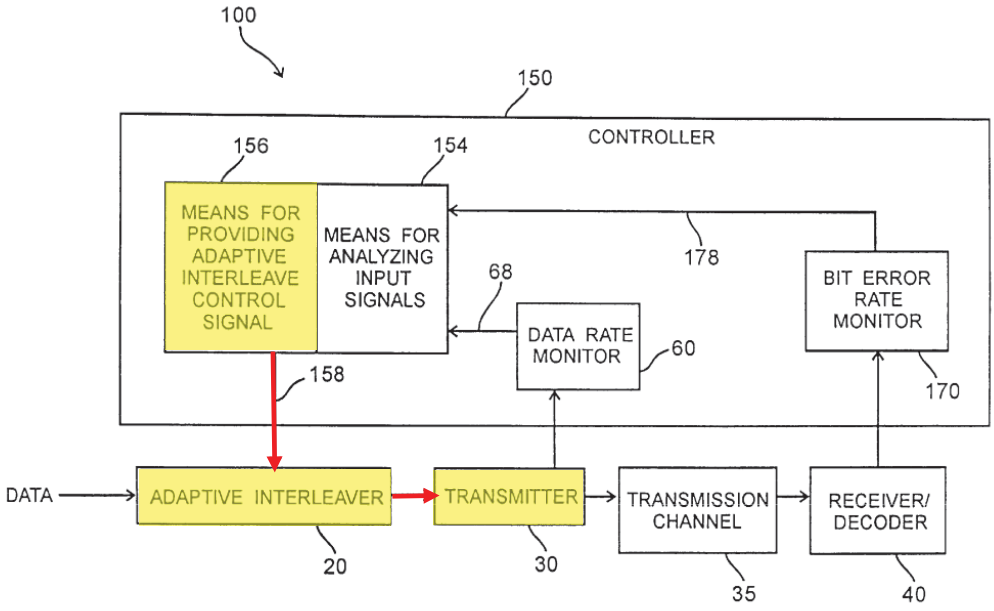


Fig. 3

Id. at Fig. 3 (highlighted to show the means for providing the control signal 156, adaptive interleaver 20, and transmitter 30, and communicative coupling between them).

237. Starr discloses that the controller can "generate an adaptive interleave control signal . . . that controls the adaptive interleaver" and "causes the adaptive interleaver 20 to implement and interleave depth that is proportional to the SNR, BER, data rate or combination thereof." *Id.* at 9:18-25. In another embodiment, Starr specifically teaches that the control signal "can be based in-whole or in-part on the BER." *Id.* at 7:66-8:5; *see also id.* at 7:44-48 (teaching a control signal based in whole or in part on the SNR). Thus, Starr teaches that the controller generates a control signal which controls the adaptive interleaver (i.e., transmitter in Starr) to implement a new interleave depth based on BER or SNR. It would have been obvious to a POSITA to use the control signal taught by Starr such that the transmitter in Agarwal-Starr applies the new forward correction code length received from the primary interface to transmit signals corresponding to the new forward error correction code value via a control signal. This control signal is a retransmission overhead control signal as it instructs the transmitter to adjust the forward error correction coding to decrease the overhead associated with retransmission.

238. A POSITA would have been motivated to combine the teachings of Agarwal and Starr for the reasons discussed in Part VIII.B.2 above.

239. Accordingly, it is my opinion that Agarwal in view of Starr renders obvious limitation 20[f].

240. For the foregoing reasons, it is my opinion that Agarwal alone and/or Agarwal in view of Starr renders obvious each limitation of claim 20.

IX. NO SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

241. I am informed by counsel that evidence of secondary considerations of non-obviousness are considered when determining whether a patent is invalid as obvious. I understand that secondary considerations include: (1) an invention's commercial success; (2) a long-felt, but unmet, need; (3) failure of others; (4) professional skepticism; (5) industry praise; (6) copying; (7) unexpected results; and (8) any other relevant consideration. I also understand from counsel that it is Patent Owner's burden to demonstrate the existence of secondary considerations.

242. I understand from counsel that the Patent Owner in the related district court litigation has not affirmatively identified any evidence with respect to secondary considerations of non-obviousness. To the extent that the Patent Owner subsequently identifies any other evidence of non-obviousness, I reserve the right to consider and revise any of my opinions if necessary.

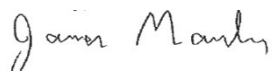
X. CONCLUSION

243. For at least the preceding reasons, in my opinion, claim 20 of the '996 Patent would have been obvious to a person of ordinary skill in the art at the time of invention based on the prior art references that I have cited and analyzed above.

244. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in this proceeding. If required, I will appear for cross-examination at the appropriate time. I reserve the right to offer opinions relevant to the invalidity of the '996 Patent claims and/or offer testimony in support of this declaration.

245. I hereby declare that all statements made herein of my own knowledge are true and that all statements are made on information and belief and believed to be true. Furthermore, these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Dated: September 16, 2024 Respectfully submitted,



James Martin, Ph.D.

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APPENDIX A

RESUME – James Martin

PERSONAL DATA

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EDUCATION

Ph.D., North Carolina State University, 1999, Electrical Engineering (dissertation topic: end-to-end congestion avoidance for TCP, first to introduce and evaluate delay-based TCP)
M.S., Arizona State University, 1989, Computer Science
B.S., University of Illinois (Champaign/Urbana), 1983, Electrical Engineering

PROFESSIONAL EXPERIENCE

Clemson University, 2023-, Professor Emeritus, Clemson University Emeritus College.
Clemson University, 2020-2023, Professor of Computer Science.
Clemson University, 2008-, Associate Professor of Computer Science.
Clemson University, 2002-2008, Assistant Professor of Computer Science.
Gartner, 2000 to 2002, consultant for Gartner Consulting Group. Office focused on telecommunications strategy and technology assessments. Engagements included network analysis studies, cybersecurity assessments, technical white papers for ISPs.
IBM Corporation, 1991 to 2000, Software Engineer. Contributions include Systems Network Architecture (SNA) architecture extensions: SNA over async, RTP (Rate-based Transport Protocol), Performance study of RTP and delay-based TCP, Device drivers for Unix and OS/2, team leader for the IBM Firewall product (AIX, OS/2).
Filenet Corporation, 1989 to 1991, Unix kernel/application developer, performance study their proprietary hardware/software platform (an image storage work flow product).
Motorola Government Electronics Division, 1983 to 1989, design engineer. Developed hardware and software for military communications systems.

CONSULTING EXPERIENCE

MIT Lincoln Labs, 2019-, Performance analysis of MAC protocols for multibeam directional radios, exploration of emerging content-centric networking systems for future tactical edge environments.
Comcast Corporation, 2022, Technical guidance in areas related to DOCSIS.
Cox Communications, 2020-2021, Modeling and analysis of low latency enhancements for DOCSIS 4.0.

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BitRipple, 2020-2021, Technical guidance, Linux system performance, Board Member.
Vecima Corporation, 2017, Modeling and analysis of DOCSIS 3.1 standards using the open source ns2 simulator.
Cox Communications, 2013, Modeling bandwidth/spectrum consumption in emerging DOCSIS 3.0 based cable networks.
CableLabs, 2012, Modeling and analyzing the DASH streaming protocol over cable networks.
Cox Communications, 2010-2011, Network performance analysis.
CableLabs, 2009-2010, analyzing effects of buffer management techniques operating at upstream queues in a cable modem.
The South Carolina Educational Broadband Service Commission, 2008-2010, served as a technical expert to SC's statewide broadband wireless project.
CableLabs, 2006-2008, evaluated the impact of peer-to-peer traffic on Voice-over-IP in broadband cable networks.
South Carolina's Coalition for Mathematics and Science, South Carolina Department of Education (Math and Science Unit), 2006, provided technical assistance to select and deploy web collaboration tools.
CableLabs, 2005-2006, cable network traffic modeling and protocol evaluation. First to suggest the concept of two-queue AQM which evolved to the current low latency DOCSIS enhancement to DOCSIS3.1/4.0.
Expert Witness/Consultant to law firms, multiple engagements with different law firms serving as a technology advisor, an expert consultant or an expert witness supporting law teams on Intellectual Property disputes.

OTHER ORGANIZATIONS

SEMPRE, Inc., Advisory Role, 2021-2023.
BitRipple Inc., Advisory Board Member, 2020-2021.
CableLabs Inc, Advisory Role, contributor to DOCSIS 3.0 and 3.1 standards
WiMAX Forum, member and contributor to standards, 2006 – 2009.

MEMBERSHIPS

Member Association for Computing Machinery, ACM, (1989-).
Member IEEE and IEEE Communications Society, (1989-).
Member UPE (CS Honor Society), (1989-).

PUBLICATIONS

Book Chapters:

F. Jackson, R. Amin, Y. Fu, J. Gilbert, J. Martin, "A User Study of Netflix Streaming", *SpringerLink Lecture Notes in Computer Science*, vol. 9186, pp. 481-489 (2015).

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A. Bhargava, J. Martin, S. Babu, “Comparative Evaluation of User Perceived Quality Assessment of Design Strategies for HTTP-Based Adaptive Streaming”, *ACM Transactions of Applied Perception*, 16(4), 22:1-22:20 (2019).

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M. Toy, J. Martin, M Schmitt, V. Blaked, "Next generation cable networks with DOCSIS 3.1 technology", Guest Editorial, *IEEE Communications Magazine 53(3)*, 106-107 (2015).

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Jiong Gong, David Reed, Terry Shaw, Daniel Vivanco, Jim Martin, "QAM Resource Allocation in Mixed-Format VoD Systems", *Journal of Communications*, 2(1), 1-9 (2007).

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Amin, R., Jackson, F., Gilbert, J.E., Martin, J., & Shaw, T., “Assessing the Impact of Latency and Jitter on the Perceived Quality of Call of Duty Modern Warfare 2” , *Proceedings of the 15th International Conference (HCI International 2013),* (Las Vegas, NV, July 2013).

K. Xu, R. Izard, K. Wang, J. Martin, “Cloud-based Handoff as a Service for Heterogeneous Vehicular Networks with OpenFlow (short paper)”, *Proceedings of the GENI Research and Educational Experiment (GREE2013)*, (Salt Lake City UT, March 2013).

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G. Hong , J. Martin, S. Moser, J. Westall, "Fair Scheduling on Parallel Bonded Channels with Intersecting Bonding Groups", *Proceedings of the IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (Mascots),* (Washington DC, August 2012).

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R. R. Brooks, K.-C. Wang, J. Martin, K. Cameron, J. Deng, and L. Yu, “WiMAX: Bandwidth Contention Resolution – Vulnerability to Denial of Service Attacks,” *Proceedings of the First GENI Research and Educational Experiment Workshop*, (Los Angeles, CA, March 2012).

A. Hussien, A. Eltawil, R. Amin and J. Martin, “Energy Aware Task Mapping Algorithm For Heterogeneous MPSoC Based Architectures”, *Proceedings of International Conference on Computer Design (ICCD)*, (Montreal, Quebec, October 2011).

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A. Swaminathan, J. Martin, "Fairness Issues in Hybrid 802.11b/e Networks*",* *Proceedings of the IEEE Consumer Communications and Networking Conference*, (Las Vegas, NV, January 2006).

R. Geist, J. Martin, J. Westall, V. Yalla, "Performance Tuning of Gigabit Network Interfaces*", Proceedings of the 31st Annual International Conference of the Computer Measurement Group (CMG 2005),* (Orlando, Florida, December 2005).

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R. Geist, J. Martin, J. Westall, "Small Aggregations of ON/OFF Traffic Sources", *Proceedings of the IASTED International Conference on Communication and Computer Networks*, (Boston, MA, November 2004).

S. Biyani, J. Martin, "A Comparison of TCP-Friendly Congestion Control Protocols", *Proceedings of the International Conference on Computers Communications and Networks 2004*, (Chicago, IL, October 2004).

J. Martin, "The Interaction Between the DOCISS 1.1/2.0 MAC Protocol and TCP Application Performance", *Proceedings of the International Working Conference on Performance Modeling and Evaluation of Heterogeneous Networks*, (Ikley, UK, July 2004).

J. Martin, "Managing Best Effort IP Networks over Heterogeneous WANs", *Proceedings of the International Working Conference on Performance Modeling and Evaluation of Heterogeneous Networks*, (Ikley, UK, July 2004).

J. Martin, N. Shrivastav, "Modeling the DOCSIS 1.1/2.0 MAC Protocol", *Proceedings of the 2003 International Conference on Computer Communications and Networks*, (Dallas TX, October 2003).

J. Martin, A. Nilsson, "On Service Level Agreements for IP Networks", in *Proceedings of INFOCOM*, (New York, New York, July 2002).

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J. Martin, A. Nilsson, I. Rhee, "The Incremental Deployability of RTT-based Congestion Avoidance for High Speed TCP Internet Connections", in *Proc. of ACM SIGMETRICS 2000, International Conference on Measurement and Modeling of Computer Systems* (ACM SIGMETRICS), (Santa Clara, CA, 2000).

J. Martin, A. Nilsson, "On Congestion Avoidance for TCP/IP Networks", *Proceedings of the 15th IFIP World Computer Congress*, (Budapest, Hungary, 1998).

J. Martin, A. Nilsson, "Congestion Control in HPR", in *Proceedings of IEEE GLOBECOM,* (Phoenix, AZ, 1997).

Technical Reports (available at https://people.cs.clemson.edu/~jmarty/papers/papers.html) :

J. Martin, G. Comert, M. Kaur, A. Alsuhaim, "Uncertainty Quantification of Cyber Attacks on Connected Vehicles and Infrastructure (Part 1)", United States Department of Transportation, National Transportation Library, Report #56057, Available online at https://rosap.ntl.bts.gov/view/dot/56057, June, 2020.

J. Martin, KC Wang, I. Seskar, "SciWiNet: Evaluating the Efficacy of a Mobile Virtual Network Operator for the Research Community – Project Report", August, 2017. Available online: https://people.cs.clemson.edu/~jmarty/papers/SciWiNetProjectRecap.pdf

J. Martin, Y. Fu, G. Hong, "On the Efficacy of the Dynamic Adaptive Streaming over HTTP (DASH) Protocol - Extended Version", April, 2013.

J. Martin, M. Westall, R. Amin, "Mulicasting Video in Dense 802.11g Networks Using Application FEC", 2010

J. Westall, J. Martin, "An Introduction to Galois Fields and Reed-Solomon Coding", October 2010.

M.Bidwell, "MAC Layer DoS Vulnerabilities", 2006

J. Martin, A. Nilsson, "A Comparison of RTP and TCP/Reno Transport Protocols", IBM TR 29.2337, December 1997.

J. Martin, A. Nilsson, "The Evolution of Congestion Control in TCP/IP networks", IBM TR 29.2277, June 1997.

J. Martin, "Optimal MultiLink Transmission Group Scheduling Algorithms, IBM TR 29.1967, August 1997.

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AWARDS

January 30, 2020, **Informal recognition** by Clemson students through results from the National Education Benchmarking Assessment Survey as "**a faculty who has made a positive difference to them during their time at Clemson University"**

Award, Wiley Publisher for my **services to Transactions on Emerging Telecommunications Technologies**, July 2019.

Best paper award : K. Chen, Xin Xing, Mijanur Rahaman Palash, Jianwei Liu, and James Martin, "Improving Wireless Network Performance under MPTCP based Multipath Access", *Proceedings of the 43nd IEEE Conference on Local Computer Networks* (October 2018) **[best paper award: 1 out of 45].**

Clemson University **Board Of Trustees Award** for Excellence, received 2/8/18.

Three **IBM Faculty Awards**: 2004, 2013, 2015.

Competition Winner: Winner of Department of Transportation's Connected Vehicle Technology Challenge, June 2011, http://connectedvehicle.challenge.gov/submissions.

PRESENTATIONS

"Thoughts on a LEO Satellite Mesh Network for Broadband Access", Invited Talk, SpaceX, March 2020.

"Emerging Application Systems and the Need for the Citizen's Wireless Internet (CWI)", Invited Talk MIT Lincoln Labs, June 2019.

"USIgnite: "Enabling Connected Vehicle Applications Through Advanced Networking" Floor Demo, *USIgnite Application Summit*, Austin TX, June 2017.

"ThinGs In a Fog (TGIF): A Framework to Support MultiDomain Research in the Internet of Things", Presented at the *CAIDA Workshop on Active Internet Measurements (AIMS2017)*, March 2017.

"Enabling Connected Vehicle Research in a Campus Environment", Presented at *GENI Network Innovators Community Event, (GENI/NICE),* December 2016.

"USIgnite: "Enabling Connected Vehicle Applications Through Advanced Networking" Floor Demo, *USIgnite Application Summit, Co-Located with Smart Cities Innovation s Summit*, Austin TX, June 2016.

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"Software Defined Networks for Connected Vehicles", *Presented at the 5'th Annual Automotive Summit*, Greenville, SC, Febuary 2016.

"Enabling Connected Vehicle Applications Through Advanced Networking", Presented at the Cellular Wireless Research Updates, *GENI/Network Innovators Community Event (GENI/NICE)*, November 2015.

"SciWiNet: A Large Scale Wireless Testbed for the Academic Community", Presented at the *CAIDA Workshop on Active Internet Measurements (AIMS2014)*, March 2014.

"SciWiNet: a Science Wireless Network for the Research Community", *4G LTE for Research Panel, Mobicom 2013*, October 2013.

"Building Cooperative Heterogeneous Wireless Networks With Re-Configurable Devices", *Keynote at Workshop on Cooperative Heterogeneous Networks (coHetNet)*, ICCCN 2011, August 2011.

"Evaluating IEEE 802.16 Broadband Wireless as a Communications Infrastructure for Public Safety Activities", Presented at the *International Association of Chiefs of Police 32nd Annual Law Enforcement Information Management Training Conference*, Nashville, TN, May 2008.

"Public Safety Requirements for WiMAX", *WiMAX Forum, Application Architecture Working Group*, Washington DC, April 2007.

"Modeling a MAC Scheduler: Experiences with a DOCSIS Cable Network Simulation Model", *WiMAX Forum, Application Architecture Working Group*, San Deigo, CA, July 2006.

"Understanding the Impact of BitTorrent on Cable Networks", *National Cable and Telecommunication Association's National Show*, Atlanta, GA, April 2006.

"DOCSIS Performance Issues", *National Cable and Telecommunication Association's National Show*, San Francisco, CA, April 2005.

PATENTS

An Optimal Multilink Scheduling Algorithm, United States, patent number 6178448, granted January 23, 2001.

Adapting Receiver Thresholds to Improve Rate-Based Flow Control, United States, patent number 6657954, granted December 2, 2003.

Optimal Link Scheduling for Multiple Links, United States, patent number 6862618, granted March 1, 2005.

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SPONSORED RESEARCH

Current Funding:

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Past Funding:

"Network and Compute System Requirements for Ultra-reliable, Low Latency Applications Systems", MIT Lincoln Labs, Principal Investigator, $230,000 (August 15 2019 – May 15 2022).

"CPS:Synergy: Security of Distributed Cyber-Physical Systems with Connected Vehicle Applications", NSF, Co-PI (P. Pisu PI, R. Brooks Co-PI), $998,581 (November 2015 - December 2020).

"US Ignite: Track 1: Enabling Connected Vehicle Applications through Advanced Network Infrastructure", NSF, Principal Investigator, (R Chowdhury, K. Wang Co-PIs), $598,582 (September 2015 – December 2020).

"Uncertainty Quantification of Cyber Attacks on Intelligent Traffic Signals", US DOT, Regional Center for Connected Multimodal Mobility, Principal Investigator, $67,500 (Oct 2017 – December 2020).

"Extreme Orange: Engaging Clemson Students in Systems of Discovery", IBM Faculty Award, Principal Investigator, (E. Kraemer, J. McClendon Co-PIs), $200,000 (August 2015 -December 2019).

"DOCSIS 3.0/3.1 Studies", Huawei Corporation, Principal Investigator, $199,000 (August 2013 - December 2016).

"EAGER: Collaborative Research: SciWiNet: a Science Wireless Network For the Research Community", NSF, Principal Investigator (KC Wang Co-PI), $298,090 (August 2013 – December 2016).

"Understanding and Optimizing Dynamic Adaptive Streaming over HTTP in the Internet", Comcast Corporation, Principal Investigator, $95,000 (August 2013 – August 2016).

"Using Apache Virtual Classroom Lab (VCL) for Networking/Systems/Security Courses at Clemson University", IBM Faculty Award, Principal Investigator, $30,000 (June 2013 – December 2015).

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"GENI Spiral 3 : GENI WiMAX at Clemson", NSF, Co-PI (KC Wang PI), $300,000, (January 2011 – December 2015).

"Assessing Perceived Quality of Dash-Based IPTV Broadcasts: Methods and Human Factors", Intel Research , Co-PI, (J. Gilbert PI), $50,000, (June 2013 - December 2014).

"Assessing Perceived Quality of Dash-Based IPTV Broadcasts: Methods and Human Factors", CableLabs Research Grant, Principal Investigator, (J. Gilbert Co-PI), $50,000, (June 2012 - December 2013).

"Developing the CyberInfrastructure to Support the Emerging Smart Grid", IBM Faculty Award, Principal Investigator, $20,000, (September 2011 – December 2012).

"Correlating the Perceived Quality of Networked Games to Broadband Cable Network Design Parameters", CableLabs Research Grant, Principal Investigator, (J. Gilbert Co-PI), $30,000, (May 2011 - May 2012).

"Broadcasting Video Content in Dense 802.11g Sports and Entertainment Venues", Cisco Research Grant, Principal Investigator (M. Westall Co-PI), $95,000, (August 2010 – December 2012).

"EAGER:Collaborative:Towards a Unified Wireless Network Involving Reconfigurable Devices", NSF, Principle Investigator, $75,000, (September 2009 – September 2011).

iTiger, internally funded CyberInfrastructure research project $150,000 plus equipment donations from Cisco ($150,000) and Apple $50,000, (Jan 2008 – December 2009).

"DOCSIS 3.0 Scheduling Algorithms", Cisco Research Grant, Principal Investigator, (M.Westall Co-PI), $98,000, (August 2007 – December 2011).

"CableLabs DOCSIS Research", CableLabs Corporation, Principal Investigator, $14,630, (May 2007 – December 2007).

"Evaluation XEN and Microsoft Virtual Server", BMW Corporation, Principal Investigator, (S. Goasguen Co-PI), $12,000, (January 2007 - December 2007).

DELL Equipment Grant, Co-PI (S. Goasguen PI), $20,000, (December 2006).

"Evaluating IEEE 802.16 Broadband Wireless as a Communications Infrastructure for Public Safety Activities", Department of Justice National Institute of Justice, Principal Investigator, (M. Westall Co-PI), $300,000, (October 2006 –October 2008).

"Evaluating IEEE 802.11 and 802.16 Wireless MAC Protocols for use in Future NASA Space Exploration Missions", NASA/South Carolina Space Grant REAP program, Principal Investigator, $30,000, (May 2006 – December 2007).

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"Developing a Prediction-based Service Management System", IBM University Partnership Proposal, Principal Investigator, $30,000, (August 2005-August 2006).

Equipment gift from Cisco, Principal Investigator (M. Westall Co-PI), $20,000, (January 2005).

"Developing Application Level Prediction Services in a WebSphere and Globus Grid Environments", IBM University Partnership Proposal, Principal Investigator, $40,000, (August 2004 - August 2005).

IBM SUR Equipment Grant, $125,000, augmented by $100,000 with a cost matching grant from the Provost, Co-PI, (M. Westall Co-PI and R. Geist PI), (June 2004).

GRADUATE STUDENT ADVISING

PhD Graduates

Manveen Kaur (PHD CS), "SNAP: A Software-Defined & Named-Data Publish-Subscribe Framework for Emerging Wireless Application Systems", (August, 2022).
Jianwei Liu (PHD CS), "Unified Wireless Systems Involving Multiple Operators", (Dec, 2019).
Anjan Rayamajhi (PHD ECE), (CoAdvising with Dr Harlan Russell, ECE) "Exploring Smart Infrastructure Concepts to Improve the Reliability and Functionality of Safety Oriented Connected Vehicle Applications", (August 2019).
Mizan Raman (PHD Civil Eng), (CoAdvising with Dr Ronnie Chowdhury, Civil Eng) "Queue Warning Connected Vehicle Application: Assessing the Impacts of Heterogeneous Wireless Infrastructure", (Dec, 2018).
Gongbing Hong (PHD CS), Bandwidth Management in Emerging DOCSIS-based Broadband Access Networks, (December 2015).
Rahul Amin (PHD ECE), "Towards Viable Large Scale Heterogeneous Wireless Networks", (August 2013).
Scott Moser (PHD CS), "Scheduling Algorithms in DOCSIS-based networks", (August 2011).

Masters Graduates

Adam Hodges (MSCS), "Broadband Mapping Emerging Heterogeneous Wireless Networks", (August 2014).
Eric Harney (MSCS), "Modeling the Network Impacts of Live Migration in XEN", (December 2009).
Rob Johnson (MSCS), "Evaluating the Use of SNMP as a Wireless Network Monitoring Tool for IEEE 802.11 Wireless Networks", (May 2009).

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Will Spearman (MSCS), "Distributed Adaptive Algorithm for 802.11e QoE", (December 2007).
Ben Sangster (MSCS), "DoS Attacks in DOCSIS-based Networks", (August 2007).
Himadeepa Karlapudi (MSCS), "Web Application Performance Prediction", (August 2004).
Vinod Rajasekaran (MSCS), "Impact of Virtual Machine Overhead on TCP Performance", (August 2004).
Shobhana Kirtane (MSCS), "Predicting the Performance of the gridFTP Application over Wide Area Grid Environments", (May 2004).

Current Graduate Advising

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TEACHING EXPERIENCE

Courses Taught at Clemson:

CPSC 1110, Computer Programing in "C", Fall 2018.
CPSC 3600, Distributed and Network Programming, Spring 2020, 2018, Fall 2017, Spring 2012, Fall 2012, Spring 2010-2011, Spring 2006-2007, Summer 2005,Spring/Fall 2004-2005.
CPSC 4240/6240, Linux System Administration and Security, Spring 2014-2019.
CPSC 8510, Software Systems for Data Communications, Fall 2016, Fall 2012-2014.
CPSC 8520 (formerly CPSC 8260), Internet Protocols, Fall 2019, Fall 2015, Spring 2014, Fall 2006-2011, Spring 2009, Spring 2003-2006, Fall 2002.
CPSC 8540 (formerly CPSC 8810), Internet Performance Analysis, Spring 2008-2012, Fall 2003-2006.

New Course Development at Clemson:

CPSC 8540, Internet Performance Analysis, Fall 2003-2006, Spring 2008-2012.

Courses Taught at North Carolina State University:

CSC/ECE 573, Internet Protocols, Spring 2001.

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UNIVERSITY AND PUBLIC SERVICE

Committees:

School of Computing, Director's Advisory Committee (chair) 2019-2022.
School of Computing, Undergraduate Affairs Committee, 2019-2022.
School of Computing PhD Curriculum Committee, 2008-2009.
School of Computing, Faculty Advisory Board, 2018-2019.
School of Computing, External/Industrial Affairs Committee, 2014-2017.
School of Computing, Honors Program Director, 2012-2018.
School of Computing, Upsilon Pi Epsilon (UPE) Faculty Advisor, 2012-2019.
School of Computing, Space (lab and classroom) Committee, 2014-2017.
School of Computing, Faculty Search Committee, 2010-2013, 2015.
School of Computing, Sabbatical Review Committee, 2013-2019.
School of Computing, PhD Graduate Student Recruiting Committee, 2010-2011.
School of Computing, Graduate Affairs Committee, 2009-2010.
Department Research Committee, 2003-2004.
Department Computing Facilities Committee, 2004-2007.

Other service:

*Advisory Board Member, BitRipple 2020-.
*Editorial Board Member, Wiley's Internet Technology Letters, 2020-.
*Editorial Board Member, MDPI, Internet of Things Open-Access Journal, 2020-.
* IEEE International Conference on Mobile Ad-Hoc and Smart Systems Program Committee Member, 2019-.
*Review Committee, Urban Transportation Systems and Mobility, Frontiers in Sustainable Cities 2019-.
* Editorial committee for Transactions on Emerging Telecommunications, 2018-.
*Advisor for NSF Research Experience for Undergraduates (REU) students 2004-.
*Invited participant, NSF's PAWR Platform POWDER Workshop, June, 2018.
*Adhoc NSF Proposal Review, June 2018.
*Invited Session Chair, CAIDA Workshop on Active Internet Measurements, 2014,2017.
*IEEE ICCCN Program Committee Member, 2008-2017.
*IEEE Globecom Program Committee Member, 2015-2017.
*IEEE Communications Magazine, Guest Editor, 2015.
*Vice-Chair of the IEEE Cable Networks and Services Subcommittee (CNS), 2015-2017.
*NSF proposal review panel member, 2004, 2005, 2007, 2010, 2011, 2017.
*Guest editor, IEEE Communications Magazine, Feature on "Next Generation Cable Networks with DOCSIS 3.1 Technology", March 2015.
*Participant NSF PhantomNet Users' Workshop, Feb 2015.
*Participant NSF Workshop on Future Research Infrastructure for the Wireless Edge
*IEEE TridentComs Program Committee Member, 2014-2015.
*Organizing Committee Member, NSF Workshop on Vehicular Sensing (DriveSense'14), Old Dominion, November 2014.
*Publicity Chair, IEEE International Conference on Network Protocols, October 2014.
*Participant DOCSIS 3.1 Active Queue Management Working Group,
*Author of sections of CableLabs DOCSIS 3.1 specifications.

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*Clemson's Representative to NSF's Access Computing program, 2012- 2020.
*NSF Future Heterogeneous Networks Workshop, Mountain View, CA, March 2011.
*Public safety communications technology outreach through collaboration with DOJ National Institute of Justice, 2008 - 2015.
*Clemson's Emerging Scholars, an outreach program to provide rural South Carolina high school students Computer Science and Internet skills, Summers 2005 - 2012.
*Program committee member, IEEE Broadnets, 2007.
*Advisory Board, International Conference on Performance Modeling and Evaluation of Heterogeneous Networks, Ikley, UK, July 2005 - 2006.

Last update: 2/18/2024

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