

**UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION**

TQ DELTA, LLC,

Plaintiff,

v.

**COMMSCOPE HOLDING COMPANY, INC.,
COMMSCOPE INC., ARRIS US HOLDINGS,
INC., ARRIS SOLUTIONS, INC., ARRIS
TECHNOLOGY, INC., and ARRIS
ENTERPRISES, LLC**

Defendants.

CIV. A. NO. 2:21-CV-310-JRG
(Lead Case)

TQ DELTA, LLC,

Plaintiff,

v.

**NOKIA CORP., NOKIA SOLUTIONS AND
NETWORKS OY, and NOKIA OF AMERICA
CORP.,**

Defendants.

CIV. A. NO. 2:21-CV-309-JRG
(Member Case)

**OPENING EXPERT REPORT OF BRUCE MCNAIR ON THE INVALIDITY OF
THE ASSERTED CLAIMS OF THE FAMILY 9 PATENTS**

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I. INTRODUCTION

1. My name is Bruce McNair. I have been asked by Defendants CommScope Holding Company, Inc., CommScope Inc., ARRIS US Holdings, Inc., ARRIS Solutions, Inc., ARRIS Technology, Inc., and ARRIS Enterprises, LLC (collectively, “CommScope”) and Nokia of America Corp., Nokia Corp., and Nokia Solutions and Networks Oy (collectively, “Nokia”) (together, “Defendants”) to provide this report in connection with the above-captioned District Court action. Specifically, I have been asked to opine on the validity of claims 10 and 18 of U.S. Patent No. 8,468,411 (“the ’411 patent”), claims 1, 2, 9, and 10 of U.S. Patent No. 9,094,348 (“the ’348 Patent”), claims 11 and 17 of U.S. Patent No. 9,485,055 (“the ’055 Patent”), and claims 8, 11, and 13 of U.S. Patent No. 10,833,809 (“the ’809 Patent”) (collectively, the “Asserted Family 9 Claims”).¹ I understand that plaintiff TQ Delta, LLC has alleged that certain CommScope and Nokia products infringe these claims. I further understand that these patents are referred to in this action as “the Family 9 patents.”

II. BACKGROUND AND QUALIFICATIONS

2. I have summarized in this section my educational background, work experience, and other relevant qualifications. A detailed curriculum vitae showing more of my credentials is attached to this report as Appendix A.

3. I received a Bachelor of Engineering Degree in Electrical Engineering from Stevens Institute of Technology in 1971 and a Master of Electrical Engineering Degree from Stevens Institute of Technology in 1974. I have also taken numerous Ph.D-level courses in Electrical Engineering, Computer Engineering, and Computer Science at Stevens Institute of Technology over the years.

¹ In this report, I have been asked by Nokia for my opinions as to the ’055 Patent. As a result, my comments on the ’411, ’348, ’809 patents are on behalf of CommScope alone.

4. From 1971 to 1973 and 1974 to 1978, I was employed by the United States (“US”) Army Electronics Command at Fort Monmouth, New Jersey, where I worked with voice, data and wireless communications systems. In 1973, I was employed by ITT Defense Communications Division in Nutley, New Jersey, where I designed digital hardware and computer software to investigate signal processing of speech signals and transmission of satellite communications signals using advanced forward error correction schemes.

5. From 1978 to 2002, I was employed by AT&T Bell Laboratories and AT&T Laboratories at various New Jersey locations. My work there involved public data networks, high-speed digital communications over analog networks, speech processing, network security, and wireless communications. Several of my positions were closely associated with the subject matter of asserted patents. In particular, while I was in the Bell Labs Data Services Center in the late 1970s, I participated in the design of the Advanced Communications Service, a network very much like today’s Internet, built on X.25 and related international standards, rather than the TCP/IP protocol stack that the Internet is based on. While I was in the Bell Labs Data Communications Laboratory in the early 1980s, I worked on high-speed analog modems using techniques that others in the organization later applied to DSL signaling. John Cioffi, a recognized authority in the field of digital subscriber line (“DSL”) technologies, was one of my colleagues during this time period. Rich Gitlin, who was the supervisor of that group and later the head of the same department is the recognized inventor of the initial concept of DSL technologies for the local telephone plant. From 1987 to 1994, I created and supervised the Bell Labs Security and System Reliability Architecture Group. In this role, I investigated network security issues including those created in TCP/IP networks. Later in my AT&T/Bell Labs career, from 1994 to 2002, I investigated the use of Orthogonal Frequency Division Multiplexing (“OFDM”) for

wireless communications. OFDM forms the basis for DSL communications, although the characteristics of a wireless network environment make communications far more difficult than the relatively benign DSL environment. My research in OFDM for wireless applications included the use of interleaving, forward error correction (“FEC”), synchronization and Reed-Solomon (“RS” or R-S”) codes. My teaching at Stevens Institute of Technology has included several graduate courses that have components that address issues in TCP/IP networks, and I have supervised a number of undergraduate senior design projects that have emphasized TCP/IP networking.

6. My list of publications is shown in my CV. *See* Appendix A. Several of my publications are closely related to the subject matter of the asserted patents. For example, at several Institute of Electrical and Electronics Engineers (“IEEE”) Vehicular Technology Conferences (“VTC”) held between 1998 and 2002, I presented on multiple subjects related to telecommunications technology, including my results from an experimental implementation of OFDM in a wireless environment.² I have also presented further results for this OFDM system at the Sarnoff Symposium in 2001.³ Seven more of my papers are also OFDM related.

7. Some of my other presentations include topics related to error control. For example, at an IEEE International Conference on Communications (ICC) in 2002, I presented a paper focused on extending a wireless local area network (WLAN) into an outdoor cellular network based on modifying the IEEE 802.11 specification.⁴ During this presentation, I described

² Bruce McNair, Leonard J. Cimini, Jr. & Nelson R. Sollenberger, *Performance of an Experimental 384 kb/s 1900 MHz Radio Link in a Wide-Area High-Mobility Environment*, PROC. IEEE VEHICULAR TECHNOLOGY CONFERENCE - VTC00, Boston, MA, October 2000.

³ Bruce McNair & Leonard J. Cimini, Jr., *OFDM for High Data Rate, High-Mobility, Wide-Area Wireless Communications*, PROC. IEEE SARNOFF SYMPOSIUM, Princeton, NJ, March 2001.

⁴ Kin K. Leung, Bruce McNair, Leonard J. Cimini, Jr. & Jack H. Winters, *Outdoor IEEE 802.11 Cellular Networks: MAC Protocol Design and Performance*, Conference Proceedings, 1 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS 595, 595-599 (2002).

modifications to a timing scheme specified by the medium access control (MAC) protocol of the IEEE 802.1 specification. The modified timing scheme extended an amount of time required to trigger packet retransmission, which in turn optimized error control by minimizing or preventing unnecessary or inadvertent retransmissions of packets that may or may not be error-corrupted.

8. In 2007, I published a paper supplementing the subject matter of my 2002 IEEE ICC presentation.⁵ The paper described extending a WLAN into an outdoor cellular network based on modifying the IEEE 802.1b specification and studying the performance of three different receivers in the outdoor cellular network. The paper specifically notes that the IEEE 802.1b specification was chosen because of its physical-layer design.

9. A complete list of cases in which I have testified at trial, hearing, or by deposition within the preceding five years is provided in my curriculum vitae, which is attached as Appendix A to my report.

10. Based on my education and experience, I believe I am qualified to render the opinions set forth here.

III. COMPENSATION

11. I am being compensated for my time at my customary rate of \$650 per hour. This compensation is not contingent on my performance, the outcome of this matter, or any issues involved in or relating to this matter.

12. I expect to testify at trial on the opinions set forth in this report and the bases for those opinions. I also reserve the right to present exhibits and demonstratives as appropriate to help demonstrate and explain my opinions if I am asked to testify at trial.

⁵ Kin K. Leung, Martin V. Clark, Bruce McNair, Zoran Kostic, Leonard J. Cimini, Jr. & Jack H. Winters, *Outdoor IEEE 802.11 Cellular Networks: Radio and MAC Design and Their Performance*, Conference Proceedings, 1 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS 595, 595-599 (2002).

IV. DOCUMENTS AND OTHER MATERIALS RELIED UPON

13. In forming the opinions set forth in this report, I have reviewed the Family 9 patents. Additionally, I have considered my own experience and expertise concerning the knowledge of a person having ordinary skill in the relevant art during the timeframe of the claimed priority date of the Family 9 patents. I have reviewed information generally available to, and relied upon by, a person having ordinary skill at the time of the alleged invention. I have also reviewed the parties' claim construction briefing and the Court's order on the same.

14. In addition, I have reviewed the materials listed in Appendix B and all references cited in this report.

15. I was told to assume the time of the alleged invention of the Family 9 patents is April 12, 2006, the date on which the earliest-filed provisional application, No. 60/792,236, was filed. I am also informed, however, that once an accused infringer has introduced sufficient evidence to put at issue whether there is prior art alleged to anticipate the claims being asserted, and that prior art is dated earlier than the apparent effective date of the asserted patent claim, the patentee has the burden of going forward with evidence and argument to the contrary.

V. LEGAL PRINCIPLES

16. I am not licensed to practice law, and I am not offering any legal opinions in this Report. My opinions are based on the Court's constructions and, where the Court did not construe a term, the meaning that term would have had to a person having ordinary skill in the art in light of the specification and the prosecution history at the time of the filing of the earliest priority application.

A. Anticipation Under 35 U.S.C. § 102

17. I am informed and understand that to anticipate a patent claim under 35 U.S.C. § 102, a single asserted prior art reference must disclose each and every element of the claimed

invention, either explicitly, implicitly, or inherently, to a person of ordinary skill in the art. There must be no difference between the claimed invention and the disclosure of the alleged prior art reference as viewed from the perspective of the person of ordinary skill in the art. Also, I understand that in order for a reference to be an anticipating reference, it must describe the claimed subject matter with sufficient clarity to establish that the subject matter existed and that its existence was recognized by persons of ordinary skill in the field of the invention. In addition, I am informed and understand that in order to establish that an element of a claim is “inherent” in the disclosure of an asserted prior art reference, extrinsic evidence (or the evidence outside the four corners of the asserted prior art reference) must make clear that the missing element is necessarily found in the prior art, and that it would be recognized as necessarily present by persons of ordinary skill in the relevant field.

18. In my opinions below, when I say that a person of ordinary skill would understand, readily understand, or recognize that an element or aspect of a claim is disclosed by a reference, I mean that the element or aspect of the claim is disclosed explicitly to a person of ordinary skill in the art.

B. Obviousness Under 35 U.S.C. § 103

19. I am informed and understand that obviousness is a determination of law based on various underlying determinations of fact. In particular, these underlying factual determinations include (1) the scope and content of the prior art; (2) the level of ordinary skill in the art at the time the claimed invention was made; (3) the differences between the claimed invention and the prior art; and (4) the extent of any proffered objective indicia of nonobviousness. I understand that the objective indicia that may be considered in such an analysis include commercial success of the patented invention (including evidence of industry recognition or awards), whether the invention fills a long-felt but unsolved need in the field, the failure of others to arrive at the

invention, industry acquiescence and recognition, initial skepticism of others in the field, whether the inventors proceeded in a direction contrary to the accepted wisdom of those of ordinary skill in the art, and the taking of licenses under the patent by others, among other factors.

20. To ascertain the scope and content of the prior art, it is necessary to first examine the field of the inventor's endeavor and the particular problem for which the invention was made. The relevant prior art includes prior art in the field of the invention, and also prior art from other fields that a person of ordinary skill in the art would look to when attempting to solve the problem.

21. I understand that a claim may be rendered obvious if a person having ordinary skill in the art would understand the claimed invention as a predictable variation of a known reference.

22. I am informed and understand that an obviousness evaluation can be made using either a single reference or a combination of several prior art references. An obviousness analysis involving two or more references generally requires a reason why a person having ordinary skill in the relevant field would have combined aspects of those references in the way the asserted patent claims do. I understand that the prior art references themselves may provide a suggestion, motivation, or reason to combine, but other times the link may simply be common sense. An obviousness analysis can recognize that market demand, rather than scientific literature, often drives innovation, and that is sufficient motivation to combine references.

23. I understand that a particular combination of prior art references may be made by merely showing that it was obvious to try the combination. For example, common sense is a good reason for a person having ordinary skill to pursue known options when there is a design need or market pressure to solve a problem, and there are a finite number of identified, predictable solutions.

24. I am informed and understand that a determination of obviousness cannot be based

on the hindsight combination of components selectively culled from the prior art to fit the parameters of the patented invention. Instead, it is my understanding that in order to render a patent claim invalid as being obvious from a combination of references, there must be some evidence within the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination in a way that would produce the patented invention.

25. I am further informed and understand that a proper obviousness analysis focuses on what was known or obvious to a person having ordinary skill in the art, not just the patentee. Therefore, in an obviousness analysis, neither the motivation nor the purpose of the patentee is controlling. What is important is whether there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. For example, any need or known problem in the field at the time of the alleged invention that is supposedly addressed by the patent can provide a reason for combining the limitations in the manner claimed if a combination of prior art would address the same.

26. In addition, it is my understanding that in order to find a patent claim invalid for obviousness, there must be a finding that each element in each limitation of the patent claim is disclosed, taught, or suggested by the asserted combination of prior art references or elsewhere in the relevant prior art. I understand, however, that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. But multiple prior art references or elements may, in some circumstances, be combined to render a patent claim obvious. I understand that I should consider whether there is an "apparent reason" or motivation to combine the prior art references or elements in the way the patent claims. To determine whether such an "apparent reason" or motivation to combine the prior art references or elements in the way a patent claims exists, it will often be necessary to look

to the interrelated teaching of multiple prior art references, to the effects of demands known to the design community or present in the marketplace, and to the background knowledge possessed by a person of ordinary skill in the art.

27. I am further informed and understand that when an element is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation of that available element, Section 103 likely renders the invention obvious. For the same reason, I am informed and understand that if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that such technique would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. Following these principles often requires one to look to interrelated teachings of multiple patents; the effects of demands known to the design community present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known element in the manner claimed by the patent at issue. I am further informed and understand that the analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, because one can take account of the inferences and creative steps that a person of ordinary skill in the art would employ.

28. I am further informed and understand that although the use of the “teaching, suggestion or motivation” test for combining references has not been completely rejected, the obviousness analysis cannot be confined by a formalistic conception of the words teaching, suggestion, and motivation, or by overemphasis on the importance of published articles and the explicit content of issued patents. I am informed and understand that in many fields there is little

discussion of obvious techniques or combinations, and it is often the case that market demand, rather than scientific literature, drives design trends. Under the correct analysis, any need or problem known in the field of endeavor at the time of the invention and addressed by the patent can provide a reason for combining the elements in the manner claimed. Finally, I am informed and understand that common sense teaches that familiar items may have obvious uses beyond their primary purposes and, in many cases, a person of ordinary skill in the art will be able to fit the teachings of multiple patents together like pieces of a puzzle.

29. I am also informed and understand that even though a prior art reference does not fully anticipate a claim of a patent, a claim may, nonetheless, be rendered obvious to one of ordinary skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the subject matter as a whole of the claim would have been obvious at the time the claimed invention was made.

30. I further am informed that in determining whether the claimed subject matter is obvious, one must also examine any objective indicia of nonobviousness (also called secondary considerations). I also have been informed that secondary considerations cannot overcome a strong showing of obviousness. In that regard, I am informed that secondary considerations must be commensurate in scope (proportional) with respect to the claims for which the evidence is offered to support. I have been informed that evidence of secondary considerations is not commensurate in scope if the claims are broader than the scope of such evidence. Relatedly, I have been informed that a nexus or connection between the merits of the claimed invention and the alleged evidence of secondary considerations is necessary. Specifically, I have been informed that the secondary considerations must be tied to purported novel or new elements of the claimed invention.

31. I also am informed that secondary considerations of nonobviousness include (1) whether the claimed subject matter achieved unexpected results or benefits, (2) whether the claimed subject matter satisfied a long-felt but unmet need, (3) whether the claimed subject matter was commercially successful as a result of the merits of a claimed subject matter (rather than the result of design needs, market pressure, advertising, or similar activities), (4) whether other skilled artisans failed in their attempts to solve the same problems addressed by the invention, (5) whether others copied the claimed subject matter, and (6) whether others in the field praised claimed the subject matter.

32. Specifically, I am informed that evidence that other skilled artisans failed in their attempts to solve the same problems addressed by claimed invention is potential evidence of nonobviousness. To demonstrate failure of others, I am informed that plaintiff must establish that others skilled in the art tried and failed to find a solution for the problem allegedly solved by the invention claimed by the asserted patents. I further understand that for such evidence of failure to be relevant as an objective indicia of nonobviousness, these prior unsuccessful attempts must have failed because they lacked the claimed features of the asserted inventions. Purported failures unrelated to the patented invention are not relevant secondary considerations of nonobviousness.

33. I also am informed that evidence of a long-felt unmet need for the claimed invention is one factor courts may consider when assessing the obviousness of that invention. The underlying rationale for accepting evidence of a long-felt unmet need as evidence of nonobviousness, as I understand it, is based on the assumption that if an unmet need persists for a long time despite commercial incentives to offer a solution, the resolution of the problem may not be obvious. I also understand that the long-felt unmet need must be directly related to the subject matter of the claimed invention and must actually provide a result that meets the claimed

need. I further am informed that the length of time that must pass to constitute a “long felt” need is to be determined in the light of the speed of innovation in the relevant industry. I also have been informed that long-felt, unmet need should be based upon alleged inadequacies in the technical knowledge of those skilled in the art, not due to business-driven market forces. Lastly, I have been informed that any evidence of a need that post-dates the filing date of a challenged patent is irrelevant to the determination of nonobviousness.

34. I am further informed that “commercial success” is a legal construct that has been established through case law. I have been informed that analysis of commercial success is premised on the concept that if a product is economically successful, it may provide objective evidence of nonobviousness. I further understand that any purported commercial success of the product must be attributable to the alleged novel features of the claimed invention. I understand this to mean that, to support a finding of nonobviousness, any alleged commercial success must be driven by and attributable to the purported merits of the patented invention, and not by other factors unrelated to the allegedly novel features of the claimed invention. In other words, there must be a causal correlation, or “nexus,” between the unique merit of the claimed invention and the success of the product. I also understand that if purported commercial success is due to an element in the prior art, no nexus exists.

35. I additionally understand that an alleged infringer’s copying of a claimed invention rather than one that is in the public domain can support a finding of nonobviousness. Likewise, I am informed that to support a finding of nonobviousness, alleged industry praise must be linked to the patented invention. In other words, a patentee must show that any industry praise is attributable to material differences between the prior art and the patented invention. I have been informed that a patentee’s statements that are intended to generate interest in a product are not

evidence of industry praise. Similarly, publications authored or sponsored by or on behalf of a patentee fail to demonstrate true industry praise.

36. I further understand that the near simultaneous invention by two or more equally talented inventors working independently may or may not be an indication of obviousness. In other words, the fact that another person simultaneously and independently created the same invention claimed in the patent-in-suit can serve as an indication that the invention was obvious.

VI. LEVEL OF SKILL IN THE ART

37. I am informed and understand that the claims of a patent are judged from the perspective of a hypothetical construct involving a “person of ordinary skill in the art.” The “art” is the field of technology to which the patent is related. I understand that the purpose of using the viewpoint of a person of ordinary skill in the art is for objectivity. I understand that a person of ordinary skill in the art is presumed to know and be familiar with all of the relevant art in the field at the time of invention.

38. I was also asked to provide an opinion regarding the skill level of a person of ordinary skill in the art of the Family 9 patents. I considered several factors, including the types of problems encountered in the art, the solutions to those problems, the pace of innovation in the field, the sophistication of the technology, my experience as a person who worked in the art on the Family 9 patents’ priority date, and the education level of active workers in the field.

39. In my opinion, at the time of the earliest claimed priority date (April 12, 2006), a person having ordinary skill in the art (“POSA”) of the Family 9 patents would have had a bachelor’s degree in electrical engineering or computer engineering and at least 5-6 years of experience in that field, a Master’s degree in electrical or computer engineering and 2-3 years of experience, or a Ph.D. in electrical or computer engineering with 1-2 years of experience. At the time of the earliest claimed priority date (April 12, 2006) I exceeded this level of skill in the art.

40. My opinions regarding the level of ordinary skill in the art are based on, among others, my experience developing, presenting, and testing novel data communication technologies, my experience teaching and mentoring students at graduate and undergraduate levels, and my experience working in organizations responsible for data transmission standards. Although my qualifications and experience exceed those of a person of ordinary skill in the art, my qualifications enable me to provide opinions regarding the Family 9 patents from the perspective of one of ordinary skill in the art, as I have done in this report.

VII. BACKGROUND OF THE TECHNOLOGY

41. Below, I provide a brief summary of the technology and the state of the art as of the priority date of the Family 9 patents as context for understanding the disclosure and claims of the Family 9 patents and how they compare to the prior art.

42. The Family 9 patents relate to communication systems that utilize interleaving⁶ and retransmission for error control. Both interleaving and retransmission were old and well-known techniques by the Family 9 patents' priority date, and communication systems using both interleaving and retransmission were well known and used in commercial products before the priority date of the Family 9 patents. For example, by 1998, the use of both interleaving and retransmission had been standardized for digital subscriber line (DSL) communication systems.

43. Although the claims of the Family 9 patents patent are not limited to DSL, the applicant's presentation of the material in the patents is in the context of DSL. *See, e.g., '411 patent, 8:54-67.* Therefore, I provide below a discussion of relevant DSL principles and technology.

⁶ For convenience, in this report I sometimes use the term "interleaving" to refer to the overall interleaving process, which includes interleaving by the transmitter and deinterleaving performed by the receiver. When necessary, I will distinguish between interleaving and deinterleaving.

44. The *downstream* direction, sometimes abbreviated as “DS,” is defined in DSL as the direction from the service provider (or operator) to the subscriber (e.g., from the central office (CO) to the customer’s home or office). The *upstream* direction, sometimes abbreviated as “US,” is the direction from the subscriber toward the service provider. In ADSL, the transceiver at the subscriber’s location, called the “ATU-R,” transmits data in the upstream direction and receives data in the downstream direction. Conversely, the ADSL transceiver in the CO (or other location in the service provider’s network), called the “ATU-C,” transmits data in the downstream direction and receives data in the upstream direction. In VDSL, the transceiver at the subscriber’s location, called the “VTU-R,” transmits data in the upstream direction and receives data in the downstream direction, and the VDSL transceiver at the service provider’s end of the subscriber line, called the “VTU-O,” transmits data in the downstream direction and receives data in the upstream direction.

A. Overview of Telecommunications Technologies

45. Telecommunications technologies directed to communicating electronic data (*i.e.*, analog and digital data) have been around for quite some time. Ayre, R., Hinton, K., Gathercole, B., Cornick, K., *A Guide to Broadband Technologies*, 43 Austl. Econ. Rev. 200-08 (June 2010) (“Ayre”), §§1-2.⁷ One example is the plain old telephone or telephony service (“POTS”), which was originally created to provide “basic telephone service” between two end users. *See id.* §2. Implementing POTS requires coupling a service provider’s central office (“CO”) equipment to

⁷ As used herein, “communication” and its variations includes: “transmitting” and its variations; “receiving” and its variations; or any combination thereof. *See, e.g., Fundamentals of DSL Technology* (Golden, P., Dedieu, H., Jacobsen, K. eds., Auerbach Publ’ns, 1st ed. 2004, prtng. 2006) (“Jacobsen”), §6.5.5-6 (disclosing that communication requires transmitting a signal, receiving a signal, or a combination of both).

an end user's customer premises equipment via a local loop.⁸ *See* Starr, T., Sorbara, M., Cioffi, J., Silverman, P., DSL ADVANCES (Prentice Hall PTR 2003) ("Sorbara"), §1.2, Figure 1.1. A local loop refers to "cables containing twisted pairs of copper wires." Ayre, §2.

46. Early POTS systems could only transport analog data, such as sounds produced by a voice, between a CO and customer premises.⁹ *Id.* For example, customer premises equipment may receive analog voice data, convert (*i.e.*, encode) it into analog signals, and transmit the analog signals over or along a local loop to a CO. *Id.* Equipment at the CO can convert (*i.e.*, decode) the received analog signals back into voice data. *Id.*

47. POTS has many shortcomings, such as signal attenuation, crosstalk noise from signals on a wire interfering with other signals on other wires, signal reflections, radio-frequency ("RF") noise, and impulse noise. *Id.* It was also incapable of communicating voice and digital data at the same time because it used a single communication channel comprising a "single narrow frequency band." *See* Ayre, §2.

48. To mitigate some of its shortcomings, POTS was later modified to include modems (e.g., a dial-up or voiceband modem) for communicating analog voice data, other type of analog data, digital data (e.g., video, multimedia, etc.), or a combination thereof. *Id.* A modem generally refers to an apparatus whose functions include modulation, demodulation, and communication of data. *See, e.g.*, Sorbara, §§2.1, 2.1.1-2. A modem is sometimes called a transceiver. *See, e.g.*, Fukushima, 03:36-04:28; Figure 1.

49. There are two types of modulation—analog and digital. *See, e.g.*, FUNDAMENTALS OF DSL TECHNOLOGY (Golden, P., Dedieu, H., Jacobsen, K eds., Auerbach Publ'ns, 1st ed. 2004,

⁸ CO equipment includes telephone switching equipment, while customer premises equipment includes telephones. *See* Sorbara, §1.2, Figure 1.1.

⁹ The term "voice data" and its variations, as used herein in this report, refer to sound. It is to be appreciated that sound and faxes are some of many examples of analog data.

prtg. 2006) (“Jacobsen”), §6.2, Figure 6.1. Demodulation is the reverse of modulation. *Id.*

50. Analog demodulation is directed to mapping a representation of analog or digital data into a symbol, which is a waveform that represents an analog signal.¹⁰ *Id.* The analog data can be represented using one or more of its characteristics, such as amplitude. *Id.* The digital data can be represented using at least one bit. *Id.* Mapping, in this scenario, enables converting the analog or digital data into the analog signal for propagation over a transmission medium. *See, e.g., Jacobsen, §6.2.*

51. Digital modulation is directed to mapping an analog or digital data representation to a waveform represented by a digital signal. *Id.* Here, mapping allows for converting the analog or digital data into the digital signal for propagation over a transmission medium. *Id.*

52. An integrated services digital network (“ISDN”) eventually replaced POTS. *Id.* The ISDN mitigated some of POTS’ shortcomings above by enabling faster, synchronous communication of voice and digital data over a local loop. *Id.* Nevertheless, ISDN was not widely adopted because of its cost. *Id.*

53. A “new generation of high-speed data transmission technologies” called digital subscriber line (“xDSL”) superseded the ISDN. *Id.* Earlier generations of xDSL replaced the voiceband modem described above with a DSL modem at the customer premises side and a DSL access modem (“DSLAM”) at the CO side. *Id.* DSL modems and DSLAMs could use multiple channels comprising “a hundred or more narrow frequency bands simultaneously,” as opposed to a single channel formed with a single narrow frequency band. *Id.* Both devices communicate voice data using lower channels formed with lower narrow frequency bands and all other types

¹⁰ Broadly speaking, a waveform is a graphical representation of a signal. *See, e.g., Jacobsen, §6.2, Figure 6.1.* It can be presented in the time domain, the frequency domain, or both. *See, e.g., Sorbara, §2.2.4*

of data using higher channels formed with higher narrow frequency bands. *Id.*

54. Implementation details of xDSL are publicly available in specifications created by the ITU-T Study Group 15. *See, e.g.*, ITU-T Recommendation G.995.1, “Overview of digital subscriber line (DSL) Recommendations” (Feb. 2001 (“G.995.1”), §§3.2, 5.1-5.4, 5.8; ITU-T Recommendation G.995.1, “Overview of digital subscriber line (DSL) Recommendations Amendment 1” (Nov. 2001) (“G.995.1-Amendment No. 1”), §5.9. xDSL includes but is not limited to: (i) ADSL1 (ITU-T Recommendation G.992.1, “Asymmetric digital subscriber line (ADSL) transceivers” (July 1999), Sp-ADSL1 (ITU-T Recommendation G.992.2, “Splitterless asymmetric digital subscriber line (ADSL) transceivers” (July 1999)), ADSL2 (ITU-T Recommendation G.992.3, “Asymmetric digital subscriber line transceivers 2 (ADSL2)” (Jan. 2005) (“G.992.3”)), Sp-ADSL2 (ITU-T Recommendation G.992.4, “Splitterless asymmetric digital subscriber line transceivers 2 (splitterless ADSL2)” (July 2002)), and ADSL2-plus (ITU-T Recommendation G.992.5, “Asymmetric Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2+)” (Jan. 2005) (“G.992.5”)); (ii) HDSL (ITU-T Recommendation G.991.1, “High bit rate digital subscriber line (HDSL) transceivers” (Oct. 1998) (“G.991.1”)); (iii) SHDSL (ITU-T Recommendation No. G.991.2, “Single-pair high-speed digital subscriber line (SHDSL) transceivers” (Dec. 2003) (“G.991.2”)); and (iv) VDSL1 (ITU-T Recommendation G.993.1, “Very high speed digital subscriber line transceivers” (June 2004) (“G.993.1”)) and VDSL2 (ITU-T Recommendation G.993.2, “Very high speed digital subscriber line transceivers 2 (VDSL2)” (Feb. 2006) (“G.993.2”)).

55. The ADSL family of standards requires asymmetric upstream and downstream

data rates.¹¹ *See, e.g.*, G.992.1, i. HDSL requires “a two-wire bidirectional transceiver for metallic wires” that is directed to transporting “several types of applications” using an echo cancellation method. G.991.1, §1. SHDSL employs symmetric, as opposed to asymmetric, upstream and downstream data rates. G.991.2, i. The VDSL family “permits the transmission of asymmetric and symmetric aggregate data rates” on twisted pairs of copper wires. G.993.1, §1.

B. Open Systems Interconnection Basic Reference Model

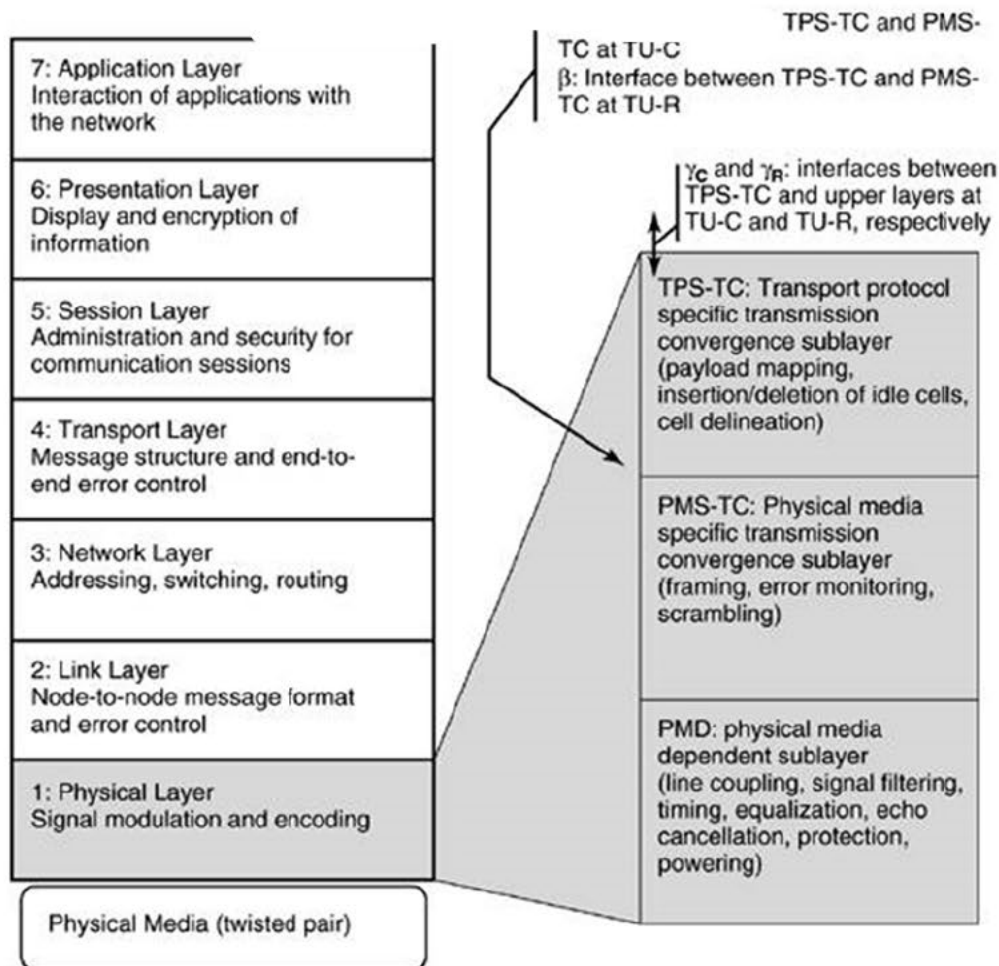
56. Most, if not all, telecommunications technologies using transceivers operate at a physical layer, which is the lowest layer of an open systems interconnection (“OSI”) basic reference model (hereinafter “OSI model”). *See e.g.*, Sorbara, §1.4 and Figure 1.6. This model is an “overall framework” that conceptually characterizes and defines data communication in, from, and to an electronic system, such as a telecommunications or computing system. *See* Reynders, §2.4.2, p. 21.

57. In plain English, an OSI model represents an electronic system’s information processing and communication capabilities at a high level without regard to the system’s complexity, internal structure, or technologies. *See e.g.*, Sorbara, §1.4 and Figure 1.6. OSI models are useful because they allow for different types of electronic systems, including existing and future electronic systems, to be represented in an easy-to-understand and standardized way. *Id.* Every electronic system’s OSI model abstracts the system into a maximum of seven layers. *Id.* Each layer includes one or more entities, which are abstract devices, such as programs, functions, or protocols, that implement one or more capabilities of the layer. *See* Reynders, §2.4.2, pp 21-22; *see also* ITU-T Recommendation X.200, “Information technology - Open Systems

¹¹ Asymmetric data rates require downstream data rates for communications to customer premises equipment to differ from (e.g., exceed) upstream data rates for communications to CO equipment.

Interconnection - Basic Reference Model: The basic model” (July 1994) (“X.200”), §5.2.1.1-5.2.2.7. Furthermore, each layer may or may not be subdivided into sub-layers depending the technologies being represented. *See* X.200, §5.2.2.2, note 2.

58. One example of a seven-layer OSI model is reproduced below with additional detail shown for the physical layer.



See Sorbara, Figure 1.6.

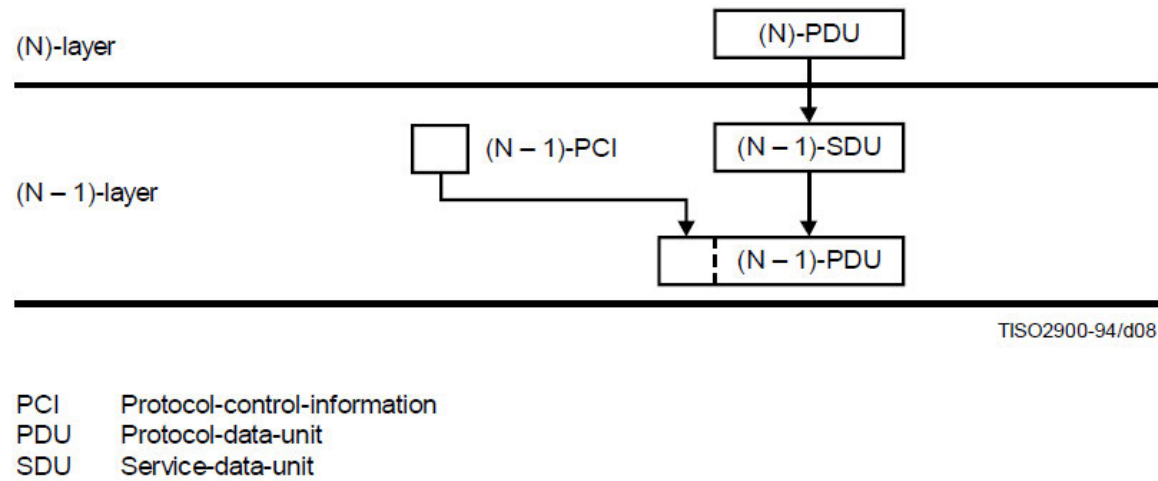
59. In an OSI model, “[i]nformation is transferred in various types of data units.” *See* X.200, §5.6.2.1. There are four main types of data units: user data; protocol control information (“PCI”); protocol data unit (“PDU”); and service data unit (“SDU”). *See id.* §§5.6.1.1-5.6.1.5.

60. User data, which is sometimes called payload, refers to substantive information (e.g., voice, video, text, etc.). *Id.* PCI is supplemental information that enables peer layers of communicating systems to coordinate their operation. *Id.* A PDU is generated by a layer using PCI generated by the layer and a data unit received from an adjacent higher layer. *Id.* An SDU is a data unit that is not interpreted by a layer and is received by the layer from an adjacent layer. *Id.*

61. Relationships between the data units are illustrated below.

	Control	Data	Combined
(N)-(N)-peer-entities	(N)-protocol-control-information	(N)-user-data	(N)-protocol-data-unit

See id. Figure 8.



See id. Figure 9.

62. Electronic systems abstracted in OSI models communicate with each other by passing data units through their respective layers and across physical transmission media that communicatively couples the systems. *See id.* Figure 2.9 of Reynders, reproduced below, illustrates two electronic systems in communication using two OSI models. The following Figure

also shows one example of each layer's PDU.

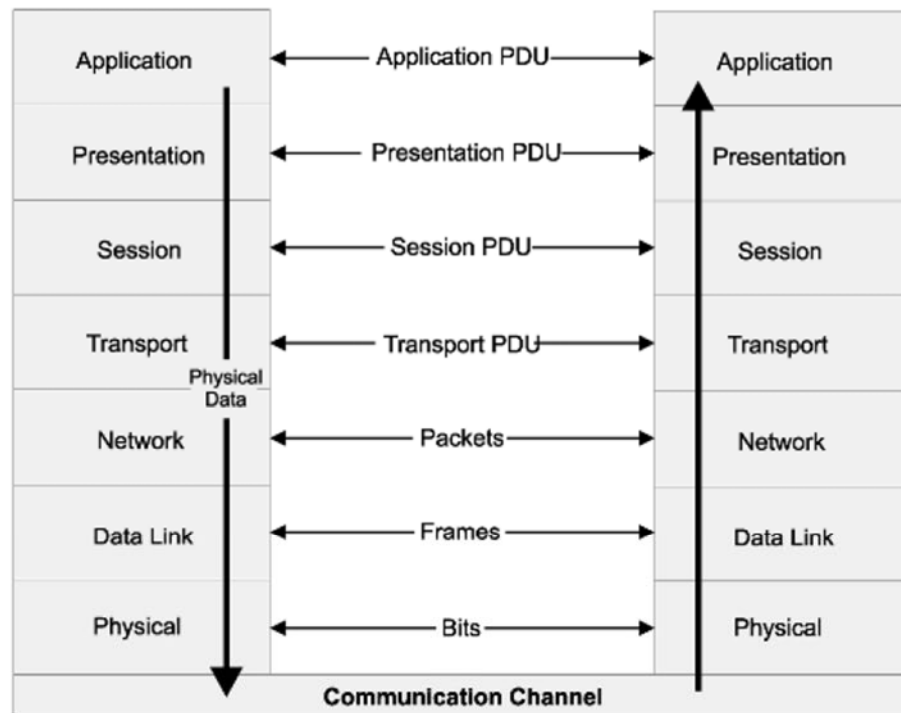


Figure 2.9
Full architecture of OSI model

See Reynders, Figure 2.9, p. 24; *see also id.* §§2.4.1-2.4.10, pp. 20-28.

63. A transmitting system (e.g., the left OSI model in Figure 2.9 above) passes data units “physically down through” its layers, which can include generating a PDU at one of its layers by adding PCI to a data unit received by the layer. *See id.* §2.4.2, pp. 23-24. Furthermore, the receiving system (e.g., the right OSI model in Figure 2.9 above) passes data units physically upward through its layers, which can include generating an SDU at a layer by stripping PCI from a data unit received by the layer. *Id.*

64. Some electronic systems, such as relay or distribution servers whose main function is passing data between other electronic systems, can be abstracted into OSI models made up of less than seven layers. *See X.200*, §6.1.6. One example is shown below. *See id.* Figure 12.

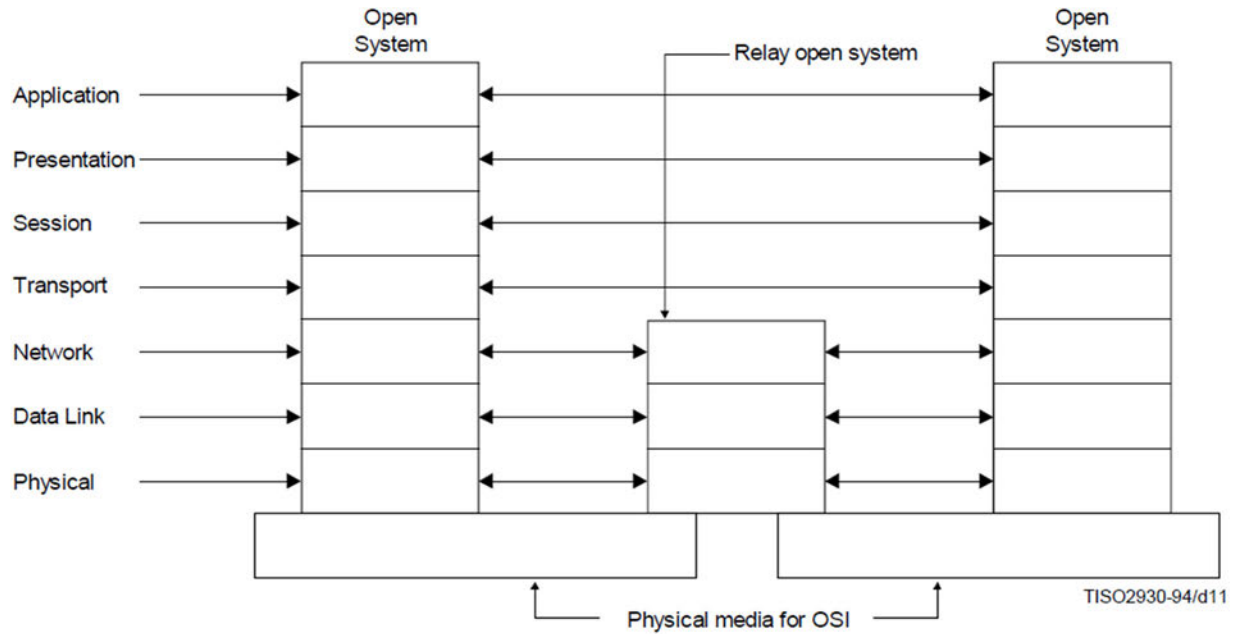


Figure 12 – Communication involving relay open systems

See id.

65. “[P]eer layers across sites communicate with the use of the protocol control information.” *See* Reynders, §2.4.2, p. 24. Consequently, each layer of an OSI model “converse[s] with its peer layer at the other end of the communication channel in a virtual (‘logical’) communication” using PCI. *See id.* p. 21 (quotations in original). This means “there is NO connection or direct communication between the peer layers of” multiple electronic systems that have been abstracted into OSI models. Instead, “all physical communication is across the physical layer, or the lowest layer of the stack.” *See id.* p. 24.

66. A PCI data unit can include a header comprising header information, a trailer comprising trailer information, or a combination of both. *See id.* p. 23. Thus, a layer of an OSI model can add a header, a trailer, or both to a data unit received by the layer from an adjacent higher layer. *Id.* The following Figure shows a non-limiting example of a PDU in each layer of a seven-layer OSI model. In the Figure, each PDU includes a non-limiting example of a PCI data

unit.¹²

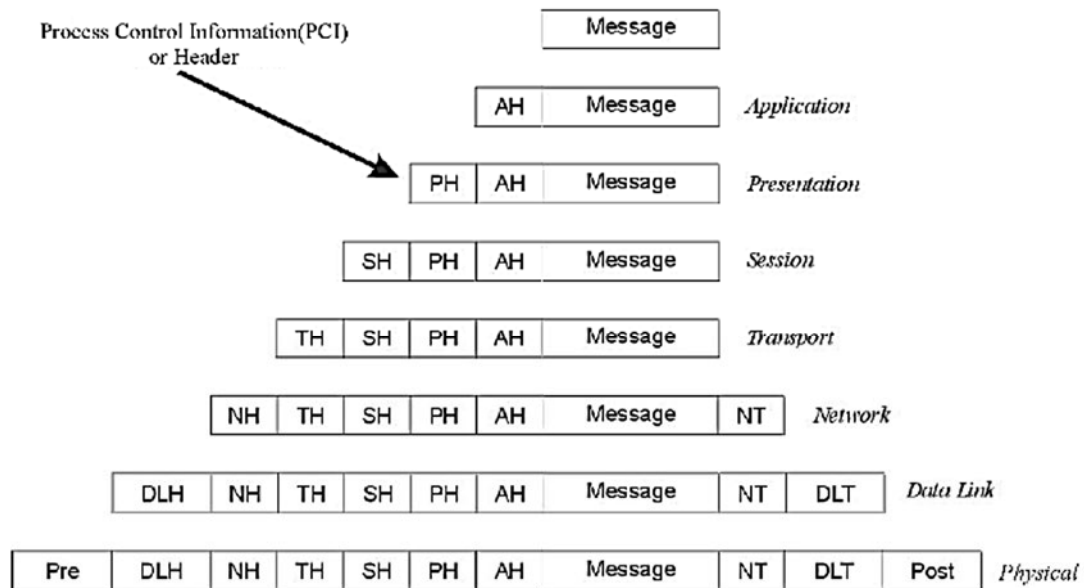


Figure 2.10
OSI message passing

See Reynders, Figure 2.10, p. 24; *see also id.* §2.4.2, pp. 23-24.

C. Shortcomings of Telecommunications Technologies

67. As described in detail above in §VII.B, telecommunication technologies require data communication “across the physical layer.” *See id.* §2.4.2, p. 24. One example of this type of telecommunication technology is xDSL, which can be used to exchange analog and/or digital data between multiple devices, such as between xDSL transceivers of a customer premises and a CO. G.995.1, §5.1. Implementing xDSL requires at least one pair of twisted telephone wires to communicatively couple multiple xDSL transceivers, such as xDSL transceivers at a customer premises and a CO. *Id.* The performance, stability, and data rate or reach of the telephone wires

¹² “AH” denotes the header of the application layer’s PDU. *See* Reynders, Figure 2.10, p. 24. “PH” denotes the header of the presentation layer’s PDU. *Id.* “SH” denotes the header of the session layer’s PDU. *Id.* “TH” denotes the header of the transport layer’s PDU. *Id.* “NH” and “NT” respectively denote the header and the trailer of the network layer’s PDU. *Id.* “DLH” and “DLT” respectively denote the header and the trailer of the data link layer’s PDU. *Id.* “Pre” and “Post” respectively denote the header and trailer of the physical layer’s PDU. *Id.*

can fluctuate in response to unpredictable “environmental conditions.” *See* Jacobsen, §9.1. For example, variations in weather, material quality and age, and electromagnetic energy can introduce noise into communication channels or communicated information, which results in noise that corrupts communicated data with one or more errors. *See id.*

68. Noise can have a negative impact on the quality and stability of telecommunication systems, such as xDSL. Noise can be categorized based on the location of corruption. The categories include, but are not limited to, noise that corrupts data: (i) before a transmitter transmits the data (“hereinafter transmitter noise”); (ii) as the data is passing through the communication channel (hereinafter “channel noise”); and (iii) after a receiver receives the data (hereinafter “receiver noise”).

69. Transmitter and receiver noise typically originates from a faulty component in the transmitter and receiver, respectively. *See* Jacobsen, §7.3.2 (disclosing that power requirements of a DMT transceiver may “require components with higher precision” and a failure to design the transceiver with suitable components will result in unwanted transmitter and/or receiver noise).

70. One example of transmitter and receiver noise corrupts input signals processed by one or more components (e.g., an analog filter, an analog front end). *See id.* §§13.1.1, 13.3.2. This type of noise can be attributable to a component’s age, material quality, and the like. Another example of transmitter and receiver noise is “quantization noise,” which can be introduced into a signal during a quantization operation performed by a digital-to-analog converter (“DAC”) of a transmitter or an analog-to-digital converter (“ADC”) of a receiver. *Id.* Yet another type is “clipping” which is detrimental to DMT symbols in VDSL2 and caused by a DAC’s or ADC’s inability to handle a signal beyond its capabilities. *Id.*

71. Channel noise includes crosstalk noise, impulse noise, radio noise, background

noise, or any combination thereof. *See, e.g.*, Sorbara, §2.6. In the three noise categories, crosstalk noise can have the most detrimental effect on the performance of telecommunication systems, such as xDSL. *See* Starr, T., Cioffi, J., Silverman, P., UNDERSTANDING DIGITAL SUBSCRIBER LINE TECHNOLOGY (Prentice Hall PTR 1999) (“Starr”), §3.6.1. Crosstalk noise occurs when an electromagnetic field radiating from each wire in a twisted pair that is part of a cable comprising multiple twisted pairs of wires causes interferes with the signals communicated by the neighboring twisted pairs of wires. *Id.* For example, a signal being communicated by a twisted pair of wires “crosses” into a neighboring twisted pair of wires, where the signal is seen as noise. *Id.* The crosstalk signal can cause a decrease in the signal-to-noise (“SNR”) of the transmission on the affected twisted pair of wires. *Id.*

72. There are two types of crosstalk noise: near end crosstalk noise (“NEXT”); and far end crosstalk noise (“FEXT”). *Id.* NEXT occurs when signals are communicated in “opposite directions on two twisted pairs of wires” or “between a transmitter and an ‘near-end’ receiver.” *Id.* (quotations in original). FEXT occurs when signals are communicated “in the same direction on two twisted pairs of wires” or “between a transmitter and a ‘far-end’ receiver” on the opposite end of a subscriber loop. *Id.* (quotations in original).

73. Impulse noise consists of bursts of energy “inject[ed]” into a twisted pair of wires carrying a signal. *Id.* §3. These bursts are usually temporary, have a high amplitude, and are generated by sources that are external to the twisted pairs of wires. *Id.* These sources include “electromagnetic events” originating from electrical devices such as motors, power lines, voltage sources, and the like. *See id.*

74. Radio noise, which is sometimes referred as or RF interference (“RFI”) or radio ingress, can also have negative effects on xDSL communications. *Id.* §3.6.2. Radio noise is caused

by RF signals “imping[ing]” on signals communicated using twisted pairs of wires. *Id.* The RF signals can originate from a wide variety of sources, such as “AM radio broadcasts and amateur (HAM) operator transmissions.” *Id.* §3.6.2. Radio noise can reach levels that exceed crosstalk noise levels. *Id.* §3.6.2.

75. Background or intrinsic noise is typically the least detrimental type of noise because it represents a “noise floor”—the lowest possible noise affecting twisted wire pairs. *See* Sorbara, §2.6.1. The noise floor, in one scenario, is based on the assumption that degradation of twisted wire pairs from exposure to thermal energy generated by electronic devices and circuitry implementing xDSL prevents twisted pairs from performing optimally. *See id.*

76. Remedying the above and other shortcomings of telecommunications systems, such as xDSL, can assist with improving communication stability and quality.

D. Error Control

77. Data units may become error-corrupted when subjected to noise during processing and communication. Mitigating noise and its effects (i.e., error corruption of data units) is an important aspect of telecommunications technologies. As used herein, the term “error control” refers to noise and error mitigation.

78. xDSL, for example, achieves error control by detecting and correcting noise using several techniques, including cyclic redundancy check (“CRC”) coding, forward error correction (“FEC”), interleaving, retransmission, or a combination thereof. *See, e.g.,* Jacobsen, §§9.1-9.6; *see also* Sorbara, Glossary.

1. CRC and FEC Coding

79. xDSL uses CRC codes for error detection. *See* Jacobsen, §9.1. CRC coding appends a CRC code (i.e., one or more additional bits) to a data unit comprised of bits. *Id.* The CRC code is calculated based on the data unit’s content (e.g., its bits). *Id.* For example, a CRC

code is a linear, cyclic, block code for appending “ r symbols of redundancy” to a data with a size of “ k symbols” to form a “codeword” comprised of “ $n = k + r$ symbols.” *Id.* §9.2.2 (italics in original). In the resulting CRC codeword, k is the number of “unaltered data symbols,” r is the number of “redundant symbols,” and n is the total number of symbols that make up the codeword.” *Id.* An important capability of CRC error detection is detection of errors *anywhere* in an n -symbol CRC codeword—that is, *anywhere* in the k unaltered data symbols and *anywhere* in the r redundant symbols that make up the n -symbol CRC codeword. *See id.* §9.1. The following Figure illustrates an example of CRC coding.

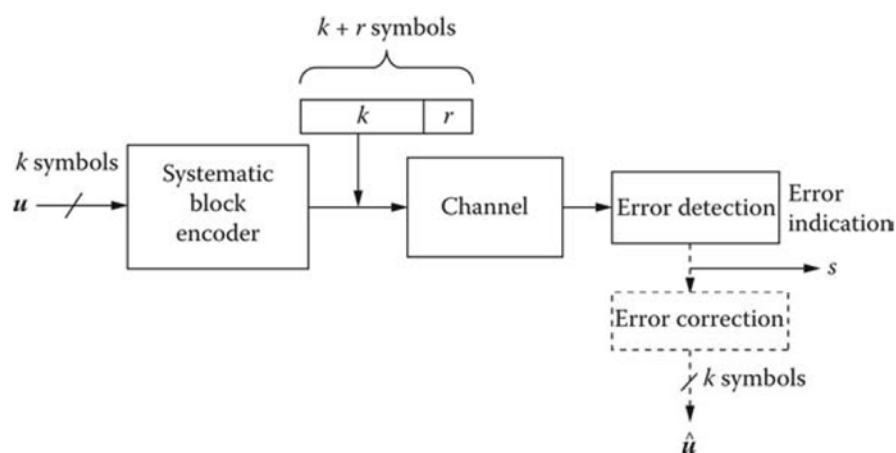


FIGURE 9.1

Illustration of block coding. k information symbols are encoded with r redundant symbols and transmitted over a channel. At the receiver, errors can be detected or possibly corrected.

Id. Figure 9.1.

80. A transmitter can transmit a generated CRC codeword to a receiver, which can process the CRC codeword to determine whether the original data unit has any errors. *Id.* §9.1. If an error exists, the receiver-side CRC codeword generated at the receiver will differ from the transmitted CRC codeword that originated from the transmitter side. *Id.* When the receiver-and transmitter-side CRC codewords match, it is highly unlikely that any error exists. *Id.* An erroneous CRC codeword can be corrected using one or more error correction techniques. *Id.*

§9.1, Figure 9.1.

81. One error correction technique is FEC, which can detect and “correct errors without retransmitting data.” *Id.* §9.2.5. FEC includes using of a coding technique called Hocquenghem, Bose, and Chaudhuri (“BCH”) coding. *See id.* §9.2.3. BCH codes can encode a data unit into a BCH codeword capable of error detection and correction. *Id.*

82. The most common type of BCH coding is Reed-Solomon (“RS” or “R-S”) coding. *Id.* §9.2.5. RS codes are a subclass of BCH codes that are “used widely in DSL for error correction” because they “provide powerful error correction capability for relatively little overhead.” *Id.* A data unit with a size of k unaltered data symbols intended for communication is used, together with an RS code, to generate an RS codeword with a size of n symbols comprised of k number of unaltered data symbols and r number of redundant symbols. *Id.* The RS code enables correction of t errors that occur anywhere in the n -symbol RS codeword at the receiver. *Id.*; *see also* §9.1. In one scenario, an RS code can correct up to $t = (r \div 2)$ errors anywhere in an n -symbol RS codeword made up of k number of unaltered data symbols and r number of redundant symbols. *Id.* §9.2.6. However, RS coding is limited in that, “[i]f the number of errors exceeds the capability of the [RS] code, the errors cannot be corrected.” *Id.* §9.2.7. For example, when there are more than t errors in an RS codeword made up of n symbols = (k unaltered data symbols + r redundant symbols), the errors in the RS codeword cannot be corrected by an RS code designed to correct no more than t errors. *Id.* In this and other similar scenarios, other error correction techniques, such as interleaving, retransmission of error-free copies of data, or a combination thereof may be used. Each of these techniques are described in further detail below.

2. Interleaving

83. Interleaving is a type of error control technique that may remedy at least one

limitation of FEC based on RS coding. *Id.* §9.2.7.1. In particular, RS coding can be paired with an interleaving technique at the transmitter to “combat long bursts of errors” in data at the receiver. *Id.* §§9.1, 9.4. An interleaver is “a device that accepts codewords from a finite alphabet and returns the identical codewords but in a different order.” *Id.* §9.4. Interleaving is performed after modification of a data unit using an RS code. *Id.* Specifically, interleaving consists of “spread[ing] the data out or shuffl[ing] the data after it is encoded by the Reed-Solomon code. This way, if there is a long burst of errors, the errors will be evenly distributed over many [RS] codewords. If the data is sufficiently shuffled so that each [RS] codeword has only a small number of errors, the [RS] code will correct them.” *Id.* Consequently, an interleaver can “spread long strings of errors over several RS codewords.” *Id.* The spreading is sufficient to correct a burst of errors if the burst causes no more than t errors in any one RS codeword made up of n symbols = (k unaltered data symbols + r redundant symbols) when the RS code is designed to correct no more than t errors. *Id.*; *see also id.* §9.1.

84. There are at least two types of interleaving—block interleaving and convolutional interleaving. *Id.* Block interleaving requires a block of data represented using RS codewords to be written into columns of a rectangular array and read out from the rows of the rectangular array. *Id.* In this way, a block interleaver generates any entirely new set of RS codewords from the original RS codewords. The number of columns of the rectangular array is a depth of the interleaver, which is a pre-determined separation between adjacent symbols from the same codeword that is measured in symbols. *Id.* Each row of the rectangular array is a newly generated RS codeword that is made up of I number of symbols. *Id.* Note that a new generated RS codeword’s size (i.e., I number of symbols) can be less than or equal to the original RS codeword’s size (i.e., n number of symbols). *See id.* For example, I can be a divisor of n . *Id.*

Following interleaving, a transmitter communicates the interleaved RS codewords to a receiver, where an inverse of the interleaving process called deinterleaving is applied to the interleaved RS codewords to recover the original RS codeword. *Id.*

85. In some scenarios, a data unit encoded into an RS codewords may be inflicted with eight consecutive errors. Here, each RS codeword has a size n of 7 symbols and an RS code for the RS codeword is designed to correct no more than $t = 2$ errors. In this situation, the RS code would be unable to correct the errors because the RS code cannot correct the extra six errors. The uncorrectable errors could cause decoder errors at the receiver. *See id.* Interleaving may be used to mitigate or eliminate this issue. *See id.* For this example, interleaving will be performed using an interleaver depth d of 4 and an interleaved codeword size of $I = n$, which is 7 symbols. The result is shown below.

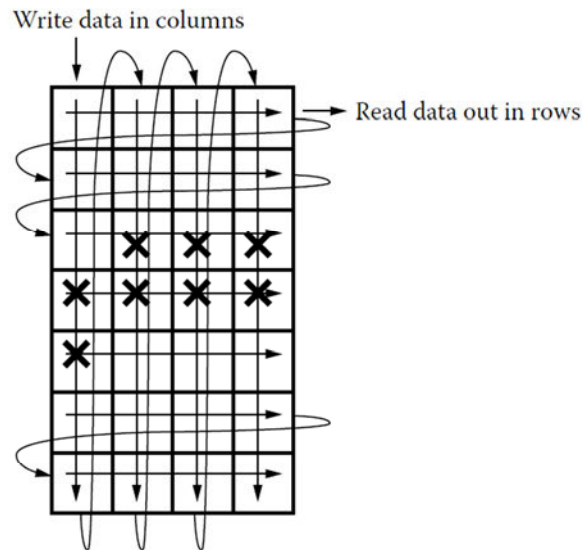


FIGURE 9.12

Block interleaver with seven rows and four columns. Codewords are written in columns and then read out in rows. As an example, each of eight consecutive errors is marked by an X. Each codeword has only two errors.

See id. Figure 9.12.

86. As shown above, interleaving produces four rearranged RS codewords from the original RS codeword, which are read out as rows. In this way, each newly generated RS

codeword only has two errors, which can be fixed by an RS code designed to correct no more than $t = 2$ errors.

87. Block interleaving is not without limitations. For example, a sizeable amount of memory is required to perform block interleaving when compared to using RS coding alone. *Id.* Performing interleaving necessarily introduces latency into telecommunications processes, which would in turn increase data travel times. *See* Bingham, J., ADSL, VDSL, AND MULTICARRIER MODULATION (John Wiley & Sons, Inc. 2000), (“Bingham”), §8.2.5. In block interleaving, all rearranged RS codewords produced by interleaving an original RS codeword must be written into or read out of the interleaver memory before communication can occur. *Id.* Additionally, and in block interleaving, all rearranged RS codewords produced by interleaving an original RS codeword must be written into or read out of the deinterleaver memory before the original RS codeword can be recovered. *Id.* Consequently, as a depth associated with interleaving increases, the number of read/write operations in memory associated with interleaving also increases. As processing times increase, telecommunications are delayed. *Id.*

88. Convolutional interleaving is an alternative to block interleaving that is more memory-efficient. *Id.* This type of interleaving is similar to block interleaving in that symbols are written into a rectangular array in columns and read out in rows. *Id.* Unlike block interleaving, however, convolutional interleaving does not require the memory to be filled before symbols are read. *Id.*; *see also* Jacobsen, §9.4.

3. Retransmission and ARQ

89. Retransmission, commonly referred to as automatic repeat request (ARQ), is an old, well-known, and well-understood technique in which a transmitter resends a block of data, which can be referred to as a packet, to a receiver after the receiver reports, or the transmitter infers, that the received packet was not received error-free. As of 1964, “[e]rror detection

combined with retransmissions on request [had] been used for many years as a means of obtaining reliability in digital data transmission.” R.J. Benice and A.H. Frey, Jr., “An Analysis of Retransmission Systems,” *IEEE Trans. On Comm. Tech.*, vol. 12, no. 4, 135-145, Dec. 1964 (“Benice I”), 135.

90. Each packet includes overhead in the form of bits (e.g., parity bits or a CRC) that allow the receiver to determine whether the received packet contains errors. If there are no errors, the receiving transceiver sends a positive acknowledgment (ACK) to the transmitting transceiver. If there are errors, the receiving transceiver sends a negative acknowledgment (NACK) to the transmitting transceiver. In response to a NACK, the transmitter sends the packet again. If the transmitting transceiver does not receive either an ACK or NACK within a specified time period after transmitting a packet (referred to in the art as a time-out period), it assumes the packet was not received correctly and retransmits it.

91. The transmitting transceiver retains each transmitted packet in a buffer (memory) until it receives a corresponding ACK. Therefore, implementing a retransmission protocol requires memory in at least the transmitter. The amount of memory needed depends on the retransmission protocol.

92. It was known well before the priority date of the Family 9 patents that retransmission can be used instead of or in addition to FEC coding and/or interleaving. For example, in the 1970s, the use of FEC coding was considered to be both an alternative and a complement to ARQ. *See, e.g.*, Burton, 1300 (disclosing that in high-error-rate environments, “a more symptomatic treatment of the problem would be to imbed a forward-error-correcting code within the ARQ system”); *id.* (“it is likely that the more elegant FEC techniques discussed in this paper will be limited to applications where the customer cannot, or prefers not to, use

retransmission. Where ARQ systems are used, the role of FEC will most likely be a minor one, involving relatively simple short high-rate codes, designed for a limited amount of error correction.”).

93. Similarly, ARQ was known to be an alternative to interleaving. *See, e.g.*, ITU-T SG15/Q4 Contribution BI-089, G.gen: ARQ for ADSL Transceivers, Oct. 2000 (“BI-089”), 1 (“the use of ARQ will reduce or eliminate the need for interleaving”).

a. ARQ Approaches

94. There are several ARQ approaches. In this expert report, I will describe three of them, which I refer to as “stop-and-wait ARQ,” “go-back-*N* ARQ,” and “selective repeat ARQ.” Each of these approaches has been known in the art since at least the 1980s. *See, e.g.*, Lin *et al.*, “Automatic-Repeat-Request Error-Control Schemes,” IEEE Communications Magazine Vol. 22, No. 12 (Dec. 1984) (“Lin”) at 6-7.

95. In stop-and-wait ARQ, the transmitter sends a packet and then waits for an ACK before sending the next packet. *See, e.g.*, RFC 3366 (Aug. 2002) at 7. (Depending on the type of communication system, the transmitter might transmit nothing between packets, or it might send “idle” packets or some other signal to help the receiver remain connected.) If the transmitting transceiver receives a NACK, or the time-out period expires without the transmitting receiver having received an ACK, the transmitter retransmits the packet. *See id.*

96. An obvious disadvantage of stop-and-wait ARQ is that it is inefficient because the transmitter must wait for each packet to be positively acknowledged before transmitting the next packet. *See id.* The overall throughput is dependent on whether retransmission is needed, and, if so, how many times.

97. A benefit of stop-and-wait ARQ is that it requires a known, small amount of memory to implement. The transmitter only has to retain the last-transmitted packet while it waits

for a positive acknowledgment. The receiver does not need any additional memory to implement stop-and-wait ARQ because all packets arrive in order, are acknowledged in order, and are passed on in order to the next component or function in the receive path.

98. In contrast to stop-and-wait ARQ, other ARQ protocols—sometimes referred to collectively as “sliding-window protocols”—avoided the need to pause after transmitting each packet by assigning each packet a number, so that multiple packets could be tracked at once. *See, e.g., RFC 3366 at 7-8.* One example of such an ARQ approach that provides better throughput than stop-and-wait ARQ, but also requires more memory, is referred to as go-back- N ARQ. In this approach, the transmitter sends a packet with index i and then continues to transmit subsequent packets with indices $i + 1$, $i + 2$, etc. while waiting for the ACK for packet i . Assuming that the transmitter sends a total of $N - 1$ additional packets before it expects to receive the ACK or NACK for packet i , when the transmitter receives a NACK for packet i , or it experiences a time-out, it retransmits packet i as well as all of the $N - 1$ packets transmitted after packet i .

99. Relative to stop-and-wait ARQ, go-back- N ARQ provides better throughput because the transmitter does not waste time waiting for ACKs. Go-back- N ARQ is still inefficient, however, because the transmitter retransmits N packets every time one received packet has errors (or is not received). If the communication channel causes a significant number of errors, the throughput of go-back- N ARQ can be poor.

100. In addition, because the transmitter generally has multiple unacknowledged transmitted packets outstanding, each packet needs to include an identifier or index, often referred to as a sequence identifier, so that the transmitter knows which packet is being acknowledged (positively or negatively).

101. Another drawback is that implementing go-back- N ARQ requires memory in the transmitter because the transmitter must temporarily store all N packets it might need to retransmit. The amount of memory needed can be determined and fixed, however: it is the amount needed to store N packets. In operation, assuming the memory size has been selected to accommodate the longest acknowledgment delays and the largest packet sizes, the transmitter's memory requirements will not exceed the amount of memory provided for temporary storage of transmitted packets.

102. A receiver implementing go-back- N ARQ does not need to provide any additional memory for retransmission because the transmitter will resend all packets it sent after the errored packet. Once the receiver detects an errored i th packet, it can simply discard all packets received after the i th packet until it receives the i th packet without errors. Thus, the receiver does not need to provide any additional memory to implement go-back- N ARQ because it will always receive the packets in the correct order.

103. In selective repeat ARQ, the transmitter continues to transmit subsequent packets while waiting for ACKs of previously transmitted packets. When it receives a NACK or experiences a time-out for the i th packet, it retransmits only the i th packet.

104. Relative to stop-and-wait ARQ and go-back- N ARQ, selective repeat provides the best efficiency because the transmitter does not waste time waiting for ACKs, and when it receives a NACK or experiences a time-out for the i th packet, it retransmits only the i th packet.

105. The primary drawback of selective repeat ARQ is its complexity. As in go-back- N ARQ, a transmitter that implements selective repeat ARQ must store all of the packets it might need to retransmit, which includes all packets transmitted but not yet positively acknowledged by the receiver. As compared to the go-back- N approach, the amount of memory needed may need

to be significantly larger if the communication channel is expected to be noisy. If the amount of memory provided turns out to be insufficient in operation due to the channel error rate being high, the transmitter will drop data.

106. Another factor that increases the complexity of selective repeat ARQ is that the transmitter must keep track of which packets have been positively acknowledged and which have not. In addition, the transmitter must insert packets to be retransmitted in its transmit queue.

107. A receiver implementing selective repeat ARQ is also more complex than a receiver implementing either stop-and-wait or go-back- N ARQ. First, because the transmitter does not retransmit any packet that was positively acknowledged, the receiver must provide a buffer (memory) to store the packets received correctly after an errored packet so that it can put the received packets back into the correct sequence once it receives the retransmitted packet. As with that of the transmitter, the amount of memory needed by the receiver is difficult to determine because it is dependent on the error rate of the channel. If the amount of memory provided turns out to be insufficient in operation due to the channel error rate being high, the receiver will drop data. *See, e.g.,* Z. Rosberg and N. Shacham, “Resequencing Delay and Buffer Occupancy Under the Selective-Repeat ARQ,” *IEEE Trans. On Information Theory*, Vol. 35, No. 1, 166-73, 167, Jan. 1989 (“Rosberg”) (“performance under selective-repeat is strongly dependent on the buffer capacity at the receiver. If that capacity does not meet the demand arising from the packet arrivals and the error rate, performance deteriorates drastically. . . . [O]ne has to be very careful when designing the size of the resequencing buffer.”).

108. Thus, there are tradeoffs between efficiency and memory requirements of ARQ approaches. Stop-and-wait ARQ requires little memory but also has poor throughput because the transmitter waits for each packet to be positively acknowledged before transmitting the next one.

Go-back- N ARQ has better throughput, but it requires more memory at the transmitter. Selective repeat ARQ provides the best throughput, because only packets received in error are retransmitted, but it requires additional memory at both the transmitter and receiver. *See, e.g.,* M.J. Miller and S. Lin, “The Analysis of Some Selective-Repeat ARQ Schemes with Finite Receiver Buffer,” *IEEE Trans. On Comm.*, Vol. COM-20, No. 9, 1307-15, Sep. 1981 (“Miller”), 1314 (selective repeat ARQ can achieve “markedly superior throughput performance . . . over Go-Back N schemes for channels with high bit rate and large round-trip delay. This improvement is at the expense of required logic complexity and buffer storage provision in the transmitter and receiver.”); Rosberg, 166 (“The resequencing buffer requirements [of selective repeat ARQ] and the resulting packet delay constitute major factors in overall system considerations.”).

109. By the 1980s, the benefits and drawbacks of the various ARQ approaches in the presence of different types of error environments (i.e., performance in the presence of random errors versus performance in the presence of error bursts) had been studied. It was known, for example, that go-back- N ARQ “exhibits much lower message delays than [stop-and-wait ARQ], particularly as the ACK delay increases.” D. Towsley, “A Statistical Analysis of ARQ Protocols Operating in a Nonindependent Error Environment,” *IEEE Trans. On Comm.*, Vol. COM-29, No. 7, 971-81, Jul. 1981 (“Towsley”), 978. It was also known that go-back- N ARQ does not perform as well as selective repeat ARQ “under high error conditions and long ACK delays,” but it is “simpler to implement,” and the difference in performance “decreases as the error process becomes burstier for a fixed overall error rate.” *Id.* Furthermore, it was known that “[a]s the error process becomes burstier, the expected queue lengths under [selective repeat ARQ] always increase.” *Id.*

110. Accordingly, it has long been understood that the best ARQ approach to use

depends on the application and the expected error environment. *See, e.g.,* R.J. Benice and A.H. Frey, Jr., “Comparisons of Error Control Techniques,” *IEEE Trans. On Comm. Tech.*, vol. 12, no. 4, 146-54, Dec. 1964 (“Benice II”), 149 (“No one of the three logics considered has systems characteristics which make it the most desirable for all applied situations, nor does any one of the logics exhibit universal superiority in efficiency and reliability. Consequently, the selection of one retransmission logic over another for a particular application requires a consideration of the peculiarities of each logic in addition to a determination of which logic offers advantages in efficiency or reliability.”); Towsley, 980 (“The throughput of [stop-and-wait ARQ] and [selective repeat ARQ] protocols is determined solely by the overall error rate. In contrast, the throughput of the [go-back- N ARQ] protocol is highly sensitive to other aspect of the error process. This sensitivity increases as N increases. . . . As the process becomes less random, performance always degrades for the [stop-and-wait ARQ] and [selective repeat ARQ] protocols. This is not always the case for [go-back- N ARQ]. We also observed that the performance of [go-back- N ARQ] in an environment of bursty errors and high error rates can approach that of [selective repeat ARQ].”).

b. ARQ Delay and Delay Jitter

111. As is clear from the above discussion of ARQ approaches, retransmission introduces delay. First, any individual packet that needs to be retransmitted is delayed by at least the sum of (1) the round-trip delay of the channel, (2) the amount of time it takes for the receiving transceiver to determine that the packet has errors and prepare send a NACK, or the time-out period at the transmitter (if the transmitter does not receive an ACK or NACK at all), and (3) the amount of time the transmitting transceiver needs to prepare and retransmit the packet.

112. Second, if a packet that is being retransmitted is part of a sequence of packets that are processed together by the receiver, the need for that packet to be retransmitted delays the

processing of the sequence. For example, if a packet contains a portion of a message, that message cannot be processed by the receiver until all of the portions have been received. If the packets are received out of order, as in selective repeat ARQ, they must be put back into the proper order before subsequent processing. The delay due to the reordering can be referred to as the “resequencing delay.” *See, e.g.*, Rosberg, 166 (“Under the selective-repeat ARQ, however, those packets must be stored in the receiver’s buffers until they can be sent out in the original order. The buffer needed for this purpose is referred to as a resequencing buffer, and the time that packets spend there as resequencing delay.”).

113. It is also clear from the discussion above that unlike the delay caused by interleaving and deinterleaving, which is predictable, bounded (e.g., by a maximum latency constraint), and consistent, the delay caused by retransmission can vary. A packet could experience minimal delay if it is received without errors, or it could experience a large delay if it has to be retransmitted several times. Thus, retransmission results in delay variability, which can also be referred to as delay jitter. Although some applications may be able to tolerate delay jitter (e.g., a file download), others cannot (e.g., telephony). *See, e.g.*, PF-042, §1.1 (“Most real time services, especially interactive applications such as telephony and video teleconferences, can only tolerate a finite amount of latency and jitter. Latency and jitter specifications also affect the memory requirements in the hardware design.”).

114. It was known in the DSL field before the priority date of the Family 9 patents that the use of an ARQ protocol results in latency and delay jitter. *See, e.g.*, PF-042, §1.1 (disclosing that using ARQ protocol has a “cost of increasing latency and jitter.”).

c. ARQ v. Interleaving

115. It was known before the priority date of the Family 9 patents that ARQ can be used in addition to or instead of interleaving. For example, BI-089, a contribution to the ITU-T

SG15/Q4 group in October of 2000, explained that the use of retransmission “will provide a performance improvement” for DSL systems, and “will reduce or eliminate the need for interleaving.” BI-089, 1. BI-089 proposed that “when ARQ is applied, interleaving be reduced or eliminated[,] thereby freeing memory resources for ARQ as well as to reduce or eliminate the interleaver delay so as to compensate for the delay introduced by ARQ.” *Id.*, §5.

d. Retransmission in DSL

116. The benefits and drawbacks of ARQ were well known to those working in DSL before the priority date of the Family 9 patents. For example, in October 2000, Catena Networks submitted a contribution to the SG15/Q4 working group that included a proposal to implement data compression in ADSL transceivers. ITU-T SG15/Q4 contribution BI-066, G.gen: G.dmt.bis: G.lite.bis: Strawman Proposal for the Implementation of Data Compression in ADSL Modems (Oct. 2000) (“BI-066”), 1 (“This document provides a strawman proposal for the implementation of data compression as a sub-function of the ATM-TC.”). As a starting point, the proposal described how voiceband modems implement data compression, including their use of V.42, which BI-066 describes as “a generic framing protocol, which creates an error free link, based on a less reliable platform below it . . . by adding error correction using an ARQ protocol, which requests a retransmission of data, if the receiver detects a bit error.” BI-066, 2. The author of BI-066 considered this approach to have “issues,” including “[u]npredictable latency requirements due to V.42 ARQ.” *Id.* Another issue was that “[t]he repeated retransmissions introduce jitter and buffering requirements in the ADSL link,” which is “undesirable because ADSL has a relatively high ratio of latency to data rate.” *Id.* BI-066 noted that “the buffers [for ADSL] have to be larger than those implemented in voice band modems,” and that “[i]n the time that it takes a retransmission request to return from the far end, the transmitter has to buffer all the data that it has been transmitting.” *Id.* The buffering requirement is exacerbated because “this time is

multiplied by the maximum number of retransmissions allowed.” *Id.* BI-066 noted that SG15/Q4 could nevertheless adopt such an approach and “accept the limitations that come with an ARQ protocol.” *Id.*, 5.

117. The use of ARQ for ADSL was described by Alcatel in a conference paper in 2000. P. Antoine, “Parallel Concatenated Trellis Coded Modulation with Automatic Repeat Request for ADSL Applications,” in *Proc. of 2000 IEEE Intl. Conf. on Comms. (ICC 2000)*, Vol. 2, pp. 1075-79 (“Antoine”), 1075. The paper proposed to use ARQ along with parallel concatenated trellis coded modulation (PCTCM) for ADSL. *Id.* Recognizing that “ARQ is a well known method to achieve high reliability in digital transmission schemes,” the paper suggested that “ARQ based on PCTCM is particularly suitable for ADSL applications.” *Id.*, 1077. Although ARQ could ordinarily cause a substantial decrease in throughput, limiting the number of retransmissions to one would lead to an acceptable reduction in throughput for ADSL because the error rate is “very low,” meaning that “very few sequences have to be retransmitted.” *Id.*

118. It was well known as of the Family 9 patents’ priority date that retransmission can be particularly helpful in the presence of certain types of noise likely to affect DSL, including impulse noise. For example, Alcatel noted in its 2000 conference paper that one benefit of using ARQ in an ADSL system is that “it makes the system immune to impulse noise.” *Id.*, 1079; *see also id.*, 1077 (“ARQ based on PCTCM improves robustness against impulse noise.”).

119. 3Com made similar observations in its contribution BI-089 to the SG15/Q4 working group, which discusses the benefits of using ARQ along with Reed-Solomon FEC coding in ADSL. BI-089, Abstract. After noting that “the data in ADSL channels occasionally gets corrupted even with adding a 4-6 dB margin,” 3Com speculated that the burst errors observed in ADSL “must be” due to impulse noise. *Id.*, §3. Because “[i]t is already known that ARQ offers

substantial performance improvements in bursty channels,” (*id.*, §4), “ARQ is a natural and convenient method to fight the impulse noise.” *Id.*, §3. 3; *see also id.* (“The real benefit of ARQ is in the bursty channel where the likelihood of FEC failing to correct a frame increases.”).

120. Retransmission was not merely known in the DSL field well before the priority date of the Family 9 patents. It had also been incorporated into DSL standards. *See, e.g.*, G.993.2, §12.2.2.1-2 (indicating that a data unit may be retransmitted at least once to improve the likelihood that the data unit is received without errors or in response to the data unit being received with errors). For example, when a DSL transceiver on one end of a line wants to establish a connection with a DSL transceiver on the other end of the line, the transceivers execute what is known as a “handshake” procedure before beginning the initialization procedure specified for the type of DSL (e.g., ADSL2, VDSL2, etc.). The handshake procedures for DSL are standardized in ITU-T Recommendation G.994.1, which is sometimes also referred to as “G.hs” or “G.handshake.” By 2003, G.handshake included a “Retransmission Message” that allowed either transceiver to request retransmission “in response to the reception of an errored frame.” ITU-T Recommendation G.994.1, Handshake procedures for digital subscriber line (DSL) transceivers, (05/2003) (“G.994.1”), §7.15; *see also id.*, §10.5 (“Retransmission transactions occur whenever an HSTU [handshake transceiver unit] receives an errored frame and wishes to transmit the REQ-RTX [retransmission request] message to initiate a retransmission instead of transmitting the NAK-EF [abort handshake] message.”), §4 (indicating that HSTU stands for “Handshake Transceiver Unit”), §12 (indicating that NAK-EF message indicates that receiving transceiver is aborting handshake session).

4. Combinations of Techniques for Error Control

121. Error control can also be achieved by combining at least two of the preceding techniques. *See, e.g.*, Fukushima, 26:45-28:34 (indicating that at least two of CRC coding, FEC,

and retransmission may be used together); *see also* U.S. Patent No. 5,907,563 (“Takeuchi”), Figures 7-8 and accompanying text; Lin at 11-15 (discussing “Hybrid ARQ Error-Control Schemes”).

E. Memory Management

122. Before the priority date of the Family 9 patents, it was known in the art that memory is a finite resource that must be managed. *See, e.g.*, ITU-T SG15/Q4 contribution PF-042, The proposed MAC for PNT3, (“PF-042”) (Aug. 2003), §3.2.1 (“Failure to balance memory and media resource allocation can cause over-utilization of scarce memory resources by aggressive best-effort applications (e.g. FTP). Efficient memory management is also important in designing consumer affordable consumer products, because memory is a costly resource.”).

123. As I explain further in the prior art discussion below, the idea of a transceiver sharing a common memory for multiple functions was well known as of the priority date of the Family 9 patents.

124. There are two ways to provide memory for the functions of an apparatus or system. One way is to provide a dedicated, permanently allocated quantity of memory to each function so that each function is always guaranteed access to its assigned memory. I will refer to this approach as using “dedicated memory.” One advantage of using dedicated memory is that resource management is simple because each function that needs memory always has access to its assigned memory, and the quantity of memory that is available is always known. The obvious disadvantage of using dedicated memory is that the amount of memory allocated to each function must be the maximum amount of memory that function might need, or there is a risk that the function will not have enough memory. Providing for each function the maximum amount of memory that function might ever need is expensive. It may be the case, however, that under typical conditions, various functions do not need some or all of their assigned memory, in which case the assigned memory

is underutilized.

125. The other way to provide memory for the functions of an apparatus or system is to provide a pool of memory that can be flexibly allocated to different functions at different times depending on need. I will refer to this approach as using “shared memory.” One advantage of shared memory is its flexibility. Memory that might otherwise be unused if always dedicated to a particular function can be assigned (e.g., temporarily) to a function that needs it. The disadvantage of using shared memory is that assignments of memory must be managed to avoid conflicts between functions (e.g., if two functions try to use the same memory locations at the same time) and to ensure that the memory allocations to various functions do not exceed the total amount of memory available.

126. By the priority date of the Family 9 patents, the disadvantages of dedicated memory were well known. *See, e.g.*, U.S. 7,266,132 (“Liu”), 1:36-47 (“Static memory used by a network device gives each data for each channel a set amount of memory space for storage. This constant and predetermined memory space size is established conservatively to account for all possible data demands in a particular channel. For static allocation to work, the static allocation must allocate for the worst case. Since the majority of bit streams being processed are much smaller than this conservative estimation, static memory schemes usually result in excessive memory allotment. This increases network device costs.”).

127. By the mid-1990s, it was commonplace for computers to use shared memory. *See, e.g.*, J.L. Hennessy and D.A. Patterson, “Computer Architecture A Quantitative Approach, Second Edition,” 1996 (“Hennessy”), p. 439 (“It would be too expensive to dedicate a full-address-space worth of memory for each process, especially since many processes use only a small part of their address space. Hence, there must be a means of sharing a smaller amount of

physical memory among many processes. One way to do this, *virtual memory*, divides physical memory into blocks and allocates them to different processes.”) (italics in original). For example, the C programming language has a built-in function going back to its 1970s origins that allows a program to dynamically request memory allocation. *See, e.g.*, Brian Kernighan, Dennis Richie, *The C Programming Language* (2nd Ed. Prentice Hall 1988) (1978) at 143. The function to allocate memory is `malloc()`. *Id.* The function `calloc()` allocates contiguous blocks while `free()` releases memory allocations. *Id.* at 167.

F. Shared Interleaver/Deinterleaver Memory

128. The use of shared memory for interleaving and deinterleaving was well known as of the priority date of the Family 9 patents.

129. For convenience, I will sometimes distinguish in this Report between a “near-end” transceiver and the “far-end” transceiver that is on the other side of a communication channel from the near-end transceiver. When the transmitter of a near-end transceiver performs interleaving, the transmitter needs to have access to an amount of memory sufficient for the transmitter to perform the interleaving procedure. Likewise, when the transmitter in the far-end transceiver performs interleaving, the near-end transceiver’s receiver must have access to an amount of memory sufficient to enable it to deinterleave the data interleaved by the far-end transceiver’s transmitter. And, of course, the far-end transceiver needs sufficient memory to deinterleave the data transmitted by the near-end transmitter and to interleave the data it is transmitting to the near-end receiver.

130. There are two ways to provide the memory needed for a transceiver’s interleaving and deinterleaving procedures. The first way is to provide a specified amount of dedicated interleaver memory and a specified amount of dedicated deinterleaver memory. The transmitter has exclusive access to the interleaver memory and can, at least in theory, use as much as all of

the interleaver memory for interleaving. Similarly, the receiver has exclusive access to the deinterleaver memory and can, at least in theory, use as much as all of the deinterleaver memory for deinterleaving.

131. The second way to meet the transceiver's memory requirements for interleaving and deinterleaving is to provide shared memory that the transceiver can partition between its interleaver and deinterleaver. Use of a shared memory for interleaving and deinterleaving, including in DSL, was well known before the priority date of the Family 9 patents. *See, e.g.*, U.S. Patent Pub. No. 2005/0034046 by Berkmann *et al.* ("Berkmann"), §(57) (Abstract) (disclosing a "combined interleaving and deinterleaving circuit" with "data memory (RAM) for temporary storage of the data to be interleaved and deinterleaved"); U.S. Patent No. 6,707,822 to Fadavi-Ardekani *et al.* ("Fadavi-Ardekani"), §(57) (Abstract) (disclosing an "Interleave/De-Interleave Memory" that "is shared by multiple ADSL sessions and by the transmit and receive processes within an individual session"); U.S. Patent No. 6,381,728 to Kang ("Kang"), col. 5:35-38 (disclosing "double buffering [that] allows the channel interleaver memory to be used, along with the app memory, as the turbo deinterleaver memory"); U.S. Patent Application Publication No. 2003/0021338 to Mazzoni *et al.* ("Mazzoni"), §(57) (Abstract) (disclosing memory having "a first memory space ESM1 assigned to the interleaver means and a second memory space ESM2 assigned to the deinterleaving means"); *id.*, ¶[0002] ("The invention is advantageously be applied to a (VDSL) (Very High Rate Digital Subscriber Line) environment or system. . ."); U.S. Patent No. 5,751,741 to Voith *et al.* ("Voith"), col. 4:47-50 (disclosing external interleave/deinterleave memory used by both transmitter for interleaving and receiver for deinterleaving); *id.* at col. 2:61-64 ("Generally, the present invention provides an ADSL transceiver. . .").

132. Once the shared memory has been partitioned between the transmitter's interleaver

and the receiver's deinterleaver, the transmitter has exclusive access to the portion of the shared memory allocated for interleaving and can, at least in theory, use as much as all of that portion of the shared memory for interleaving. Similarly, the receiver has exclusive access to the portion of the shared memory allocated for deinterleaving and can, at least in theory, use as much as all of that portion of the shared memory for deinterleaving. When a connection terminates, the shared memory can thereafter be repartitioned, possibly differently, when new connections are established.

133. Because the interleaving procedure is performed by one transceiver, and the corresponding deinterleaving procedure is performed by a different transceiver, it is necessary for at least one of the transceivers to know the capabilities or requirements of the other transceiver in order to configure the interleaver (or deinterleaver). Otherwise, for example, the transceiver performing the interleaving procedure could use an interleave depth that requires more memory than is available to the transceiver performing the deinterleaving procedure.

134. For example, before the near-end transceiver can configure its interleaver, which establishes how much of the memory available for interleaving (in either a dedicated memory or shared memory) the transmitter will use, it needs to know something about the far-end transceiver's deinterleaving capabilities; otherwise, the near-end transmitter could perform an interleaving procedure that the far-end receiver is incapable of reversing (e.g., because it does not have sufficient memory). In addition, before the near-end transceiver can configure its deinterleaver, which establishes how much of the memory available for deinterleaving (in either a dedicated memory or shared memory) the receiver will use, it needs to know how the far-end transceiver will be interleaving the data; otherwise, the near-end receiver will be unable to perform the corresponding deinterleaving procedure.

135. As discussed below, since 1995, the ADSL and VDSL standards have provided for the near-end and far-end transceivers to communicate their interleaving requirements and/or capabilities to each other during an initialization procedure.

G. PTM-TC

136. The acronym “PTM-TC” stands for “Packet Transfer Mode – Transmission Convergence,” a DSL-specific term, but the underlying concept is not unique to DSL. “Packet transfer” refers to the fact that data in a DSL system is not transmitted as a continuous data stream but is separated into discrete packets. “Transmission convergence” refers to incoming data: if incoming data is already in packet form, it can be transmitted as-is, but if it is a continuous stream, it will be rearranged and broken into packets.

137. In DSL, information that is to be conveyed across the network may originate in the form of continuous data streams or information that has already been formed into packets. If the information originated as a continuous data stream, it must be repackaged into discrete packets for transmission. On the other hand, if the information was already in packet form, for instance, IP (Internet Protocol) packets, it could be simply be trimmed or padded to fit into the desired DSL packet format, applying the appropriate QoS, error control and sequencing headers. Information that is transmitted using forward error correction is grouped into a series of bits of information and coding redundancy, the total collection referred to as a “codeword.”

138. Various DSL standards prior to the priority date required the use of PTM-TC and therefore PTM-TC codewords. *See, e.g.,* G.993.1, 143 (“In the transmit direction... [t]he corresponding TPS-TC (PTM-TC) receives the packet from the γ interface, encapsulates it into a special frame (PTM-TC frame) and maps into the PMS-TC frame (transmission frame) for transmission over the VDSL link”). Indeed, the ’055 Patent admits that PTM-TC codewords were known in the art prior to the alleged invention. ’055 Patent at 10:25-31 (“For reference,

‘Annex A’ which is of record in the identified provisional filing and incorporated by reference herein contains the PTM-TC of ADSL2 and VDSL2 systems as specified in the ITU-T G.992.3 ADSL2 standard.”); See TQD_TX-00001572-1584.

H. Overview of DSL Standards Recommendations

139. Many of the aspects of DSL have been standardized. These aspects include the use of Reed-Solomon coding and interleaving to mitigate errors, and the use of retransmission when a message or message portion is either not received at all or has errors.

140. Every DSL standard defines procedures to enable the transceivers on either end of a subscriber line to establish a connection and procedures that the transceivers conduct to maintain an established connection. The state during which the DSL transceivers establish a connection is referred to as *initialization*, and the state that immediately follows initialization, during which the transceivers can transfer user data, is called *Showtime*.

141. Multiple standardization organizations have been involved in sometimes-overlapping work. This section introduces two standardization organizations whose work predated the Family 9 patents, explains their relationship, and introduces the standards that are particularly relevant to the subject matter of this review and pre-date the priority date of the Family 9 patents.

142. The Alliance for Telecommunication Industry Solutions (ATIS) had a large role in the early standardization of ADSL. ATIS is a standardization organization based in the United States and accredited by the American National Standards Institute (ANSI). Generally, ATIS seeks to develop technical standards that ensure interoperable end-to-end telecommunication solutions that can be timely implemented.

143. ATIS was working to standardize DSL by the early 1990s. The T1E1.4 working group of ATIS carried out the earliest work on ADSL standardization, and, in 1995, ATIS

published the ANSI ADSL standard T1.413, which I will refer to herein as “T1.413 Issue 1.” The T1E1.4 working group continued its work on ADSL after 1995, and, in 1998, ATIS published a revision of T1.413 Issue 1, which I will refer to as “T1.413 Issue 2.”

144. The other standardization organization relevant to this review is the International Telecommunication Union (ITU). The ITU is an agency of the United Nations that specializes in information and communication technologies. The Telecommunications Sector of the ITU (known as the ITU-T) defines transceiver specifications for use internationally. The ITU-T generates standards called “Recommendations” for all fields of telecommunications.

145. Work in the ITU-T is carried out by Study Groups, and DSL recommendations were and are carried out by Study Group 15. The work of Study Group 15 is partitioned into work areas known as “Questions.” DSL recommendation work takes place within Study Group 15, Question 4 (abbreviated herein as SG15/Q4).

146. In 1997, SG15/Q4 began working on ADSL. Among other projects, SG15/Q4 established the projects known as G.dmt and G.lite. At that time, T1.413 Issue 1 was in force, and T1E1.4 was developing what eventually became T1.413 Issue 2. The G.dmt Recommendation was expected essentially to adopt T1.413 Issue 2 and add annexes addressing country-specific issues and requirements. The work in G.dmt was eventually released in 1999 as ITU-T Recommendation G.992.1, much of which is identical to T1.413 Issue 2. The result of the G.lite work was expected to be a lower-speed version of ADSL. The work in G.lite was eventually released, also in 1999, as ITU-T Recommendation G.992.2.

147. Once T1E1.4 completed T1.413 Issue 2, SG15/Q4 became the lead standards working group responsible for defining DSL transceiver recommendations. After releasing T1.413 Issue 2, T1E1.4 focused less on transceiver recommendations and more on providing

inputs to SG15/Q4 regarding North American requirements and preferences for emerging DSL standards.

148. By the Family 9 patents' purported priority date in 2006, the in-force ITU-T Recommendations relevant to ADSL, and relevant to this review, included G.992.1, G.992.2, G.992.3, G.992.4, G.992.5, G.993.1, and G.993.2. Each of these Recommendations specifies techniques for transmitting a range of bit rates over the existing copper local network from high bit rates over relatively short distances to lower bit rates over longer distances. Like T1.413 Issue 1 and T1.413 Issue 2, all of the ITU-T's ADSL Recommendations specify the use of DMT modulation.

149. The Recommendation G.992.1, entitled "Asymmetric Digital Subscriber Line (ADSL) Transceivers" and sometimes referred to by those skilled in the art as "ADSL1" or "G.dmt," specifies the physical layer characteristics of an ADSL transceiver at the subscriber line interface. G.992.1 specifies transceiver requirements for both the transceiver at the telephone company's central office (the ATU-C) and the transceiver at the subscriber's premises (the ATU-R) to enable connections that support at least 6.144 Mbit/s in the downstream direction (i.e., toward the subscriber) and at least 640 kbit/s in the upstream direction (i.e., away from the subscriber) without interfering with plain old telephone signals (POTS) on the same subscriber line.

150. Like G.992.1, Recommendation G.992.2, entitled "Splitterless Asymmetric Digital Subscriber Line (ADSL) Transceivers" and sometimes referred to as "G.lite," specifies the physical layer characteristics of an ADSL transceiver at the subscriber line interface. But unlike G.992.1, which was designed to maximize performance, G.992.2 was designed to provide lower bit rates (i.e., a maximum of 1.536 Mbit/s downstream and 512 kbit/s upstream) by

simplifying various aspects of the transceiver, such as not requiring a splitter to separate the DSL signals from POTS signals on the subscriber line.

151. Recommendation G.992.3, entitled “Asymmetric Digital Subscriber Line Transceivers 2 (ADSL2)” and sometimes referred to as “ADSL2” or, during its development, as “G.dmt.bis,” builds on many of the aspects of G.992.1 to enable connections that support at least 8 Mbit/s downstream and at least 800 kbit/s upstream (hence the “Asymmetric” part of its name).

152. Recommendation G.992.4, entitled “Splitterless asymmetric digital subscriber line transceivers 2 (splitterless ADSL2),” referred to as “G.lite.bis” during its development, builds on G.992.2, adding a number of features and capabilities.

153. Another relevant standard in existence on the Family 9 patents’ priority date is G.994.1, which I mentioned briefly above (§IV.A.7, *supra*). G.994.1, which is often referred to as “G dot handshake,” is entitled “Handshake procedures for digital subscriber line (DSL) transceivers.” The purpose of G.994.1 is to provide “a flexible mechanism for digital subscriber line (DSL) transceivers to exchange capabilities and to select a common mode of operation.” G.994.1, i. The procedures defined in G.994.1 are “an integral part of the start-up procedure for ITU-T Recs G.991.2, G.992.1, G.992.2, G.992.3, G.992.4 and G.992.5.” G.994.1, i.

154. Specifically, G.994.1 “defines signals, messages, and procedures for exchanging these between digital subscriber line (DSL) equipment, when the modes of operation of the equipment need to be automatically established and selected, but before signals are exchanged which are specific to a particular DSL Recommendation.” G.994.1, §1. In other words, the transceivers execute the procedures defined in G.994.1 to agree on a common mode of operation (e.g., ADSL1, ADSL2, etc.) before they begin to execute one of the initialization protocols defined in the applicable transceiver standard.

1. T1.413 Issue 1 (1995)

155. The world’s first ADSL standard, known as “T1.413 Issue 1,” was released by ATIS in 1995. This section provides an overview of some of the features of T1.413 Issue 1 that are relevant to the Family 9 patents.

a. Initialization

156. T1.413 Issue 1 specifies an initialization procedure during which, among other things, the transmitter and receiver exchange configuration information. *See, e.g.*, ATIS ADSL Standard T1.413-1995, Network and Customer Installation Interfaces—Asymmetric Digital Subscriber Line (ADSL) Metallic Interface (“T1.413 Issue 1”), §12.

b. Frames and Superframes

157. T1.413 Issue 1 organizes the bits to be transmitted into *frames*. The transmitter transmits all of the bits in a frame in the same DMT symbol, with bits allocated to subcarriers in accordance with the bit allocation determined during the initialization procedure. To construct the DMT symbol, the bits in each frame are separated into groups of bits, each group being allocated to a different subcarrier. The number of bits in each group may be different.

158. T1.413 Issue 1 defines a collection of 69 consecutive frames as a *superframe*. I prepared Figure 7 below to illustrate the superframe structure. Each superframe is composed of 68 data frames, numbered 0 through 67, followed by a symbol known as the *synchronization symbol* (or “synch symbol,” sometimes spelled as “sync symbol”). *See, e.g.*, T1.413 Issue 1, §6.2.1.1.

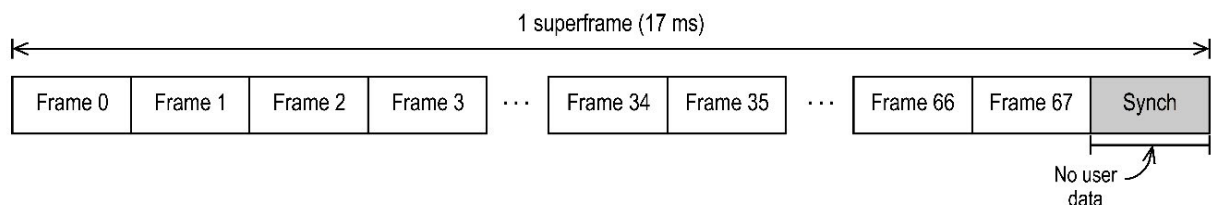


Figure 1: T1.413 Issue 1 superframe

159. Each data frame in a superframe carries data. In contrast, the synchronization symbol does not carry any data. Instead, it is a special symbol, known to the receiver, to help the receiver identify the superframe boundaries (and thus the frame boundaries). *See, e.g., id.*, §§6.9.1.2, 6.9.3, 7.9.3.

c. Latency Paths, FEC Coding, and Interleaving

160. As explained above, it is well known that different types of data have different levels of sensitivity to delays that occur during transmission. T1.413 Issue 1 was designed to allow a single ADSL connection to transfer multiple types of data having different latency requirements (or delay tolerances). *See, e.g.*, ATIS Contribution T1E1.4/93-117, Revised FEC and Interleaving Recommendations for DMT ADSL (“T1E1.4/93-117”), Abstract (“We maintain the two-buffer parameterization explained in [3] that separates the data into delay-tolerant and delay-intolerant streams.”).

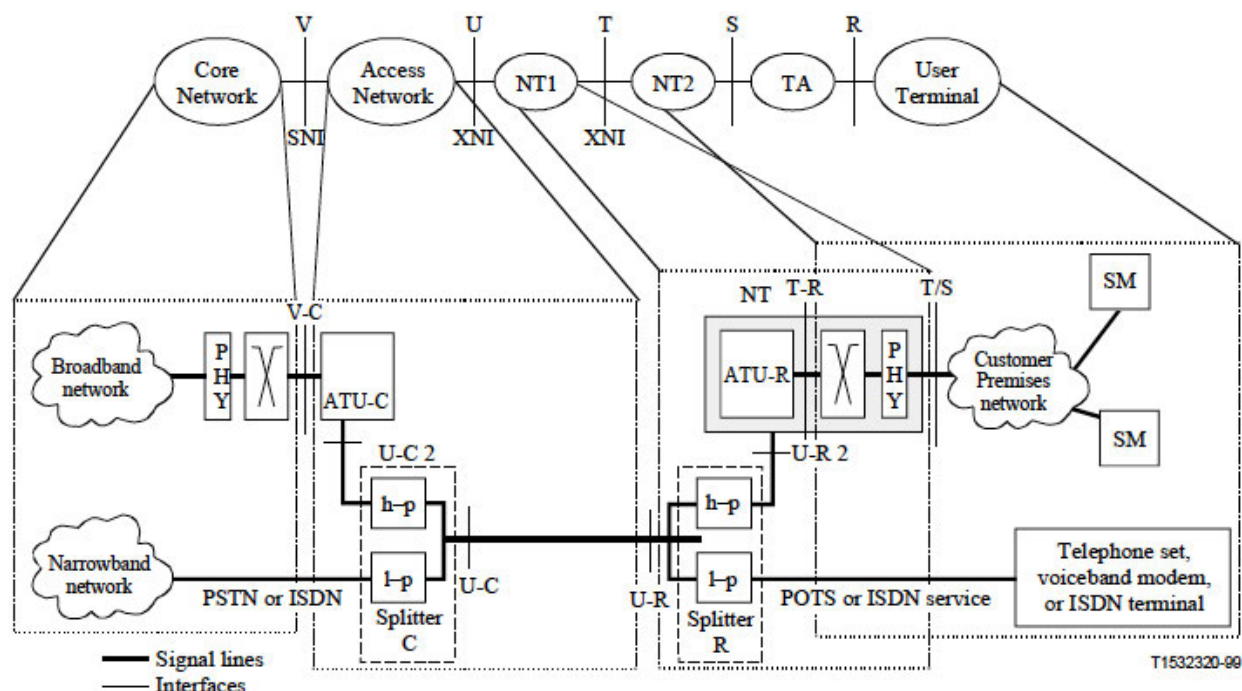
161. To allow the transmission of both delay-sensitive and delay-tolerant data over the same subscriber line, T1.413 Issue 1 supports *dual-latency* configurations using two independent *data paths*. Delay-sensitive data is routed to the so-called *fast path*, and delay-tolerant data is routed to the *interleaved path*. To mitigate errors in data transmission and reception, T1.413 Issue 1 specifies the use of FEC coding in the fast path, and both FEC coding and interleaving in the interleaved path. *See, e.g.*, T1.413 Issue 1, §6.4.1 (Reed-Solomon coding), §6.4.2 (interleaving). Thus, the key difference between the fast and interleaved paths is that data in the interleaved path is both FEC coded and interleaved, as described previously, to improve the effectiveness of the FEC code in the presence of impulse noise. In contrast, the fast path includes FEC coding, but does not include interleaving. Therefore, the fast path has lower latency than the interleaved path. *See, e.g., id.*, §§6.4.1, 6.4.2.

2. T1.413 Issue 2 (1998) and ITU-T Recommendation G.992.1 (1999)

162. In 1998, ATIS published a revision of T1.413 Issue 1 ADSL, known as “T1.413 Issue 2.” In 1999, the ITU released ITU-T Recommendation G.992.1, known as “ADSL1,” much of which is identical to T1.413 Issue 2. Accordingly, I will describe aspects of T1.413 Issue 2 and G.992.1 together in this subsection. In general, I will refer to G.992.1; when necessary, I will point out where G.992.1 and T1.413 Issue 2 differ.

163. ITU-T Recommendation G.992.1 and T1.413 Issue 2 specify requirements for ADSL transceivers to enable high-speed data transmission between the network operator end of a subscriber line, where the ATU-C is located, and the customer end, where the ATU-R is located. ITU-T Recommendation G.992.1, Asymmetric digital subscriber line (ADSL) transceivers (“G.992.1”), i. The acronym “ATU” stands for “ADSL transceiver unit.” *Id.*, §4.

164. Figure 1-1 of G.992.1, copied below, is an ADSL system reference model that illustrates the locations of the ATU-C and ATU-R within the network, as well as various defined interfaces between components.



- NOTE 1 – The U-C and U-R interfaces are fully defined in this Recommendation. The V-C and T-R interfaces are defined only in terms of logical functions, not physical. The T/S interface is not defined here.
- NOTE 2 – The V-C interface may consist of interface(s) to one or more (STM or ATM) switching systems.
- NOTE 3 – Implementation of the V-C and T-R interfaces is optional when interfacing elements are integrated into a common element.
- NOTE 4 – One or other of the high-pass filters, which are part of the splitters, may be integrated into the ATU-x; if so, then the U-C 2 and U-R 2 interfaces become the same as the U-C and U-R interfaces, respectively.
- NOTE 5 – A digital carrier facility (e.g. SONET extension) may be interposed at the V-C.
- NOTE 6 – Due to the asymmetry of the signals on the line, the transmitted signals shall be distinctly specified at the U-R and U-C reference points.
- NOTE 7 – The nature of the customer installation distribution and customer premises network (e.g. bus or star, type of media) is for further study.
- NOTE 8 – More than one type of T-R interface may be defined, and more than one type of T/S interface may be provided from an ADSL NT (e.g. NT1 or NT2 types of functionalities).
- NOTE 9 – A future issue of this Recommendation may deal with customer installation distribution and home network requirements.
- NOTE 10 – Specifications for the splitters are given in Annex E.

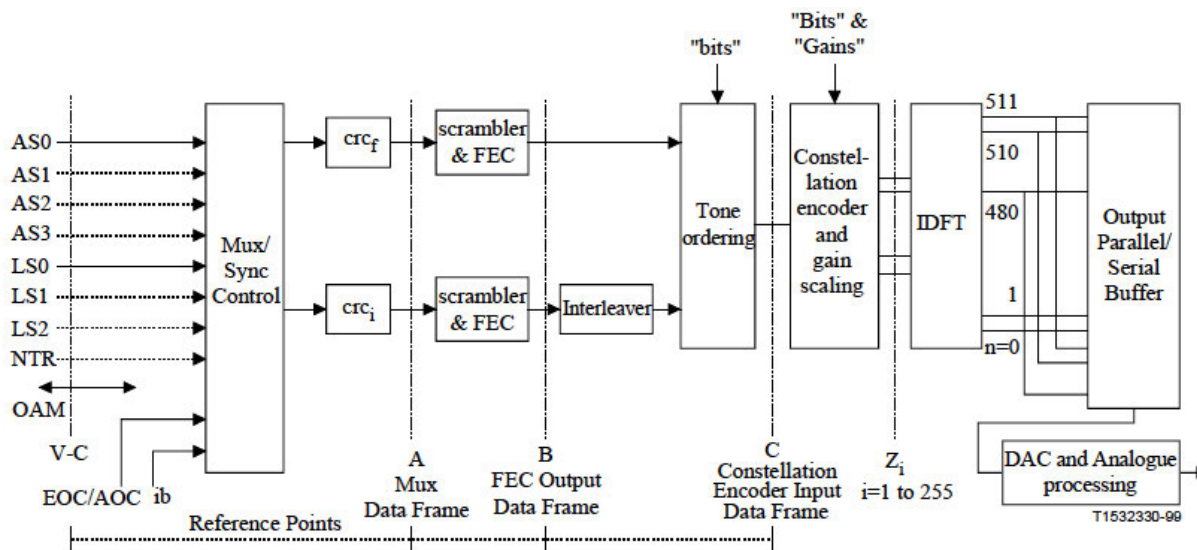
Figure 1-1/G.992.1 – ADSL system reference model

Id., Fig. 1-1.

165. Among other things, G.992.1 defines the modulation technique used in ADSL (namely, DMT), describes how data and overhead bits are organized into frames that are modulated for transmission, and it defines an initialization protocol. *Id.*, §§1, 7, 8, 10.

166. Figure 5-1 of G.992.1, copied below, is a block diagram of an ATU-C. *Id.*, §5.1.1; *see also id.*, Figure 5-2. The fast path is represented by the upper portion of the block diagram that includes the blocks “crcf” and “scrambler & FEC,” and the interleaved path is represented by

the lower portion of the block diagram that includes the blocks “crc_i,” “scrambler & FEC,” and “Interleaver.” G.992.1 provides similar block diagrams for the ATU-R. *See, e.g., id.*, Figs. 5-3, 5-4.



NOTE – Solid versus dashed lines are used to indicate required versus optional capabilities respectively. This figure is not intended to be complete in this respect, see clauses 6 and 7 for specific details.

Figure 5-1/G.992.1 – ATU-C transmitter reference model for STM transport

Id., Fig. 5-1.

167. Because of the addition of FEC redundancy bytes (in both the fast and interleaved paths) and interleaving (in the interleaved path), both of which are discussed further below, the data frames have a different appearance at different points along the data processing path. As shown above, Figure 5-1 of G.992.1 shows three reference points A, B, and C. The reference point A follows assembly of what is referred to as a *mux data frame*. The reference point B follows the mux data frames being scrambled and FEC encoded. The reference point C follows interleaving for the interleaved data, discussed below, and a process called tone ordering, which is not important for the discussion herein.

168. G.992.1 specifies the use of Reed-Solomon FEC coding for both fast and

interleaved data. *See, e.g., Id.*, §7.6.1 (“R . . . redundant check bytes . . . shall be appended to K . . . message bytes . . . to form a Reed-Solomon codeword of size $N = K + R$ bytes.”). G.992.1 defines a parameter, S, which specifies the number of mux data frames per FEC codeword. *See, e.g., id.*, §8.4.1.2 (“S = number of mux data frames per FEC codeword”). For the fast path, the value of S is always 1 (*see, e.g., id.*, §§7.4.1.2.1, 7.6, Table 7-7), which means that each DMT symbol carries exactly one FEC codeword. In other words, in the fast path, the FEC codeword boundaries are identical to and coincident with the DMT symbol boundaries. For interleaved data, in addition to FEC coding, G.992.1 also requires the use of a convolutional interleaver with a programmable interleave depth. *Id.*, §7.6.3 (“The Reed-Solomon codewords in the interleave buffer shall be convolutionally interleaved. The interleaving depth varies, as explained in 7.4, but shall always be a power of 2.”).

169. G.992.1 sets forth minimum required downstream and upstream FEC coding and interleaving capabilities for both the ATU-C and ATU-R, including all of the values of R, S, and D the transceivers must be capable of supporting. *See, e.g., id.*, §§7.6, 8.6. Table 7-7, copied below, sets forth the minimum required downstream FEC coding and interleaving capabilities for the ATU-C transmitter (and the ATU-R receiver), and Table 8-3, also copied below, sets forth the corresponding minimum required upstream FEC coding and interleaving capabilities for the ATU-R transmitter (and ATU-C receiver).

Table 7-7/G.992.1 – Minimum FEC coding capabilities for ATU-C

Parameter	Fast buffer	Interleaved buffer
Parity bytes per R-S codeword	$R_F = 0, 2, 4, 6, 8, 10, 12, 14, 16$ (Note 1)	$R_I = 0, 2, 4, 6, 8, 10, 12, 14, 16$ (Notes 1 and 2)
DMT symbols per R-S codeword	$S = 1$	$S = 1, 2, 4, 8, 16$
Interleave depth	Not applicable	$D = 1, 2, 4, 8, 16, 32, 64$
NOTE 1 – R_F can be > 0 only if $K_F > 0$, and R_I can be > 0 only if $K_I > 0$.		
NOTE 2 – R_I shall be an integer multiple of S .		

The ATU-C shall also support upstream transmission with at least any combination of the FEC coding capabilities shown in Table 8-3.

Id., Table 7-7.

Table 8-3/G.992.1 – Minimum FEC coding capabilities for ATU-R

Parameter	Fast buffer	Interleaved buffer
Parity bytes per RS codeword	$R_F = 0, 2, 4, 6, 8, 10, 12, 14, 16$ (Note 1)	$R_I = 0, 2, 4, 6, 8, 10, 12, 14, 16$ (Notes 1 and 2)
DMT symbols per RS codeword	$S = 1$	$S = 1, 2, 4, 8, 16$
Interleave depth	not applicable	$D = 1, 2, 4, 8$
NOTE 1 – R_F can be > 0 only if $K_F > 0$ and R_I can be > 0 only if $K_I > 0$.		
NOTE 2 – R_I shall be an integer multiple of S .		

The ATU-R shall also support downstream transmission with at least any combination of the FEC coding capabilities shown in Table 7-7.

Id., Table 8-3.

170. G.992.1 specifies that both the ATU-C and ATU-R must support downstream transmission with any combination of the parameter values shown in Table 7-7, and they must support upstream transmission with any combination of the parameter values shown in Table 8-3. *See, e.g., id.*, §§7.6, 8.6.

171. G.992.1 and T1.413 Issue 2 use the same superframe definition as T1.413 Issue 1, i.e., 68 data frames followed by a synchronization symbol that is identical to the synchronization symbol of T1.413 Issue 1. *See id.*, §§3.31, 7.4.1.1, 8.4.1.1. Figure 7-5 of G.992.1, copied below, illustrates superframe structure used by both the ATU-C and ATU-R.

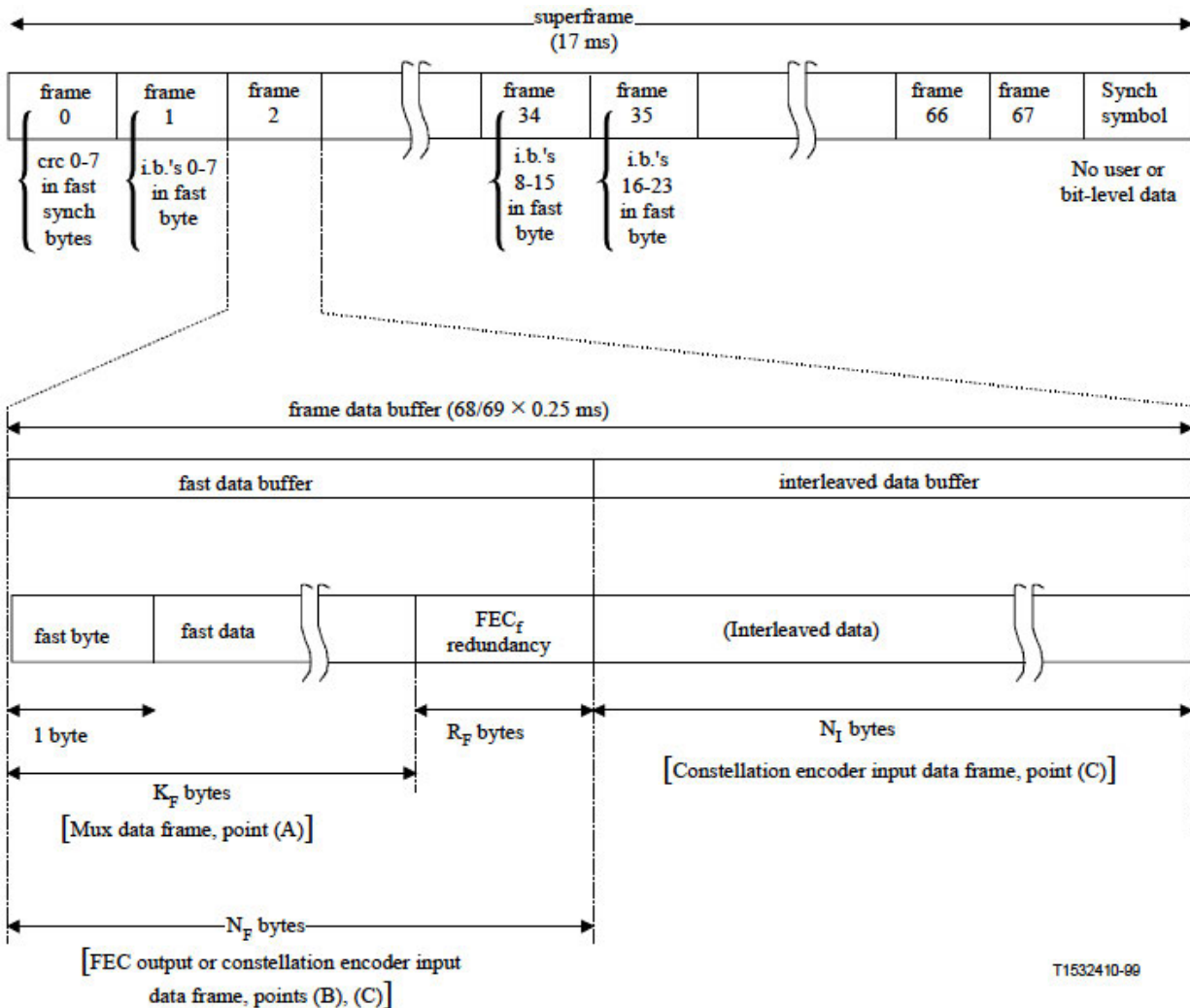


Figure 7-5/G.992.1 – ADSL superframe structure – ATU-C transmitter

Id., Fig. 7-5.

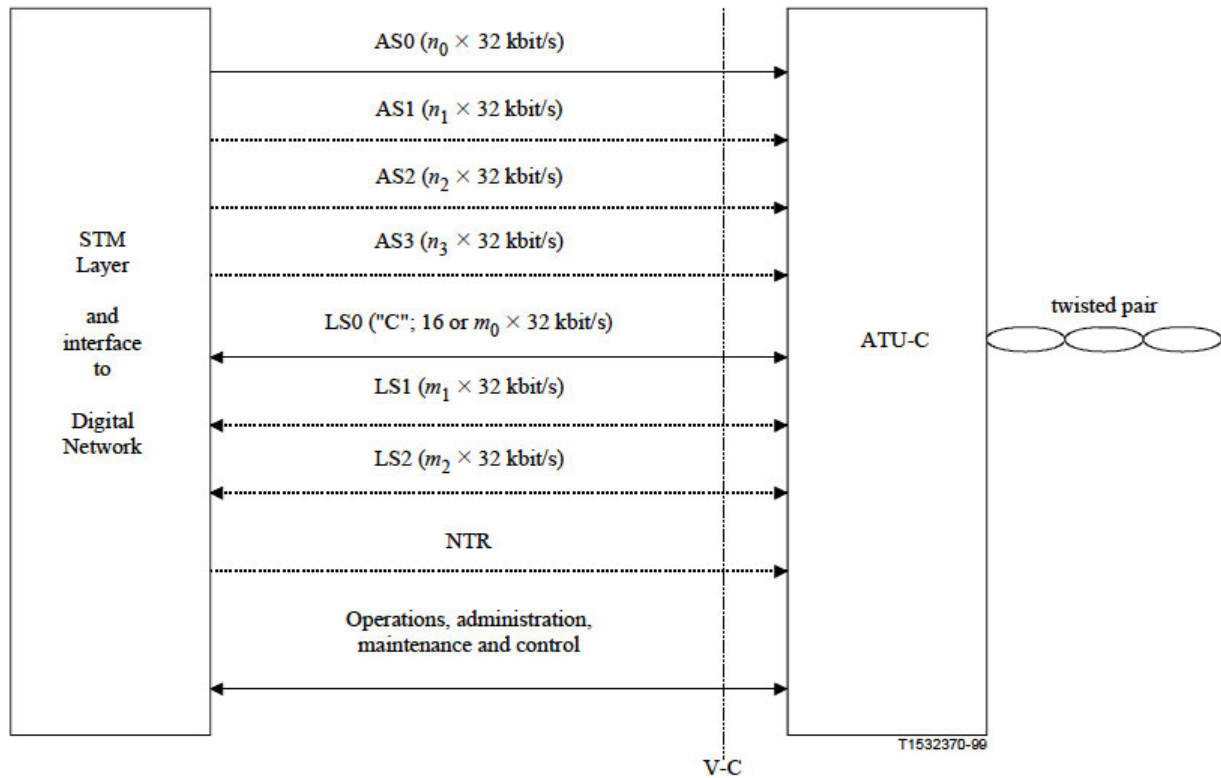
172. Like T1.413 Issue 1, to enable the transmission of both delay-sensitive and delay-tolerant data over the same subscriber line, T1.413 Issue 2 and G.992.1 support dual-latency configurations in which each data frame contains data from two data buffers, as shown in Figure 7-5 above. Delay-sensitive data is put into the fast data buffer for transmission, and delay-tolerant data is put into the interleaved data buffer. *Id.*, §7.4.1.2. But unlike T1.413 Issue 1, which always defines and uses both a fast buffer and an interleaved buffer, G.992.1 and T1.413 Issue 2 provide for the possibility that the user data requires only one latency path, whether interleaved or non-

interleaved. In this case, the amount of overhead can be reduced so that more of the total available bit rate of the connection is available for user data.

173. In the reduced overhead mode introduced in both T1.413 Issue 2 ADSL and G.992.1, the transmitter assigns data only to the fast data buffer or to the interleaved data buffer.

174. G.992.1 and T1.413 Issue 2 accommodate two ways that the two transceivers can transmit simultaneously over the subscriber line: frequency-division multiplexing (FDM) and echo canceling. *Id.*, §10.1.2 (“Manufacturers may choose to implement this Recommendation using either frequency-division multiplexing (FDM) or echo cancelling (overlapped spectrum) to separate upstream and downstream signals.”).

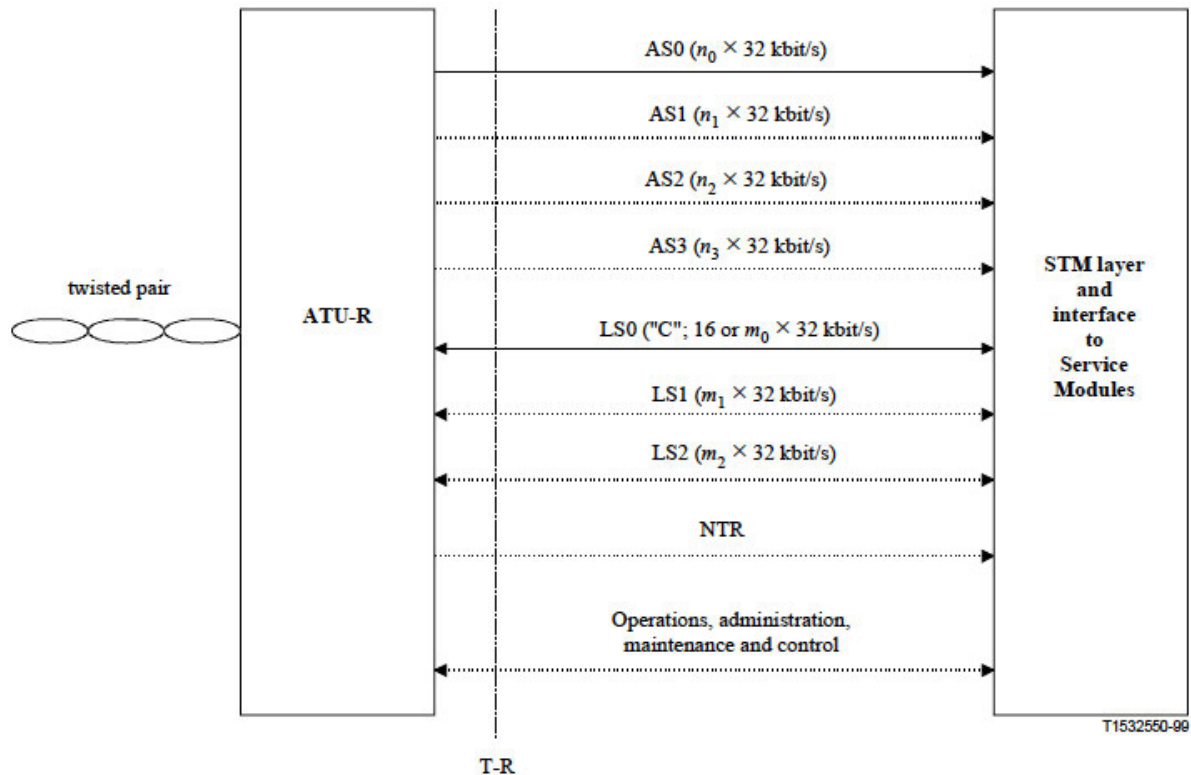
175. Figure 7-1 of G.992.1, copied below, shows the logical channels (also referred to as “bearer channels”) defined for the ATU-C, and Figure 8-1 of G.992.1, also copied below, shows the logical channels defined for the ATU-R. *Id.*, §§7.1.1, 8.1.1.



NOTE – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines.

Figure 7-1/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

Id., Fig. 7-1.



NOTE – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines.

Figure 8-1/G.992.1 – ATU-R functional interfaces for STM transport at the T-R reference point

Id., Fig. 8-1.

176. As Figures 7-1 and 8-1 show, the ATU-C and ATU-R transmit and/or receive up to nine logical channels, all of which are communicated via a single twisted-pair line. To enable the different logical channels to share the same physical line, G.992.1 specifies rules the ATU-R and ATU-C follow to prepare data from all of the logical channels in use for transmission over the twisted pair. G.992.1 organizes transmitted and received data into data frames. *Id.*, §1. The ADSL transmitter transmits all of the bits in a data frame in the same DMT symbol. *Id.*, §§3.14, 7.4.1.1.

177. G.992.1 specifies initialization procedures that are “required in order for a physically connected ATU-R and ATU-C pair to establish a communications link.” *Id.*, §10.1.1.

During initialization, “[i]n order to maximize the throughput and reliability of this link, ADSL transceivers shall determine certain relevant attributes of the connecting channel and establish transmission and processing characteristics suitable to that channel.” *Id.* Each transceiver’s receiver determines “the relevant attributes of the channel through defined transceiver training and channel analysis procedures.” *Id.* The initialization procedure also allows the transceivers to establish “[c]ertain processing and transmission characteristics.” *Id.* An exchange portion of initialization allows each receiver to communicate to the corresponding far-end transmitter certain transmission settings that it expects to see after the initialization procedure ends and the transceivers begin steady-state communication during Showtime. *Id.* For example, the ATU-C sends to the ATU-R four options for transport configuration for both upstream and downstream, each option including proposed values for the number of FEC redundancy bytes (R), the interleave depth (D), and the number of DMT symbols per FEC codeword (S). *Id.*, §10.8.3.

3. ITU-T Recommendation G.992.3 (2002)

178. In 2002, the ITU released ITU-T Recommendation G.992.3, known as “ADSL2” and, while in development, “G.dmt.bis.” G.992.3 “describes the second generation of ADSL, based on the first generation ITU-T Rec. G.992.1.” ITU-T Recommendation G.992.3, Asymmetric digital subscriber line transceivers 2 (ADSL2) (“G.992.3”), ii. Accordingly, G.992.3 builds on many of the aspects of G.992.1 to enable connections that support at least 8 Mbit/s downstream and at least 800 kbit/s upstream. G.992.3, §1. G.992.3 also adds a number of features and capabilities. *Id.*

179. Of note here, G.992.3 specifies the use of Reed-Solomon FEC and convolutional interleaving as two of the functions implemented by the physical-medium-specific transmission convergence (PMS-TC) function:

[T]he ATU transmit PMS-TC function also provides procedures for: . . . insertion of redundancy for Reed-Solomon-based forward error correction; . . . and interleaving of data frames to spread the effect of impulsive impairments on the U interface. These functions are configured by a number of control parameters described in 7.5 to provide application-appropriate FEC protection, latency, and impulse noise immunity for each frame bearer. The values of the control parameters are set during initialization or reconfiguration of the ATU. The ATU receive PMS-TC function reverses each of the listed procedures so that the transported information may be recovered.

Id., §7.2.

The FEC procedure inserts Reed-Solomon FEC redundancy octets to provide coding gain as an outer coding function to the PMD function. The FEC procedure of latency path function # p shall calculate R_p octets from $M_p \times K_p$ input octets. The octets are appended to the end of the input octets in the structure of FEC Output Data Frame at Reference Point B. When $R_p = 0$, no redundancy octets are appended and the values in the FEC Output Data Frame are identical to the input values. For all other values of R_p , the following encoding procedure shall be used to create the R_p octets: The FEC procedure shall take in M_p scrambled Mux Data Frames comprising message octets, $m_0, m_1, \dots, m_{M_p \times K_p - 2}, m_{M_p \times K_p - 1}$. The procedure shall produce R_p redundancy octets $c_0, c_1, \dots, c_{R_p - 2}, c_{R_p - 1}$. These two taken together comprise the FEC codeword of size $M_p \times K_p + R_p$ octets. The R_p redundancy octets shall be appended to the message octets to form the FEC Output Data Frame at Reference Point B. At the end of the initialization sequence, the FEC Function always starts with the first of M_p Mux Data Frames.

Id., §7.7.1.4.

To spread the Reed-Solomon codeword and therefore reduce the probability of failure of the FEC in the presence of impulse noise, the FEC Output Data Frames shall be convolutionally interleaved. The interleaver creates the Interleaved FEC Output Data Frames at Reference point C, at the output of the latency path function. This procedure is followed by the frame multiplexing procedure. Convolutional interleaving is defined by the rule (using the currently defined values of the framing control parameters D_p and the derived parameter $N_{FEC.p}$): Each of the $N_{FEC.p}$ octets $B_0, B_1, \dots, B_{N_{FEC.p} - 1}$ in an FEC Output Data Frame is delayed by an amount that varies linearly with the octet index. More precisely, octet B_i (with index i) is delayed by $(D_p - 1) \times i$ octets, where D_p is the interleaver depth.

Id., §7.7.1.5

180. Figure 7-6 of G.992.3, copied below, illustrates the PMS-TC functions of an ATU (either ATU-C or ATU-R), including the FEC coding and interleaving functions.

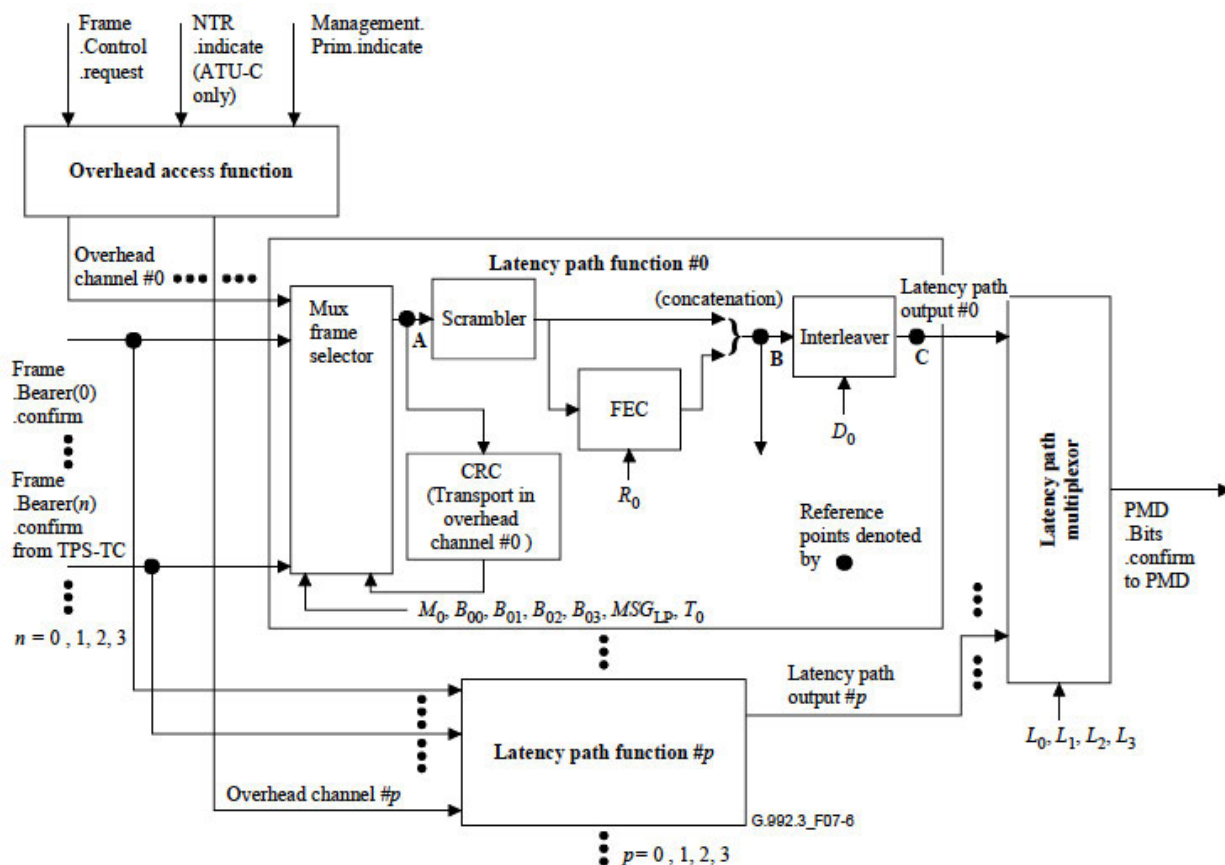


Figure 7-6/G.992.3 – Block diagram of transmit PMS-TC function

Id., Fig. 7-6.

181. Table 7-5, copied below, describes the data at the Reference Points A, B, and C in Figure 7-6.

Table 7-5/G.992.3 – PMS-TC function internal reference points

Reference point	Definition
A: Mux Data Frame	The data within a latency path function after the sync octet has been added.
B: FEC Data Frame	The data within a latency path function after the output of the FEC redundancy octets are merged with scrambled data.
C: Interleaved FEC Data Frame	The data and redundancy octets that have been interleaved. This is the output signal of a latency path function.

Id., Table 7-5.

182. A set of control parameters specified in G.992.3 controls the configuration of the PMS-TC function, including FEC coding and interleaving. *Id.*, §7.5. The control parameters include R_p , which is the number of Reed-Solomon (RS) redundancy octets per codeword (and per FEC Data Frame) in latency path function #p, and D_p , which is the interleaving depth in the latency path function #p. *Id.*

183. G.992.3 specifies valid values of each of the control parameters, including R_p and D_p . *Id.*, §7.6.2, Table 7-8. If $R_p = 0$ (FEC is off) then $D_p = 1$ (interleaving is off). *Id.*, §7.5.

184. G.992.3 specifies mandatory capabilities for the ATU-C and ATU-R for the mandatory latency path 0. *Id.*, §7.6.3.1. Specifically, ATU-Cs and ATU-Rs must support all valid values of both R_p and D_p for latency path 0 in both the downstream and upstream directions. *Id.*, §7.6.3.1, Table 7-9, Table 7-10. If the ATU-C and ATU-R support the optional latency paths, then during initialization the ATU-C and ATU-R identify the maximum values of R_p and D_p they can support on these optional latency paths, and all valid values of R_p and D_p up to and including these maximum values must be supported on the optional latency paths. *Id.*, §7.6.3.2, Table 7-11, Table 7-12.

4. ITU-T Recommendation G.993.1 (2004)

185. ITU-T Recommendation G.993.1, sometimes referred to as “VDSL1,” specifies

aspects of very-high-speed digital subscriber lines (VDSL) to permit the transmission of asymmetric (downstream greater than upstream) and symmetric (downstream and upstream equal) aggregate data rates up to tens of Mbit/s on twisted pairs. G.993.1 provides for use of a wider bandwidth than is used in ADSL, namely, up to 12 MHz. ITU-T Recommendation G.993.1, Very high speed digital subscriber line transceivers (June 2004) (“G.993.1”), §1.

186. Among other things, G.993.1 specifies the use of FEC and interleaving in the transmitter. Figure 8-1 of G.993.1, copied below, illustrates the defined “slow” and “fast” paths. As shown, the “slow” path includes both FEC and interleaving, whereas the “fast” path includes FEC but not interleaving.

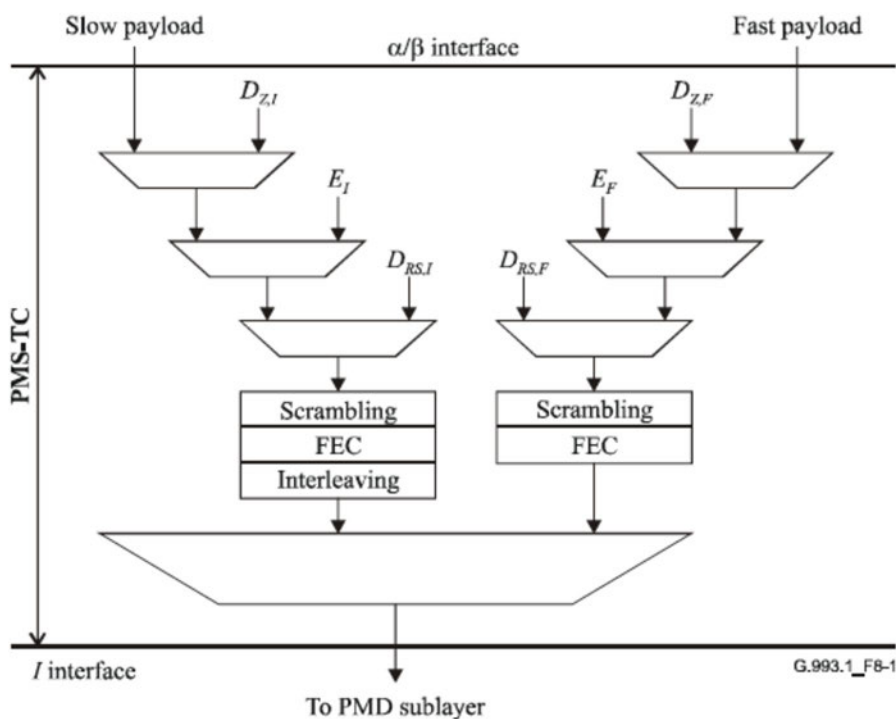


Figure 8-1/G.993.1 – Diagram of PMS-TC sublayer

G.993.1, Fig. 8-1.

187. G.993.1 specifies the use of “a standard byte-oriented Reed-Solomon code . . . to provide protection against random and burst errors” (G.993.1, §8.3) and interleaving “to protect

the data against bursts of errors by spreading the errors over a number of Reed-Solomon codewords.” G.993.1, §8.4.1. Specifically, “the codewords shall be interleaved before transmission to increase the immunity of RS [Reed-Solomon] codewords to bursts of errors.” G.993.1, §8.4.1. The interleave depth is programmable up to a maximum depth of 64 codewords when the codeword length is 255 bytes. *Id.* When the codeword is shorter than 255 bytes, the interleave depth can be larger than 64 codewords. *Id.*

188. G.993.1 specifies that “[i]t shall be possible to adjust the interleave depth via the management system to meet latency requirements.” *Id.* The interleaver “uses a memory in which a block of I octets is written while an (interleaved) block of I octets is read.” *Id.* G.993.1 teaches that the receiver requires the same size of memory for deinterleaving as the transmitter uses for interleaving. *Id.*

189. G.993.1 specifies an initialization procedure to allow the VTU-O and VTU-R to, among other things, exchange parameters such as Reed-Solomon settings and interleaver parameters. G.993.1, §12.4.1. Figure 12-7 of G.993.1, copied below, illustrates the timing of messages transmitted by the VTU-O and VTU-R during the channel analysis and exchange phase of VDSL1 initialization.

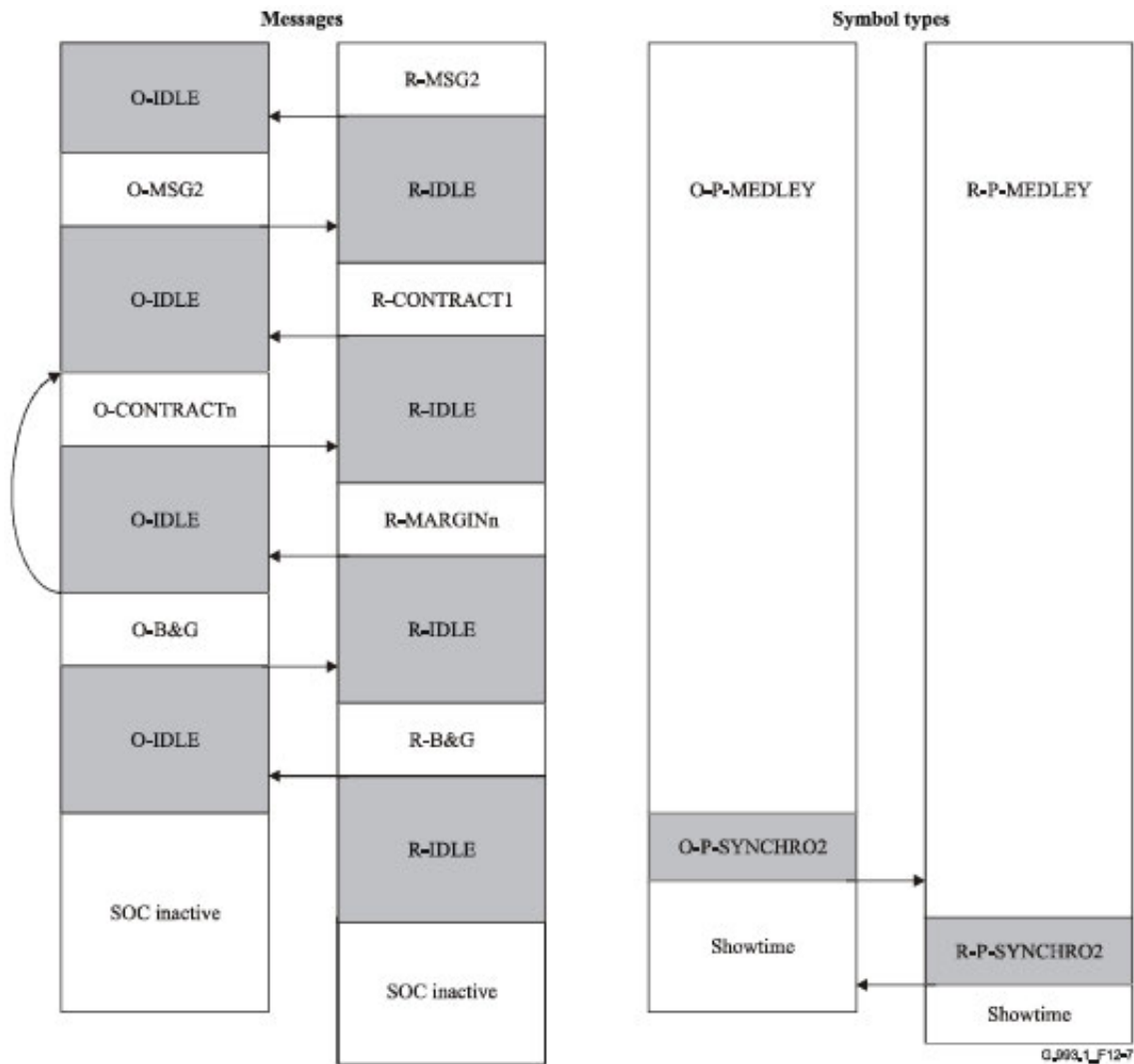


Figure 12-7/G.993.1 – Timeline of the channel analysis and exchange phase

Id., Fig. 12-7.

190. During the channel analysis and exchange phase, the VTU-R sends a message called R-MSG2, which transfers, among other things, the Reed-Solomon capabilities of the VTU-R (e.g., whether it can support only mandatory settings or all settings), the interleaver settings supported by the VTU-R (e.g., whether it can support only mandatory settings, all settings, or a number of additional settings), and the “maximal interleaver memory” in bytes. *Id.*, §12.4.6.1; §12.4.6.3.1.1.

191. After receiving R-MSG2, the VTU-O sends a message called O-MSG2, which transfers, among other things, the Reed-Solomon capabilities of the VTU-O (e.g., whether it can support only mandatory settings or all settings), the interleaver settings supported by the VTU-O (e.g., whether it can support only mandatory settings, all settings, or a number of additional settings), and the “maximum interleaver delay” in milliseconds. *Id.*, §§12.4.6.1, 12.4.6.2.1.1.

192. After receiving O-MSG2, the VTU-R sends a message called R-CONTRACT1, which contains “the proposed downstream contract based on the maximal number of bits in the slow channel based on the restrictions specified in O-MSG2 (i.e., as if only the slow channel will be used).” *Id.*, §12.4.6.3.1.2. The proposed downstream contract specifies, among other things, the bit rate for the slow channel (a multiple of 64 kbit/s), the Reed-Solomon settings for the slow channel (i.e., the codeword length and number of redundancy bytes), and the interleaver setting (i.e., the interleaver depth and block length). *Id.*, §12.4.6.3.1.2; 12.4.6.2.1.2.

193. After receiving R-CONTRACT1, the VTU-O sends a message called O-CONTRACTn, which contains a proposed upstream and downstream contract that is based on the capabilities of the VTU-O and VTU-R. G.993.1, §12.4.6.2.1.2. Table 12-25 of G.993.1, copied below, defines the O-CONTRACTn message.

Table 12-25/G.993.1 – Description of O-CONTRACTn

Field	Field or macro-field type
Message descriptor	Message code (see Table 12-12)
Downstream contract	Contract descriptor (see Table 12-26)
Upstream contract	Contract descriptor
EOC capacity (number of EOC bytes per frame)	1 byte
VOC capacity (value of V ; see 8.5.5)	1 byte

Id.

194. The “Downstream contract” and “Upstream contract” in O-CONTRACTn are of

the type “Contract descriptor.” *Id.* Table 12-26 of G.993.1, copied below, defines the contract descriptor, which includes information that allows the VTU-R to configure its interleaver (for upstream transmission) and deinterleaver (for downstream reception).

Table 12-26/G.993.1 – Contract descriptor

Field	Field or macro-field type	Remark
Rate in fast channel	2 bytes	In multiples of 64 kbit/s
RS setting in fast channel	2 bytes	B15 → B8: RS overhead B7 → B0: RS codeword length
Rate in slow channel	2 bytes	In multiples of 64 kbit/s
RS setting in slow channel	2 bytes	B15 → B8: RS overhead B7 → B0: RS codeword length
Interleaver setting	2 bytes	B15 → B8: <i>M</i> (Note) B7 → B0: <i>I</i>
NOTE – <i>I</i> must be a divider of the RS codeword length (in the slow channel).		

Id.

195. The downstream portion of the contract is based on the information provided by the VTU-R in R-CONTRACT1 and, ideally, is the same as the contract the VTU-R proposed in R-CONTRACT1. *Id.* As Table 12-26 indicates, both the upstream and downstream portions of the proposed contract include, among other things, the bit rate for the slow channel (a multiple of 64 kbit/s), the Reed-Solomon settings for the slow channel (i.e., the codeword length and number of redundancy bytes), and the interleaver setting (i.e., the interleaver depth and block length). *Id.*

196. G.993.1 also discloses the use of PTM-TC. For example, Annex H of G.993.1 is dedicated to PTM-TC. Further, “the functional model of packetized data transport is presented in Figure H.1” below. *Id.* at Annex H.

5. ITU-T Recommendation G.993.2 (2006)

197. ITU-T Recommendation G.993.2, which is entitled “Very high speed digital subscriber line transceivers 2 (VDSL2),” “is an enhancement to ITU-T Rec. G.993.1 . . . that

supports transmission at a bidirectional net data rate (the sum of upstream and downstream rates) up to 200 Mbit/s on twisted pairs.” ITU-T Recommendation G.993.2 (2006) (“G.993.2”), §1. G.993.2 specifies the use of DMT modulation and incorporates components from G.993.1 (VDSL1), G.992.3 (ADSL2), and G.992.5 (ADSL2 plus). *Id.*, §1.

198. G.993.2 provides much more flexibility than other DSL standards. For example, G.993.2 was developed to allow VDSL2 services to be deployed “from central offices, from fibre-fed cabinets located near the customer premises, or within buildings.” G.993.2, §1. G.993.2 transceivers can “provide reliable high data rate operation on short loops” as well as “reliable operation on loops up to approximately 2500 metres of 26 AWG (0.4 mm).” *Id.* Data rates can be asymmetric (greater downstream than upstream) or symmetric (equal rates in both directions). *Id.*

199. Because G.993.2 “defines a wide range of settings for various parameters (such as bandwidth and transmitter power) that could potentially be supported by a transceiver,” G.993.2 specifies “profiles” that allow VDSL2 transceivers to support subsets of all possible settings for various parameters (e.g., bandwidth, transmitter power, etc.). G.993.2, §1. The profiles “allow[] vendors to limit implementation complexity and develop implementations that target specific service requirements.” *Id.*

200. A G.993.2-compliant transceiver must comply with at least one profile and can support multiple profiles. G.993.2, §6.1. G.993.2 defines eight profiles: 8a, 8b, 8c, 8d, 12a, 12b, 17a, and 30a. *Id.*

201. G.993.2 specifies the use of frequency-domain duplexing (FDD) to allow the subscriber line to be used at the same time for downstream and upstream transmission. G.993.2, §7.1. Frequency bands are allocated either for downstream transmission, for upstream transmission, or for neither. The allocation of specific frequency bands to the two directions of

transmission is referred to as the “band plan.” *See, e.g.*, G.993.2, §7.1.

202. G.993.2 distinguishes between band plans for transceivers that use frequencies from near DC to 12 MHz, and band plans for transceivers that use frequencies from near DC to 30 MHz. G.993.2, §§7.1.1, 7.1.2. The maximum frequency that can be used by a transceiver to transmit or receive depends on the transceiver capabilities, the selected band plan, and the selected profile. *Id.*, §7.1.

203. The band plan for the frequency range up to 12 MHz is shown in Figure 7-1 of G.993.2, copied below:

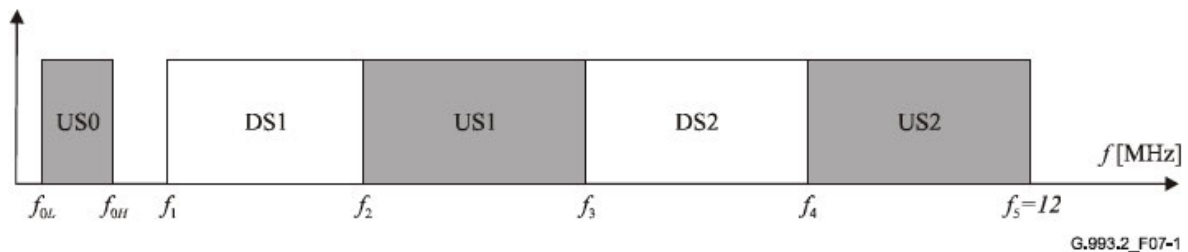


Figure 7-1/G.993.2 – Band plan in the frequency range up to 12 MHz

G.993.2, §7.1.1, Fig. 7-1.

204. The band plan shown in Figure 7-1 includes five bands: US0, DS1, US1, DS2, and US2. The bands beginning with the letters “US” are allocated for upstream transmission, and the bands beginning with “DS” are allocated for downstream transmission. G.993.2, §7.1.1.

205. The lowest-frequency band is denoted as US0. G.993.2, §7.1.1. Support of the US0 band is optional, which means a VTU-R can, but is not required to, be able to transmit in the US0 band, and, similarly, a VTU-O can, but is not required to, be able to receive in the US0 band. *Id.* As explained further below, the VTU-O and VTU-R convey their capabilities regarding usage of the US0 band during a handshake procedure conducted before the G.993.2 initialization procedure. *Id.*, §§12.3.2.1.1, 12.3.2.1.2, 12.3.2.2.1, 12.3.2.2.2. The G.993.2 initialization

procedure is discussed further below.

206. Figure 7-1 of G.993.2 illustrates that the US0 band resides between a lower frequency f_{0L} and an upper frequency f_{0H} . G.993.2, §7.1.1. The DS1 band resides between a lower frequency f_1 , which is required to be higher than f_{0H} , and an upper frequency of f_2 . *Id.* The US1 band resides between f_2 and an upper frequency f_3 , the DS2 band resides between f_3 and an upper frequency f_4 , and the US2 band resides between f_4 and 12 MHz. *Id.*

207. The values of the frequencies f_{0L} , f_{0H} , f_1 , f_2 , f_3 , and f_4 are provided by region-specific annexes. G.993.2, §7.1.1. Annex A specifies the separation frequencies for use in North America, Annex B specifies the separation frequencies for use in Europe, and Annex C specifies the separation frequencies for use in Japan. *Id.*, Annex A, Annex B, Annex C. Annexes A, B, and C also specify whether and how transceivers can use frequencies between 12 MHz and 30 MHz. G.993.2, §7.1.2.

208. The band plan specified in Annex A for North America is copied below.



Figure A.1/G.993.2 – Band plan for North America

G.993.2, §A.1, Fig. A.1.

209. As indicated in Figure A.1, most of the separation frequencies in the Annex A band plan are fixed. For example, the US1 band spans the frequency range from 3.75 MHz to 5.2 MHz, the DS2 band spans the frequency range from 5.2 MHz to 8.5 MHz, and the US2 band spans the frequency range from 8.5 to 12 MHz. G.993.2, Fig. A.1.

210. The lowest-frequency bands US0 and DS1 have variable band-edge frequencies in

the Annex A band plan. G.993.2, §A.1. The value of f_{0L} can be as low as 4 kHz if there is no plain old telephone service (POTS) signal on the line or as high as 25 kHz (e.g., if there is a POTS signal sharing the line). *Id.* The value of f_{0H} can be any frequency from 138 kHz to 276 kHz but is required to be less than or equal to the value of f_1 . *Id.*, §§7.1.1, A.1.

211. The value of f_1 is either 138 kHz or 276 kHz. G.993.2, §A.2.2, Table A.6.

212. Annex B of G.993.2 defines the band plans for use in Europe. G.993.2, §B.1. The band plans, denoted as “997” and “998,” are specified in Table B.1, copied below:

Table B.1/G.993.2 – Band plans

Band plan	Band-edge frequencies (as defined in the generic band plan Figure 7-1)						
	f_{0L} kHz	f_{0H} kHz	f_1 kHz	f_2 kHz	f_3 kHz	f_4 kHz	f_5 kHz
997	25	138	138	3000	5100	7050	12000
	25	276	276				
998	25	138	138	3750	5200	8500	12000
	25	276	276				
	120	276	276				
	N/A	N/A	138				
NOTE 1 – Flexibility in the bandwidth used for US0 is under study in ETSI TC-TM6.							
NOTE 2 – N/A in the columns f_{0L} and f_{0H} designates a band plan variant that does not use US0.							

G.993.2, §B.1.

213. Annex B states that “[t]wo variants are defined for band plan 997, and four for plan 998, to accommodate different underlying services (POTS and ISDN), and different US0 bandwidths.” G.993.2, §B.1.

214. Annex C of G.993.2 specifies the band plan for use in Japan. G.993.2, §C.1. The band plan is shown in Figure C-1, copied below:

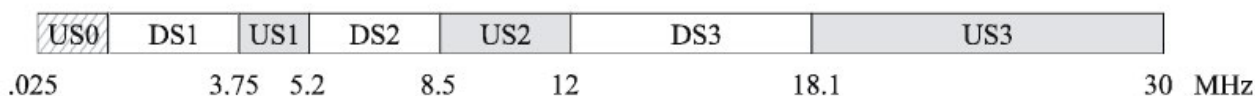


Figure C.1/G.993.2 – The band plan between 25 kHz and 30 MHz

G.993.2, §C.1, Fig. C.1.

215. Annex C states that “[t]he use of US0 is for further study.” G.993.2, §C.1.

216. The transceivers specified in G.993.2 have many of the same functionalities as the transceivers specified in earlier DSL standards (e.g., ADSL1 and ADSL2). Figure 5-1 of G.993.2, shown below, is a diagram illustrating the VTU-O and VTU-R.

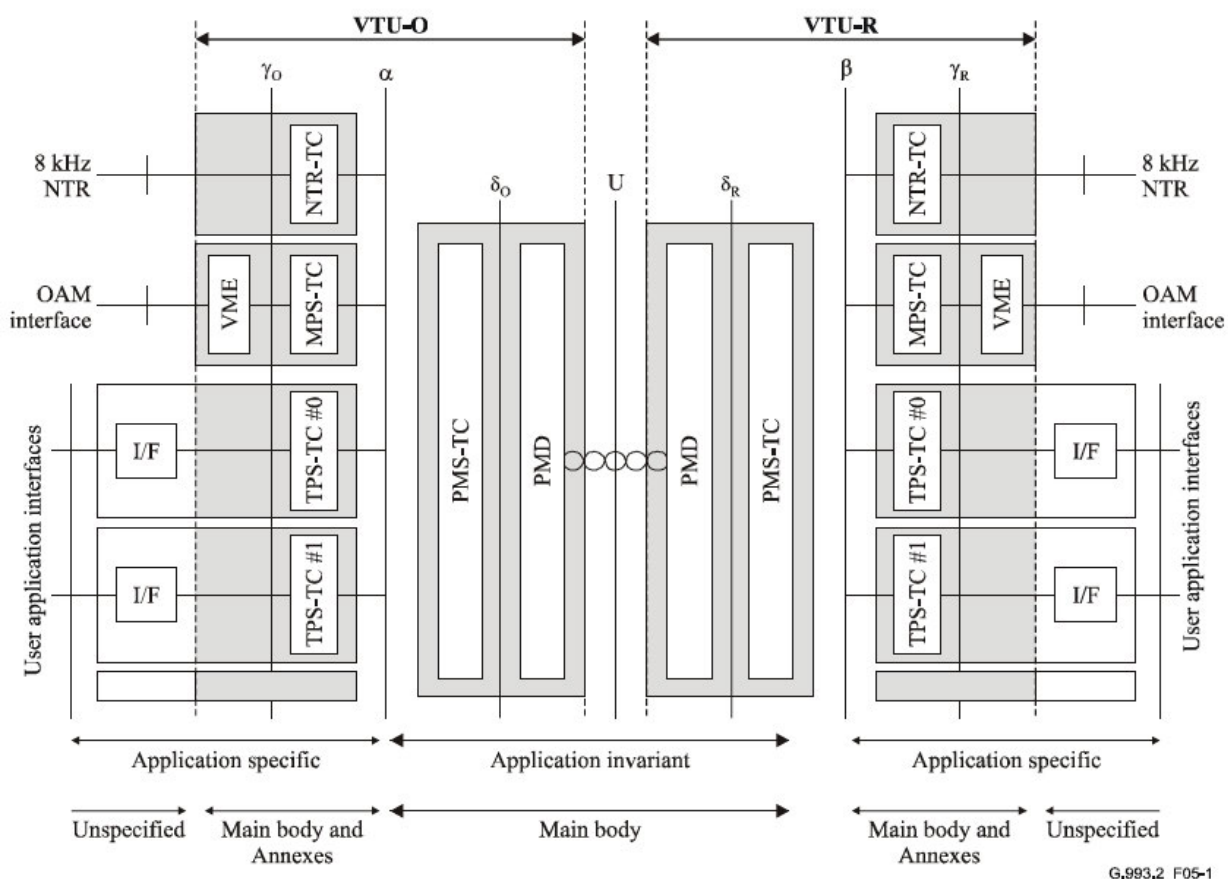


Figure 5-1/G.993.2 – VDSL2 and VTU functional model

G.993.2, Fig. 5-1.

217. Among other things, G.993.2 specifies the use of FEC and interleaving in the

PMS-TC layers of the VTU-O and VTU-R. G.993.2, §9.1. Figure 9-1 of G.993.2, copied below, illustrates PMS-TC layer, including the mandatory latency path, #0, and the optional latency path, #1, each of which includes both FEC and interleaving. *Id.*

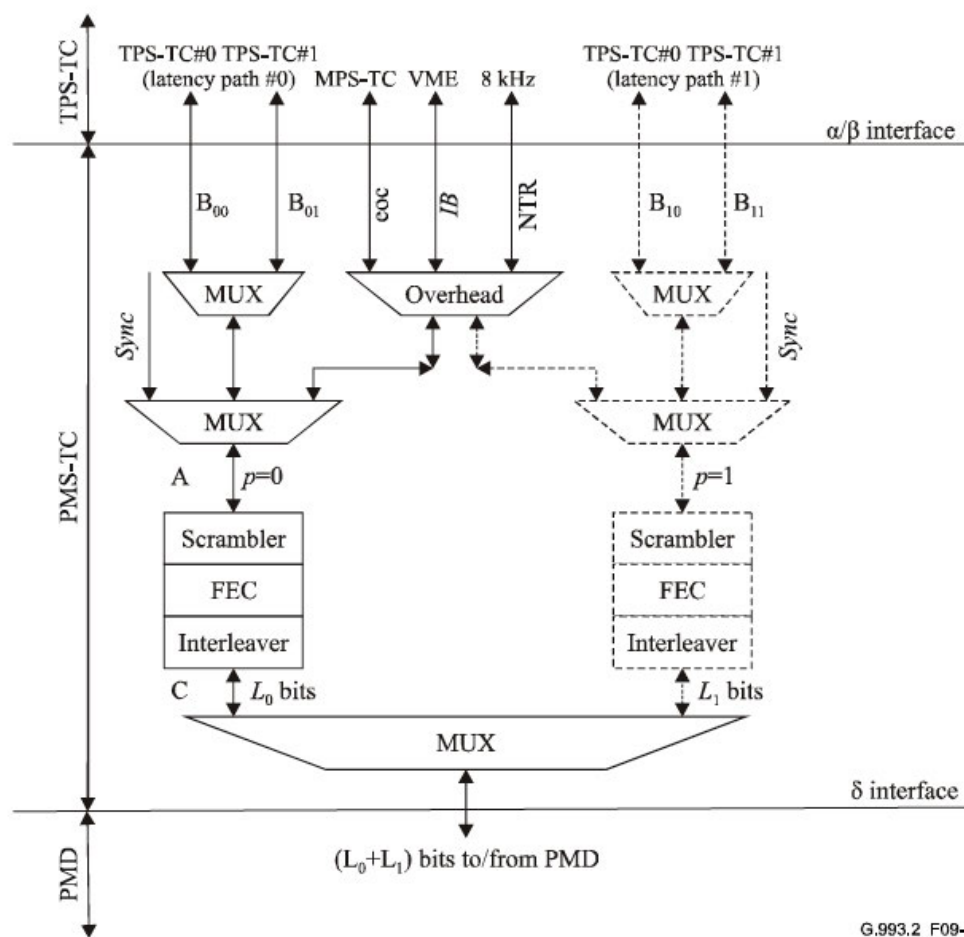


Figure 9-1/G.993.2 – PMS-TC functional model

G.993.2, Fig. 9-1.

218. Like other DSL standards, including G.993.1, G.993.2 specifies the use of “a standard byte-oriented Reed-Solomon code for forward error correction (FEC),” which “provides protection against random and burst errors.” G.993.2, §9.3. Each Reed-Solomon code word contains $N_{FEC} = K + R$ bytes, where K is the number of data bytes, and R is the number of parity bytes. *Id.* In both the downstream and upstream directions, valid values of R are 0, 2, 4, 6, 8, 10,

12, 14, and 16 bytes. *Id.* The FEC codeword length, N_{FEC} , can be any integer number of bytes from 32 to 255, inclusive. *Id.* Each VTU-O and each VTU-R must support all valid values of R and N_{FEC} . *Id.*

219. G.993.2 also specifies the use of interleaving “to protect the data against bursts of errors by spreading the errors over a number of Reed-Solomon codewords.” G.993.2, §9.4. The parameter I represents the interleaver block size in bytes, and the parameter D represents the interleaver depth. *Id.* In operation, the interleaver delays each of the I bytes in an interleaver block by an amount that varies linearly with the byte index, such that the byte B_j (with index j) is delayed by $\Delta[j] = (D - 1) \times j$ bytes. *Id.* The values of D and I are required to be co-prime, meaning they have no common divisor except 1. *Id.*

220. The overall (end-to-end) delay caused by the interleaver in the transmitter and the deinterleaver in the receiver is $(D - 1) \times (I - 1)$ bytes. G.993.2, §9.4. G.993.2 indicates that the interleaver in the transmitter needs at least $\frac{(D - 1) \times (I - 1)}{2}$ bytes of memory for interleaving, and the deinterleaver in the receiver on the other end of the line needs at least $\frac{(D - 1) \times (I - 1)}{2}$ bytes of memory for deinterleaving. *Id.*, §6.2.8.

221. G.993.2 restricts the length of the Reed-Solomon codeword, N_{FEC} , to an integer multiple of the interleaver block length I . G.993.2, §9.4. This restriction is given by the equation $N_{FEC} = q \times I$, where q is an integer between 1 and 8, inclusive. *Id.* VDSL transceivers are required to support all values of q from 1 to 8. *Id.*

222. The interleaver depth, D , is “set to meet the requirements for error-burst protection and latency.” G.993.2, §9.4. The maximum value of the interleaver depth, denoted as D_{max} , is specified by the profile. *Id.*, §6.1. A VTU that supports a particular profile must support all integer values of D from 1 to the value of D_{max} specified for that profile. *Id.*, §9.4.

223. G.993.2 contemplates that a VTU-R might use shared memory to support its interleaving and deinterleaving needs. G.993.2, §12.3.5.2.1.3 (referring to “the portion of shared interleaver memory that the VTU-R can use to de-interleave the downstream data stream”).

224. Unlike G.993.1, which uses bandwidth up to 12 MHz, (G.993.1, §1), G.993.2 allows the use of a much wider bandwidth: up to 30 MHz. G.993.2, §1.

225. To select a profile and prepare the transceivers for communication during Showtime, the VTU-O and VTU-R perform an initialization procedure. G.993.2, §12.1.3. Relative to G.993.1, G.993.2 provides “[i]mprovements to initialization.” *Id.*, §1.

226. The G.993.2 initialization procedure includes a Channel Discovery phase during which the transceivers set power levels, choose a profile, and set other modulation parameters. G.993.2, §12.3.1. The phase that follows Channel Discovery is the Training phase, during which components such as equalizers and echo cancelers (if present) can be trained. *Id.*

227. The last phase of the initialization procedure is the Channel Analysis & Exchange phase, during which the transceivers exchange information about their capabilities, and they determine and exchange the parameter values they will use during Showtime. G.993.2, §12.3.1. Figure 12-8 of G.993.2, copied below, illustrates the stages of the Channel Analysis & Exchange phase of initialization.

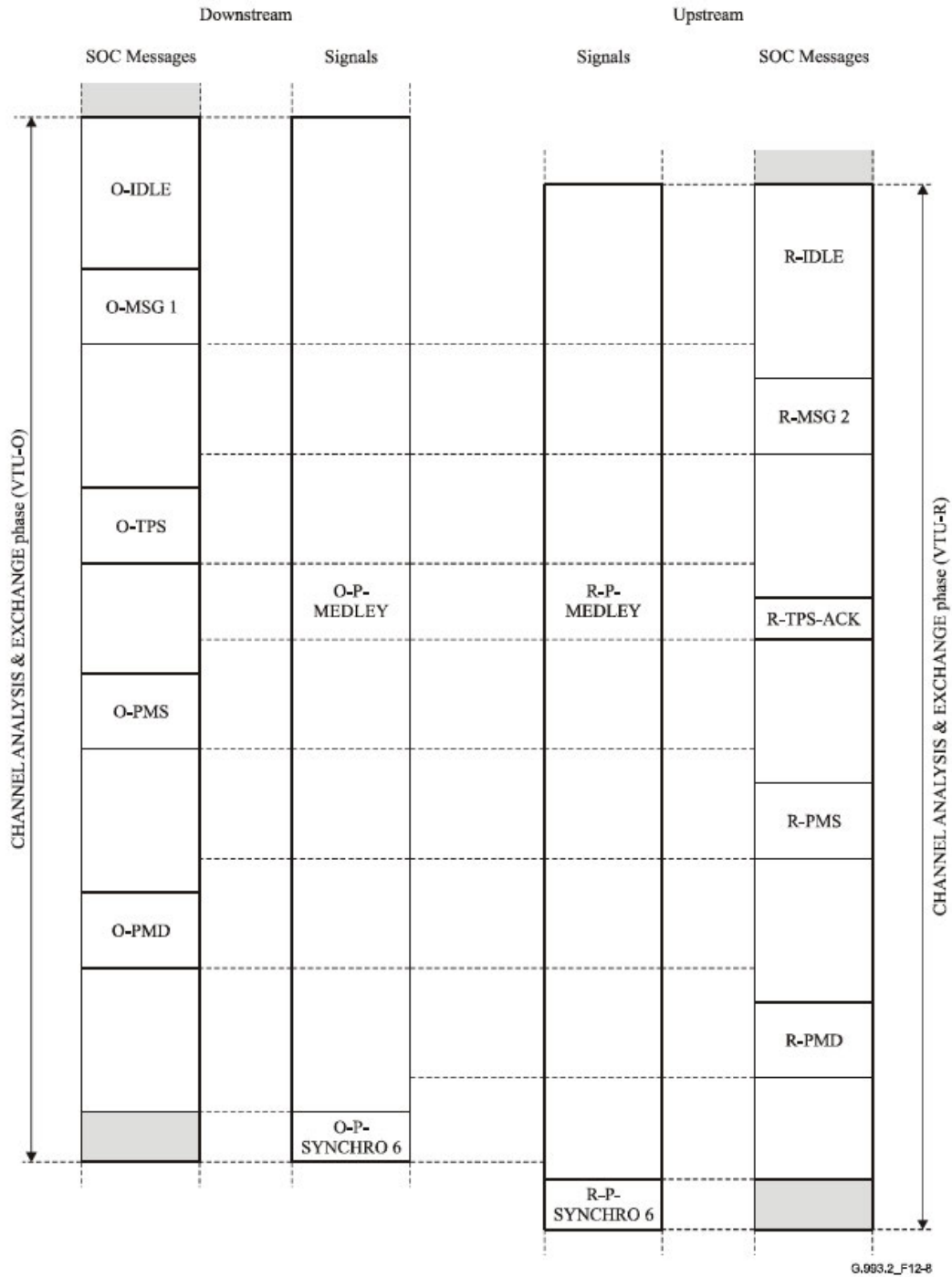


Figure 12-8/G.993.2 – Timing diagram for the stages of the channel analysis & exchange phase

228. In the O-MSG 1 message, the VTU-O sends its capabilities and various downstream configuration parameters to the VTU-R. G.993.2, §12.3.5.1. In response, the VTU-R sends the R-MSG 2 message to indicate its capabilities. *Id.* Next, the VTU-O specifies the

configuration of the bearer channels, both upstream and downstream, and their capabilities in the O-TPS message. *Id.* The VTU-R sends the R-TPS-ACK message to acknowledge the VTU-O's O-TPS message. *Id.*

229. The VTU-O then sends the O-PMS message to provide, to the VTU-R, the initial upstream PMS-TC parameters that will be used during Showtime. G.993.2, §12.3.5.1. These parameters include, for example, “the maximum interleaver delay that the VTU-R shall be allowed to use to de-interleave the data stream in downstream latency path #0,” in bytes, and “the maximum interleaver delay that the VTU-R shall be allowed to use to de-interleave the data stream in downstream latency path #1” (if used), also in bytes. *Id.*, §12.3.5.2.1.3. The O-PMS message also provides values for the FEC coding and interleaving in the upstream direction, including the values of *R*, *I*, and *D* for latency path #0 and, if used, latency path #1. *Id.* G.993.2 states that the O-PMS message “specifies the portion of shared interleaver memory that the VTU-R can use to de-interleave the downstream data stream.” *Id.*

230. The VTU-R then sends the R-PMS message to provide, to the VTU-O, the initial downstream PMS-TC parameters that will be used during Showtime. G.993.2, §12.3.5.1. These parameters include, for example, values for the FEC coding and interleaving in the downstream direction, including the values of *R*, *I*, and *D* for latency path #0 and, if used, latency path #1. *Id.*, §12.3.5.2.2.3. The VTU-R also indicates whether it will be using erasure decoding on any of the downstream latency paths. *Id.*

231. Next, the VTU-O sends the upstream bits per subcarrier and other information to the VTU-R in the O-PMD message, and the VTU-R responds with corresponding information for the downstream direction in the R-PMD message. G.993.2, §12.3.5.1. The VTU-O and VTU-R are then ready to transition to Showtime, which is coordinated using the O-P-SYNCRHO 6 and

R-P-SYNCRHO 6 signals. *Id.* The parameter settings negotiated and exchanged during the Channel Analysis & Exchange phase take effect starting from the first symbol of Showtime. *Id.*

232. To provide high robustness during some phases of initialization, G.993.2 specifies a retransmission protocol (the “RQ protocol”), “which allows the receiving VTU to ask for a retransmission of incorrectly received or missing message.” G.993.2, §§12.3.3.1, 12.3.4.1. In contrast to the automatic repeat (AR) protocol, in which messages are automatically repeated, (G.993.2, §12.2.2.1), “[i]n RQ mode, each message . . . shall be sent only once.” *Id.*, §12.2.2.2. The receiving VTU can request retransmission of the message by sending a request if the message has errors or has not arrived before a timeout timer expires. *Id.* The RQ mode is a stop-and-wait approach: “In RQ mode, a VTU shall never send a message (segment) prior to receiving an acknowledgement of the previously sent message (segment).” *Id.*

233. As did G.992.3 in the context of ADSL, G.993.2 recognizes that impulse noise can be problematic for VDSL and defines a parameter referred to as “impulse noise protection” or “INP.” Specifically, G.993.2 states that “INP_p (impulse noise protection for latency path p) is defined as the number of consecutive DMT symbols or fractions thereof, as seen at the input to the de-interleaver, for which errors can be completely corrected by the error correcting code, regardless of the number of errors within the errored DMT symbols.” G.993.2, §9.6.

234. The INP is a function of the FEC and interleaving parameters. G.993.2, §9.6. Specifically, the value of INP_p for a particular latency path *p*, in DMT symbols, is given by

$$INP_p = \frac{S_p \times D_p \times \left\lfloor \frac{R_p}{2 \times q_p} \right\rfloor}{N_{FEC,p}}$$

where, for the particular latency path *p*, *S_p* is the number of data symbols over which each FEC codeword spans, *D_p* is the interleaver depth, *R_p* is the number of redundancy bytes per FEC

codeword, q_p is the number of interleaver blocks in each FEC codeword, and $N_{FEC,p}$ is the FEC codeword size. *Id.*, §§9.6, 9.4, 9.5.4.

6. ITU-T Recommendation G.994.1 (2003)

235. ITU-T Recommendation G.994.1 is entitled “Handshake procedures for digital subscriber line (DSL) transceivers.” G.994.1 specifies a way for DSL transceivers “to exchange capabilities and to select a common mode of operation,” including “parameters relating to service and application requirements as well as parameters pertinent to various DSL transceivers.” G.994.1, i. Specifically, G.994.1 “defines signals, messages and procedures for exchanging these between digital subscriber line (DSL) equipment, when the modes of operation of the equipment need to be automatically established and selected, but before signals are exchanged which are specific to a particular DSL Recommendation.” *Id.*, §1.

236. As an example, as I explained above, during the handshake procedure that precedes G.993.2 initialization, the VTU-O and VTU-R exchange certain of their capabilities, including with regard to use of the optional US0 band. G.993.2, §§12.3.2.1.1, 12.3.2.1.2, 12.3.2.2.1, 12.3.2.2.2.

237. The procedures of G.994.1 are “an integral part of the start-up procedure for ITU-T Recs G.991.2, G.992.1, G.992.2, G.992.3, G.992.4 and G.992.5,” with an expectation that “future DSL Recommendations will also be able to make use of this Recommendation.” G.994.1, i.

238. The 2003 version of G.994.1 includes a “Retransmission Message” called “REQ-RTX” that allows either of the transceivers executing the handshake protocol (referred to in G.994.1 as “HSTUs”) to request retransmission “in response to the reception of an errored frame.” G.994.1, §7.15; *see also id.* at §10.5 (“Retransmission transactions occur whenever an HSTU receives an errored frame and wishes to transmit the REQ-RTX message to initiate a

retransmission instead of transmitting the NAK-EF [abort handshake] message.”), §4 (indicating that HSTU stands for “Handshake Transceiver Unit”), §12 (indicating that NAK-EF message indicates that receiving transceiver is aborting handshake session).

239. In my opinion, as of the priority date of the Family 9 patents, a person having ordinary skill in the art would have been familiar with the relevant standards, including T1.413 Issue 1, T1.413 Issue 2, G.992.1, G.992.2, G.992.3, G.993.1, G.993.2, and G.994.1, as well as contributions to the working groups responsible for those standards, and other publications and technology related to DSL systems.

I. The Family 9 Patents

1. Overview of the Family 9 Patents

a. The '411 Patent

240. The '411 patent describes a communications system that uses retransmission. *Id.*, 1:25-27. Specifically, the '411 patent describes transceivers capable of using both retransmission and interleaving in conjunction with forward error correction to improve DSL communications in the presence of impulse noise.

241. The '411 patent notes that depending on channel conditions, one of retransmission or interleaving could be preferred over the other:

Moreover, interleaving and RS coding methods and retransmission protocols provide different advantages with respect to error correction capabilities, latency, buffering requirements, and the like. For example, under certain configuration and noise conditions the interleaving/RS coding provides error correction/coding gain with less delay and overhead than the retransmission protocol (for packets that can be retransmitted). While under other conditions the retransmission protocol will provide better error correction with less delay and overhead than the interleaving/RS coding.

Id., 17:45-54.

242. The '411 patent describes using a shared memory for retransmission and

interleaving functions in a transceiver and allocating the shared memory between the two functions depending on which is more desirable for the channel conditions:

For example, if the configuration and noise conditions are such that the interleaving/RS coding would not provide good error correction/coding gain, then all the available memory could be used for the retransmission function and none allocated to the interleaving/deinterleaving/RS coding/RS decoding functionality, e.g., the interleaving/deinterleaving could be disabled.

Likewise, if the configuration and noise conditions are such that the retransmission protocol would not provide good error correction/coding gain, then all the available memory could be used for the interleaving/deinterleaving/RS coding/RS decoding functionality and no memory would be used for the retransmission function, e.g., the retransmission function would be disabled.

Alternatively, or addition, both methods could be used because both have their advantages, with the system, e.g., the memory management module 370, being able to dynamically allocate a first portion of the memory 250/350 to the interleaving/deinterleaving/RS coding/RS decoding functionality and a second portion of the memory to the retransmission functionality.

Id., 17:57-18:10.

243. The '411 patent describes a messaging protocol that allows a transmitting transceiver to specify the desired allocation of the shared memory to the other transceiver:

For example, the transmitting modem may send a message to the receiving modem indicating how much of the available memory is to be allocated to one or more of the interleaving/deinterleaving/RS coding/RS decoding functionality and how much memory is to be allocated to the retransmission functionality.

Id., 18:48-53.

244. The '411 patent also describes a messaging protocol that allows a receiving transceiver to inform the other transceiver of a planned allocation of the shared memory:

Alternatively, or addition, the receiving modem can send a message to the transmitting modem indicating how much of the available memory is to be allocated to one or more of the

interleaving/deinterleaving/RS coding/RS decoding functionality, and how much memory should be allocated to the retransmission functionality.

Id., 18:65-19:3.

b. The '055 Patent

245. The '055 patent discloses a communications system utilizing retransmission. *Id.*, 1:28-33. The '055 patent discloses that the system includes a transceiver 200 transmitting information to a receiving transceiver 300, shown below in Figure 1 from the patent:

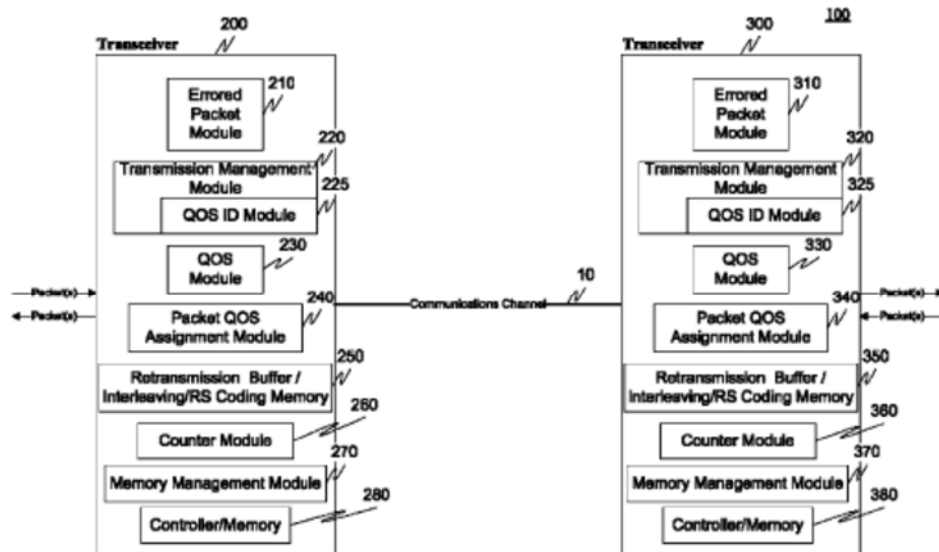


Fig. 1

Id., Fig. 1.

246. The '055 patent discloses that different types of information that the system transports have a different Quality of Service (QOS) metrics. *Id.*, 1:49-55. The '055 patent explains that two QOS metrics are latency and Packet Error Rate (PER). *Id.*, 1:56-57.

247. The '055 patent explains that video information typically requires transmission at a low error rate but can tolerate a degree of latency; whereas, voice information typically requires a lower latency but can tolerate a relatively higher error rate:

As an example, in the case where the two QOS metrics are latency and PER, packets containing, for example, video information (such as IPTV) may have the requirement for a very low packet error rate but can often tolerate higher delay. In contrast, voice or data (e.g., gaming) traffic may have very low latency requirements but can tolerate a higher packet error rate.

Id., 1:64-2:3.

248. The '055 patent describes packets of information that require a low error rate as "low-PER" packets and packets that require a low latency as "low-latency" packets. *Id.*, 2:3-6. The '055 patent discloses that packets can have header fields and the type of packet can be indicated by the information in the header:

Certain bit fields in the header of data portions of each packet could contain certain values that specify the QOS requirements a packet. For example, the packet header could contain bit fields that indicate if the packet has a "low-PER" QOS requirement or a "low-latency" QOS requirement. These fields could be read by the transmitting modem and/or receiving modem to determine the QOS level of each packet.

Id., 11:25-31.

249. The '055 patent explains that because retransmission reduces packet error but introduces latency, low-PER packets can be transmitted using a retransmission protocol; while, low-latency packets can be transmitted without retransmission:

For example, a specific QOS identifier could be assigned to the low-latency packets while a different QOS identifier could be assigned to the low-PER packets. The low-latency packets could be forwarded directly to another transceiver, or a higher layer, while the low-PER packets can be stored in a retransmission buffer, e.g., memory, that can be used to reduce packet error.

Id., 2:8-12.

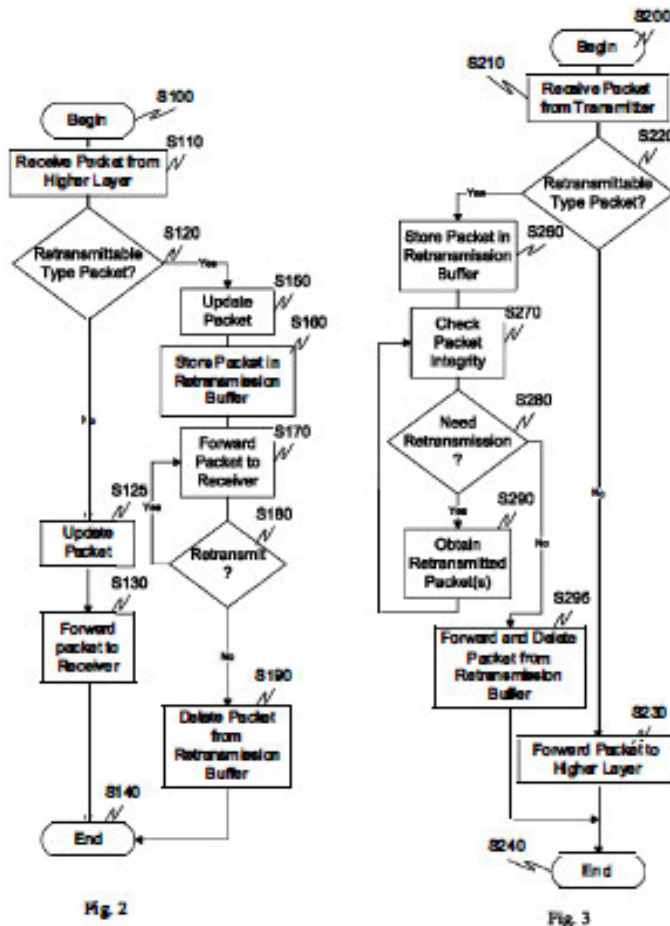
250. The '055 patent discloses that in order to keep track of which packets need to be retransmitted, the system adds a packet Sequence ID (SID) to the low-PER packets. *Id.*, 12:8-15. The packet SID, which can be appended to the header field, allows the receiving transceiver to

identify the packet that needs to be retransmitted:

For successful retransmission, the receiving modem should be able to inform the transmitting modem which packet, or packets, need to be retransmitted. One exemplary way of performing this is by transmitting packets with an appended bit field that contains a counter indicating the place of each packet in a stream of packets. This counter value is also known as a Sequence ID (SID). For example, a bit field containing a 16-bit counter could be appended to each packet and the counter module 260 would be incremented by one after each packet was transmitted. In cooperation with the packet assignment module 240, a packet counter field could be appended to the packet in a number of places, for example, at the beginning or end of the packet, or at the beginning or end of the packet header.

Id., 12:40-53.

251. The '055 patent describes how the system operates by reference to Figures 2 and 3:



Id., Figs. 2, 3.

252. As shown in Figure 2, in step S120, the system determines whether a packet is a low-PER packet or a low-latency packet. *Id.*, 21:11-12. If the packet is a low-latency packet, the system transmits the packet at step S130 without appending a packet SID and without retransmission. *Id.*, 21:12-18. Conversely, if the packet is a low-PER packet, the system appends a packet SID to the packet at step S150 and stores the packet in a retransmission buffer at step S160 before transmitting the packet to a receiving transceiver at step S170. *Id.*, 21:19-27.

253. As shown in Figure 3, the receiving transceiver also determines whether the packet is a low-PER or low-latency packet at S220 and performs similar operations on the packet depending on that determination as described with respect to the transmitting transceiver. *Id.*,

c. The '348 and '809 Patents

254. The '809 and '348 patents share a common specification. Below I describe the specification of the '348 patent, but the description is equally applicable to the '809 patent.

255. The '348 Patent generally relates to pre-existing telecommunications technologies and noise mitigation techniques, some of which are described above in connection with the “Background of the Technology” section of this Report. For example, in its *Abstract*, the '348 Patent summarizes its alleged inventive subject matter as “identification of different packet-types” and handling of packets “based on an assigned packet handling identifier.” '348 Patent, *Abstract*. The '348 Patent's *Abstract* further discloses that its packet handling identifier can “enable forwarding of latency-sensitive packets without delay and allow error-sensitive packets to be stored for possible retransmission.” *Id.* The '348 Patent's *Abstract* also discloses “a memory used for retransmission of packets [that] can be shared with other transceiver functionality such as, coding, decoding, interleaving, deinterleaving, error correction, and the like.” *Id.*

256. In its Summary section, the '348 Patent discloses the following:

[A]spects of the invention relate to assigning a packet handling identifier to one or more packets. Based on the packet handling identifier, a packet can either be, for example, forwarded directly to another communication device (or layer) or, alternatively, held for possible retransmission protocols. For example, packets received from, for example, a higher-layer of a communication device, can be designated to have a specific packet handling identifier, such as a Quality of Service (QOS) level. The QOS level of a packet indicates the importance of certain service metrics (or characteristics) of one or more packets.

Two exemplary QOS metrics are delay (or latency) and Packet Error Rate (PER). While these two metrics are used for illustrative purposes herein, it should be appreciated that other metrics can also be used with this invention. For example, other QOS metrics could include one or more of a Bit Error Rate (BER), data rate, delay

variation (or jitter), packet loss rate, time between error events (TBE), or the like.

As an example, in the case where the two QOS metrics are latency and PER, packets containing, for example, video information (such as IPTV) may have the requirement for a very low packet error rate but can often tolerate higher delay. In contrast, voice or data (e.g., gaming) traffic may have very low latency requirements but can tolerate a higher packet error rate. For this particular example, the video packets could be designated as “low-PER” QOS packets and the voice or data packets could be designated as “low-latency” QOS packets. For example, a specific QOS identifier could be assigned to the low-latency packets while a different QOS identifier could be assigned to the low-PER packets. The low-latency packets could be forwarded directly to another transceiver, or a higher layer, while the low-PER packets can be stored in a retransmission buffer, e.g., memory, that can be used to reduce packet error.

Id. 1:40-2:06.

257. Two examples of the above disclosures are illustrated in Figures 2 and 3 of the '348 Patent. *Id.* Figures 2-3. Both figures are reproduced below:

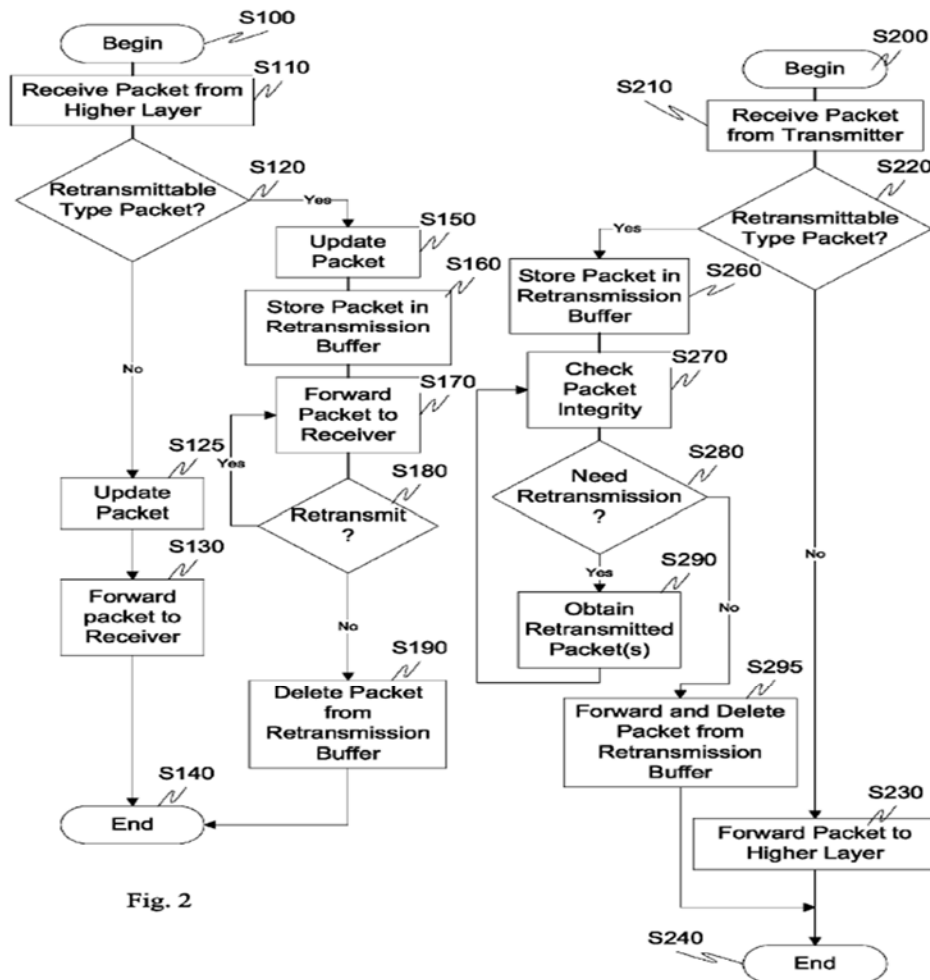


Fig. 2

Fig. 3

258. The '348 Patent states, with regard to Figure 2, the following:

Fig. 2 outlines an exemplary method of operation of a transmitting modem utilizing the retransmission protocol. In particular, control begins in step S100 and continues to step S110. In step S110, a packet is received from a higher layer. Then, in step S120, a decision is made as to whether the received packet is a retransmitted type packet. If the packet is not a retransmitted type packet, such as a low-latency packet, control jumps to step S125 where the packet is optionally updated (as discussed above) with control continuing to step S130 where the packet is forwarded to the receiver. Control then continues to step S140 where the control sequence ends.

If the packet is a retransmitted type packet, such as a low-PER packet, control continues to step S150. In step S150, the packet can be updated with information such as a sequence identifier or other information that allows a receiver to be able to determine which

packet (or packets) need to be retransmitted. Next, in step S160, the updated packet is stored in the retransmission buffer. Then, in step S170, the packet is forwarded to the receiver. Control then continues to step S180.

In step S180, a determination is made whether the packet needs to be retransmitted. If the packet needs to be retransmitted, control jumps back to step S170. Otherwise, control continues to step S190.

In step S190, the packet is deleted from the retransmission buffer. Control then continues to step S140 where the control sequence ends.

Id. 20:44-21:03.

259. Referring to Figure 3, the '348 Patent states the following:

Fig. 3 outlines an exemplary method of operation of a receiving modem utilizing the retransmission protocol. In particular, control begins in step S200 and continues to step S210. In step S210, a packet is received from the transmitter. Next, in step S220, a determination is made whether the packet has been identified as a retransmitted type packet. If the packet has not been identified as a retransmittable type packet, control jumps to step S230.

In step S230, the packet is forwarded to a higher layer. Control then continues to step S240 where the control sequence ends.

Alternatively, if the received packet is a retransmittable type packet, the packet is stored in the retransmission buffer in step S260. Next, in step S270, the integrity of the packet can be checked, for example utilizing a CRC. Then, in step S280, a determination is made whether the packet needs retransmission. If the packet needs retransmission, control continues to step S290 where the retransmitted packet is obtained, for example, based on the sending of a message(s), one or the other transceiver determining a packet is missing, or the like, as discussed above, with control continuing back to step S270 for an integrity check.

If the packet does not need retransmission, control continues to step S295 where the packet is forwarded to a higher layer and deleted from the retransmission buffer. Control then continues to step S240 where the control sequence ends.

Id. 21:04-29.

2. Asserted Claims of the Family 9 Patents

a. The '411 Patent

260. The asserted claims of the '411 patent are claims 10 and 18. Claim 10 recites:

A transceiver capable of packet retransmission comprising:

a transmitter portion capable of:

transmitting a plurality of packets,

identifying at least one packet of the plurality of packets as a packet that should be retransmitted and

allocating a memory between a retransmission function and an interleaving and/or deinterleaving function,

wherein at least a portion of the memory may be allocated to the retransmission function or to the interleaving and/or deinterleaving function at any one particular time, and

wherein a message transmitted during initialization indicates how the memory has been allocated between the retransmission function and the interleaving and/or deinterleaving function in the transceiver.

Claim 18 recites:

A transceiver capable of packet retransmission comprising:

a receiver portion capable of:

receiving a plurality of packets,

identifying at least one packet of the plurality of packets as a packet that should be retransmitted and

allocating a memory between a retransmission function and an interleaving and/or deinterleaving function,

wherein the memory is allocated between the retransmission function and the interleaving function and/or the deinterleaving function in accordance with a message received during an initialization of the transceiver and

wherein at least a portion of the memory may be allocated between the retransmission function and the interleaving and/or

deinterleaving function at any one particular time depending on the message.

b. The '055 Patent

261. The lone asserted claim of the '055 patent is claim 17. Claim 17 depends from claim 11 and therefore includes all the limitations of Claim 11, which recites:

A transceiver operable to transmit a first type of packet and to transmit a second type of packet,

wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission, and

wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet, and

wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.

Claim 17 further recites:

The transceiver of claim 11, wherein the first type of packet comprises one or more PTM-TC (Packet Transfer Mode-Transmission Convergence) codewords.

c. The '348 Patent

262. The asserted claims of the '348 patent are 9 and 10. Claim 9 recites:

An apparatus comprising:

a multicarrier transceiver including a processor and memory operable to:

receive a packet using a forward error correction encoder and a deinterleaver,

wherein the packet comprises a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords, and

wherein the header field comprises a sequence identifier (SID);

and transmit a plurality of messages using a forward error correction encoder and without using an interleaver,

wherein each message of the plurality of messages is transmitted in a different DMT symbol and

wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.

Claim 10 depends from claim 9 and recites:

The apparatus of claim 9, wherein the transmitted messages have a higher immunity to noise than the received packet.

d. The '809 Patent

263. The asserted claims of the '809 patent are 11 and 13. Claim 11 depends from claim 8 and therefore includes all the limitations of claim 8, which recites:

An apparatus comprising:

a multicarrier transceiver including a processor and memory capable of:

receiving a packet using forward error correction decoding and deinterleaving,

wherein the packet comprises a header field and a plurality of Reed-Solomon codewords, and

wherein the header field comprises a sequence identifier (SID);

and transmitting a message using forward error correction encoding and without using interleaving,

wherein the message is transmitted in a single DMT symbol and

wherein the message includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.

Claim 11 further recites:

The apparatus of claim 8, wherein a physical layer of the transceiver is capable of generating the packet and the message.

Claim 13 depends from claim 9, which depends from claim 8. Claims 9 and 13 recite:

The apparatus of claim 8, wherein the transmitted message has a higher immunity to noise than the received packet.

The apparatus of claim 9, wherein a physical layer of the transceiver is capable of generating the packet and the message.

3. File Histories of the Family 9 Patents

a. The '411 Patent

264. The '411 patent issued from U.S. Application No. 12/783,765 (“the '765 application”), May 20, 2010, as a continuation of Application No. 12/760,728, filed on April 15, 2010. *Id.*, §(60). The '765 application claims the benefit of U.S. Provisional Applications No. 60/849,650 and 60/792,236, filed on October 5, 2006 and April 12, 2006, respectively. *Id.*

265. As filed, the '765 application had 105 claims. Prosecution History of U.S. Patent Application No. 12/783,765, 58-69. In a preliminary amendment filed on September 14, 2010, the applicant canceled claims 1-105 and added new claim 106. *Id.*, 146. Claim 106 recited:

A method of packet retransmission comprising:

transmitting or receiving, using a communications transceiver, a plurality of packets; and

identifying at least one packet of the plurality of packets as a packet that should be retransmitted and at least one packet of the plurality of packets as a packet that should not be retransmitted.

Id.

266. On May 17, 2012, the Examiner rejected claim 106 for double-patenting over U.S. Patent Application No. 12/760,728, which eventually issued as U.S. Patent No. 8,595,577. *Id.*, 270.

267. On November 16, 2012, the applicant amended claim 106 and added new claims 107-126. *Id.*, 324-26. The applicant argued that the additional limitation, “wherein an interleaving/deinterleaving function shares memory in the transceiver,” in claim 106, overcame the double patenting rejection. *Id.*

268. On December 17, 2012, the examiner rejected claims 106, 107, 109-114, 116-121, and 123-126 under 102(b) as anticipated by U.S. Patent Application Publication No. 2003/0076870 to Moon; claims 107, 114, and 121 were also rejected for non-statutory obviousness-type double patenting over U.S. Patent Application No. 12/783,758. *Id.*, 350-56. The examiner stated that, among other things, that Moon disclosed sharing a memory between a retransmission function and an interleaving/deinterleaving function. *Id.*, 354.

269. The examiner indicated that claims 108, 115, and 122 would be allowable if they were amended not to depend from the rejected claims. *Id.*, 356. The examiner indicated that transmitting “a message during initialization, the message indicating how to share the memory between the retransmission function and the interleaving/deinterleaving function” rendered claims 108, 115, and 122 patentable. *Id.*, 357.

270. On April 24, 2013, the applicant amended claims 107 and 114 to incorporate the limitation found in claim 108 and 115, respectively, and added new claims 127-139 including the limitation of claims 108, 115, and 122. *Id.*, 406-409.

271. Subsequently, on May 9, 2013, the examiner issued a notice of allowance for all claims. *Id.*, 440. Claims 107, 109, and 131 issued as challenged claims 1, 2, and 9, respectively. Claims 114 and 132 issued as challenged claim 10 and 18, respectively.

b. The '055 Patent

272. The '055 patent issued from U.S. Application No. 14/159,125 (“the '125 application”), filed on January 20, 2014. *Id.*, cover page. The '125 application is a continuation of U.S. Application No. 13/766,059, filed February 13, 2013, now U.S. Patent No. 8,645,784, which is a continuation of U.S. Application No. 12/783,758, filed May 20, 2010, now U.S. Patent No. 8,407,546, which is a continuation of U.S. Application No. 12/295,828, filed October 2, 2008, now U.S. Patent No. 8,335,956, which is the national stage application under 35 U.S.C. § 371 of

PCT Application No. PCT/US2007/066522 having an international filing date of April 12, 2007, which claims the benefit of U.S. provisional Application Nos. 60/792,236, filed on April 12, 2006, and 60/849,650, filed on October 5, 2006. '055 patent, 1:6-22.

273. As filed, the '125 application had 105 claims. Prosecution History of U.S. Patent Application No. 14/159,125, 53-69. In a preliminary amendment filed on January 20, 2014, the same day the application was filed, the applicant canceled claims 9-105, leaving only claims 1-8 pending. *Id.*, 3-4. Claim 1 recited:

A method of packet retransmission comprising:
transmitting or receiving a plurality of packets;
identifying at least one packet of the plurality of packets as a packet
that should not be retransmitted.

Id., 3.

274. In addition to canceling claims 9-105, in the written description, the applicant added priority claims to U.S. Application No. 13/766,059 (U.S. Patent No. 8,645,784), U.S. Application No. 12/783,758 (U.S. Patent. No. 8,407,546), U.S. Application No. 12/295,828 (U.S. Patent No. 8,335,956), and PCT Application No. PCT/US2007/066522. *Id.*, 80. The applicant also corrected certain typographic errors and changed certain references to xDSL systems from "G.993.2" to "G.992.3" and from "G.993.5" to "G.992.5." *Id.*, 104.

275. On March 10, 2014, the applicant filed another preliminary amendment, cancelling claims 1-105 and adding new claims 106-125. *Id.*, 315-317. New claim 106 recited:

A method of packet retransmission, in a transceiver, comprising:
transmitting a first type of packet; and
transmitting a second type of packet,

wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission,

wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet, and

wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.

Id., 315. Applicant made no amendments to the written description.

276. On February 6, 2015, the Examiner sent a non-final Office Action rejecting claims 112, 113, 122, and 123 under 35 U.S.C. § 112 and claims 106-125 under 35 U.S.C. § 103. *Id.*, 346-357.

277. As to the rejections under 35 U.S.C. § 112, the examiner stated that the abbreviations “PTM-TC” in claims 112 and 122 and “ATM” in claims 113 and 123 were not defined. *Id.*, 349.

278. As to the rejections under 35 U.S.C. § 103, the examiner found all pending claims unpatentable over U.S. Application No. 2007/0206621 to Plamondon (“Plamondon”) in view of U.S. Application No. 2002/0126675 to Yoshimura (“Yoshimura”). *Id.*, 350-356. The Examiner found that Plamondon teaches a method of packet retransmission in a transceiver, including every limitation of the pending claims except the requirement that the second type of packet does not comprise the sequence identifier (“SID”) of the first type of packet. *Id.*, 350-51, 353-54. The Examiner found that Yoshimura teaches that the header field of the second type of packet does not comprise the SID of the first type of packet and found that it would have been obvious to a person having ordinary skill in the art to combine the teachings of Plamondon and Yoshimura. *Id.*, 351, 354.

279. On April 8, 2015, the applicant's representative, Jason Vick, and the Examiner held an applicant-initiated interview. *Id.*, 391-393. Mr. Vick argued that Plamondon does not teach two different types of packets or the limitation "wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet." *Id.*, 392. The Examiner disagreed with the first argument, but as to the second argument, agreed to review the reference and update the search once applicant filed a response to the Office Action. *Id.*

280. On April 23, 2015, the applicant responded to the Office Action by amending certain claims. *Id.*, 394-98. Claim 106 was amended to specify that the "transmitting" steps are both performed "by the transceiver." *Id.*, 395. Claims 112, 113, 115, 122, 123, and 125 were amended to define the acronyms "PTM-TC," "ATM," and "PER." *Id.*, 396-97. The applicant stated that the amendments addressed the rejection under 35 U.S.C. § 112 and, referencing the April 8, 2015 interview, stated that "[t]he Examiners agree the claims were distinguishable from the references" and requested withdrawal of the rejections. *Id.*, 398.

281. On June, 16, 2015, the Examiner mailed an Office Action finally rejecting claims 106-125. *Id.*, 412-25. The Examiner again found all pending claims unpatentable under 35 U.S.C. § 103 over Plamondon in view of Yashimura. *Id.*, 417-23. The Examiner noted in response to applicant's argument that Plamondon does not teach the limitation "wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet," that Yashimura teaches this limitation. *Id.*, 414-16.

282. On December 2, 2015, the applicant's representative, Jason Vick, and the Examiner held an applicant-initiated interview. *Id.*, 487-89. Mr. Vick argued that the cited portion of Yashimura fails to teach the limitation "the header field of the second type of packet does not

comprise the SID of the first type of packet.” *Id.*, 488. The Examiner agreed to review the cited references and update the search if an amendment or arguments were filed. *Id.*

283. On December 2, 2015, the same day as the interview, the applicant filed a request for continued examination (RCE) and an amendment after final. *Id.*, 472-84. The applicant submitted no amendments, and argued only that the rejections should be withdrawn on the basis of arguments made during the interview. *Id.*, 484.

284. On December 31, 2015, the Examiner sent a non-final Office Action rejecting claims 106-125. *Id.*, 510-21. The Examiner found all pending claims unpatentable under 35 U.S.C. §103 over Plamondon in view of U.S. Patent No. 6,266,337 to Marco (“Marco”). *Id.*, 513-20. The Examiner again noted that Plamondon does not teach that the second type of packet does not comprise the SID of the first type of packet, but found that Marco does teach this limitation and that it would have been obvious to a person having ordinary skill in the art to modify Plamaondon with the teachings of Marco. *Id.*, 513-14, 516-18.

285. On April 12, 2016, the applicant’s representative, Jason Vick, and the Examiner held an applicant-initiated interview. *Id.*, 566-68. Mr. Vick argued that the cited references fail to teach the limitation “wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission, wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.” *Id.*, 569. The examiner agree to review the references and update the search should applicant file an amendment or argument. *Id.* No agreement was reached. *Id.*

286. On April 26, 2016, the applicant submitted a response to the Office Action. *Id.*,

569-75. The applicant argued that neither Plamondon nor Marco teach that the header field of the first type of packet comprises a SID that is incremented after the first type of packet is transmitted. *Id.*, 573-74.

287. On August 1, 2016, the Examiner mailed a notice of allowability, indicating that claims 106-125 are allowed. *Id.*, 603-07. On October 6, 2016, the Examiner mailed a corrected notice of allowability that included a statement of reasons for allowance. *Id.*, 698-701. The Examiner noted that the documents listed in applicant's Information Disclosure Form, filed September 16, 2016, had been reviewed and none of the references anticipated or rendered obvious the allowed claims. *Id.*, 700. Claims 106-125 issued as claims 1-20, respectively.

c. The '348 Patent

288. The '348 Patent issued from U.S. Patent Application No. 14/075,194, entitled "Packet Retransmission" and filed on November 8, 2013 with an earliest priority date of April 12, 2006. Prosecution History of U.S. Patent Application No. 14/075,194 ("194 Prosecution History"), 305-307 (Filing Receipt mailed Nov. 27, 2013).

289. On January 2, 2014, applicant's representative filed a preliminary amendment deleting claims 1-105 and adding new claims 106-33. *Id.*, 322-27 (Preliminary Amendment mailed Jan. 2, 2014, pp. 1-6).

290. Only one Non Final Office Action ("NFOA") was used to substantively examine U.S. Non-Provisional Patent App. No. 14/075,194. Specifically, the USPTO issued an NFOA on January 28, 2015 rejecting claims 106-121 under 35 U.S.C. §101 as being directed to "software, per se," a type of non-statutory subject matter. *Id.*, 354 (NFOA mailed Jan. 28, 2015, p. 2). The NFOA also indicated that claims 122-133 were allowable. *Id.*

291. On February 4, 2015, the applicant's representative responded to the NFOA. *Id.*, 407-12 (Amendment and Response mailed Feb. 4, 2015, pp. 1-6). In its response, the applicant's

representative amended claims 106, 114, 122, and 128. *See id.* 408-11 (Amendment and Response mailed Feb. 4, 2015, pp. 2-5). Claims 107-13, 115-21, 123-27, and 129-33 were left unchanged. *See id.* I note that applicant's representative remarked that claims 106 and 114 were amended to include processor and memory in order to overcome the §101 rejection set forth in the NFOA. *See id.*, 412 (Amendment and Response filed Feb. 4, 2015, p. 6). The amendments to claims 106, 114, 122, and 128 are as follows:

106. (Currently Amended) An apparatus comprising:

a multicarrier transceiver including a processor and memory operable to:

transmit a packet using a forward error correction encoder and an interleaver, wherein the packet comprises a header field and a plurality of PTM-TC codewords~~or~~, a plurality of ATM cells or a plurality of Reed-Solomon codewords, and wherein the header field comprises a sequence identifier (SID); and

receive a plurality of messages using a forward error correction decoder and without using a deinterleaver, wherein each message of the plurality of messages is received in a different DMT symbol and wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the transmitted packet.

114. (Currently Amended) An apparatus comprising:

a multicarrier transceiver including a processor and memory operable to:

receive a packet using a forward error correction decoder and a deinterleaver, wherein the packet comprises a header field and a plurality of PTM-TC codewords~~or~~, a plurality of ATM cells or a plurality of Reed-Solomon codewords, and wherein the header field comprises a sequence identifier (SID); and

transmit a plurality of messages using a forward error correction encoder and without using an interleaver, wherein each message of the plurality of messages is transmitted in a different DMT symbol and wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.

122. (Currently Amended) A method, in a multicarrier transceiver, comprising:

transmitting a packet using a forward error correction encoder and an interleaver, wherein the packet comprises a header field and a plurality of PTM-TC codewords~~or~~a plurality of ATM cells or a plurality of Reed- Solomon codewords, and wherein the header field comprises a sequence identifier (SID); and

receiving a plurality of messages using a forward error correction decoder and without using a deinterleaver, wherein each message of the plurality of messages is received in a different DMT symbol and wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the transmitted packet.

128. (Currently Amended) A method, in a multicarrier transceiver, comprising:

receiving a packet using a forward error correction decoder and a deinterleaver, wherein the packet comprises a header field and a plurality of PTM-TC codewords~~or~~a plurality of ATM cells or a plurality of Reed-Solomon codewords, and wherein the header field comprises a sequence identifier (SID); and

transmitting a plurality of messages using a forward error correction encoder and without using an interleaver, wherein each message of the plurality of messages is transmitted in a different DMT symbol and wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.

See id., 408-11 (Amendment and Response mailed Feb. 4, 2015, pp. 2-5).

292. On April 8, 2015, the USPTO issued a notice of allowance for U.S. Patent Application No. 14/075,194. *See id.*, 417 (Notice of Allowance and Fee(s) Due mailed Apr. 8, 2015, p. 1). The Notice of Allowance was accompanied by a Notice of Allowability, which indicated that claims 106-33 were allowed.¹³ *See id.*, 421 (Notice of Allowability mailed Apr. 8,

¹³ Claims 106-33 of U.S. Non-Provisional Patent App. No. 14/075,194, as set forth in the Amendment and Response filed on February 4, 2015, were renumbered as claims 1--27 of the

2015, p. 1). The USPTO did not provide any reasons for allowance.

293. After the USPTO issued the '348 Patent on July 28, 2015, the applicant's representative requested and was granted a certificate of correction to correct a minor typographical error in claim 23. *See id.*, 499, 504 (Request for Certificate of Correction filed Aug. 28, 2015, p. 1; and Certificate of Correction mailed Dec. 22, 2015, p. 1). Specifically, the term "HACK" in claim 23 was corrected to "NACK." *Id.*

294. The applicant's representative disclosed and the USPTO considered several prior art references, including G.993.2, G.992.3, and G.992.5. *Id.*, 211, 361 (Information Disclosure Statement ("IDS") submitted on Nov. 08, 2013, p. 5; and IDS considered on Jan. 22, 2015, p. 5).

295. Additional references disclosed by the applicant's representative and considered by the USPTO include U.S. Patent App. Pub. No. 2003/0009717, European Patent App. No. 1006689, Japanese Patent App. Pub. No. 2001-119437, all three of which are by Fukushima et al.¹⁴ *Id.*, 448, 470 (IDS submitted on Apr. 23, 2015, pp. 1-2 and IDS considered on April 30, 2015, pp. 1-2).

296. Each of the references disclosed by the applicant's representative and considered by the USPTO, including the references explicitly mentioned above, were not subject to any substantive analysis during prosecution of U.S. Patent Application No. 14/075,194.

297. No other prior art reference relied on in this report were cited during prosecution of U.S. Patent Application No. 14/075,194, and the USPTO never considered the prior art combinations or arguments in the Grounds below.

'348 Patent. *Compare* '194 Prosecution History, -408-11 (Amendment and Response mailed Feb. 4, 2015, pp. 2--5) *with* '348 Patent, 23:29-25:15.

¹⁴ Each of U.S. Patent App. Pub. No. 2003/0009717, European Patent App. No. 1006689, and Japanese Patent App. Pub. No. 2001-119437 includes substantially the same subject matter as one of the prior art references relied upon in this report—U.S. Patent No. 7,124,333 ("Fukushima").

d. The '809 Patent

298. The '809 Patent issued from U.S. Patent Application No. 16/701,343, entitled “Techniques for Packet and Message Communication in a Multicarrier Transceiver Environment” and filed on December 3, 2019 with an earliest priority date of April 12, 2006. Prosecution History of U.S. Patent Application No. 16/701,343 (“’343 Prosecution History”), 107 (Filing Receipt mailed Dec. 26, 2019).

299. On December 3, 2019, applicant’s representative filed a preliminary amendment deleting claims 1-105 and adding new claims 106-133. *See id.*, 1-7 (Preliminary Amendment mailed December 03, 2019, pp. 1–7).

300. Only one substantive office action was issued during the prosecution of the ’343 application. Specifically, the Examiner issued a Non-Final Office Action (“NFOA”) on February 2, 2020 objecting to the title, and rejecting claims 106-133 on the ground of nonstatutory double patenting as being unpatentable over claims 1-28 of U.S. Patent No. 9,094,348 and claims 1-28 of U.S. Patent No. 9,749,235. *Id.*, 114-119 (NFOA mailed Feb. 2, 2020, pp. 1-6). The NFOA also indicated that a timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. *Id.*

301. On April 21, 2020, the applicant’s representative responded to the NFOA. *Id.*, pp. 178-186 (Amendment and Response mailed April 21, 2020, pp. 1–7). In its response, the applicant’s representative amended the title and submitted an Electronic Terminal Disclaimer in view of U.S. Patent Nos. 9,094,348 and 9,749,235 which the applicant indicated were filed and approved on April 21, 2020. *Id.*, 385-391 (Amendment and Response mailed April 21, 2020, pp.

1-7). Claims 106-133 were left unchanged. *See id.* On April 1, 2020 and May 25, 2020, the applicant's representative submitted a supplemental information disclosure statement. *Id.*, 313-351, 395-396. The supplemental information disclosure statements and with corresponding transmittal letters described including copies of cited non-patent references, foreign references, patent application references and patent application publication references. *Id.*

302. On July 23, 2020, the Examiner issued allowed the claims in an Ex Parte Quayle Action. *Id.*, pp. 410-415 (Ex Parte Quayle Action mailed July 23, 2020, pp. 1-5). Specifically, the Examiner made a request under 37 C.F.R. 1.105 that applicant specify which of the cited references, from the information disclosure statements filed on April 1, 2020 and May 25, 2020, disclose "receiving a packet using FEC decoding and deinterleaving" and "transmitting a message using FEC encoding and without using interleaving" or alternatively, "transmitting a packet using FEC encoding and interleaving" and "receiving a message using FEC decoding and without using deinterleaving" wherein "the message is received in a single DMT symbol". The examiner also requested the applicant specify which 15-20 references are most relevant to the claims in the application, including specifying any documents submitted that involve this application or direct parents of this application. The Examiner also stated that claims 106-133 are allowed, and that the application was in condition for allowance except for pending formal matters that included the request under 37 C.F.R. 1.105 and that prosecution on the merits was closed in accordance with the practice under Ex parte Quayle, 25 USPQ 74, 453 O.G. 213, (Comm'r Pat. 1935). *Id.*

303. On July 31, 2020, the applicant's representative responded to the Ex Parte Quayle Action. *Id.*, 425-426 (Amendment and Response mailed July 31, 2020, pp. 1-2). In its response, the applicant's representative thanked the Examiner for the clarifications regarding the 37 C.F.R. 1.105 request that were discussed during a telephone interview held on July 23, 2020. Applicant's

representative described that during the call the background of the subject application was discussed and an explanation provided as to how the submitted references were deemed to be material to the subject application. *See id.*

304. On August 8, 2020, the USPTO issued a notice of allowance for U.S. Patent Application No. 16/701,343. *See id.*, 446 (Notice of Allowance and Fee(s) Due mailed August 8, 2020, p. 1). The Notice of Allowance was accompanied by a Notice of Allowability, which indicated that claims 106-133 were allowed.¹⁵ *See id.*, 450 (Notice of Allowability mailed August 8, 2020, p. 1). The USPTO did not provide any reasons for allowance.

305. The USPTO issued the '809 Patent on November 10, 2020. *See id.*, 529.

306. The applicant's representative disclosed and the USPTO considered several prior art references, including G.993.2, G.992.3, and G.992.5. *See id.*, 323-324 (Information Disclosure Statement ("IDS") submitted on Apr. 1, 2020, pp. 1-39).

307. Additional references disclosed by the applicant's representative and considered by the USPTO include U.S. Patent Application Pub. No. 2003/0009717, European Patent Application No. 1006689, Japanese Patent Application Pub. No. 2001-119437, all three of which are by Fukushima et al.¹⁶ *See id.*, 316, 319, 320 (IDS submitted on Apr. 1, 2020, pp. 1-39).

308. Each of the references disclosed by the applicant's representative and considered by the USPTO, including the references explicitly mentioned above, were not subject to any substantive analysis during prosecution of the '343 application.

¹⁵ Claims 106–133 of the '343 application, as set forth in the preliminary amendment filed on December 3, 2019, were renumbered as claims 1-28 of the '809 Patent. *Compare* '343 Prosecution History, 3-6 *with* '809 Patent, 24:09-26:35.

¹⁶ Each of U.S. Patent Application Pub. No. 2003/0009717, European Patent Application No. 1006689, and Japanese Patent Application Pub. No. 2001-119437 includes substantially the same subject matter as U.S. Patent Application Publication No. 2005/0053093 by Fukushima et al.

309. No other prior art reference relied on in this report was cited during prosecution of the '343 application, and the USPTO never considered the prior art combinations or arguments in the Grounds below.

4. Claim Construction

310. I have reviewed the Court's Claim Construction Memorandum and Order, issued on June 8, 2022. A summary of the terms in the Family 9 patents' claims for which the Court provided a construction is provided below:

Patent(s)	Term or Phrase	Court's Construction
'411, '055, '348, '809	"transceiver"	"communications device capable of transmitting and receiving data wherein the transmitter portion and receiver portion share at least some common circuitry"
'348, '055	"operable to"	"configured to"

311. In my analysis, I have applied the Court's constructions. I have interpreted the remaining claim terms as they would have been understood by a person having ordinary skill in the art on the priority date of the Family 9 patents, considering the context of the claims themselves, the specification, the figures, the prior art, and the prosecution history. Consistent with these constructions and interpretations, I have considered the claims in light of the ordinary meaning of the claims based on the perspective of one of skill in the art and consistent with my experience in the field.

VIII. ANALYSIS OF THE PRIOR ART

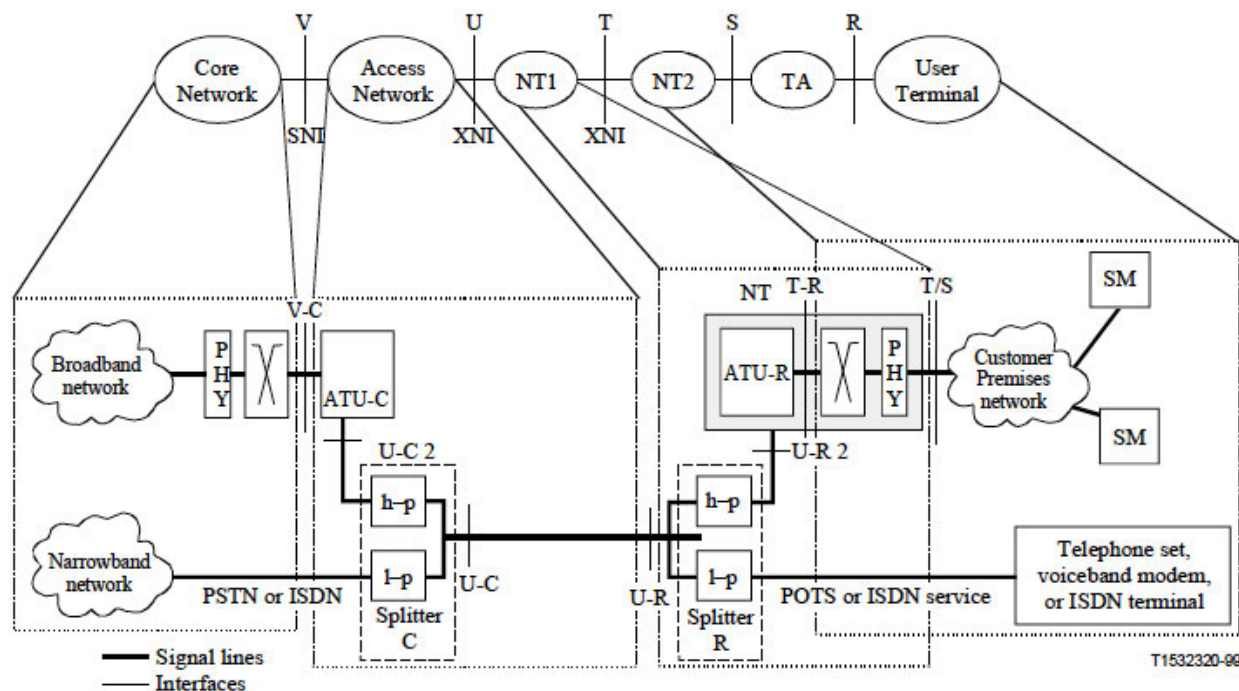
A. Summary of the Prior Art References

1. G.992.1

312. ITU-T Recommendation G.992.1, which is entitled "Asymmetric digital subscriber line (ADSL) transceivers," specifies requirements for ADSL transceivers to enable high-speed data transmission between the network operator end of a subscriber line, where the ATU-C is

located, and the customer end, where the ATU-R is located. G.992.1, i. The acronym “ATU” stands for “ADSL transceiver unit.” *Id.*, §4.

313. Figure 1-1 of G.992.1, copied below, is an ADSL system reference model that illustrates the locations of the ATU-C and ATU-R within the network, as well as various defined interfaces between components.



NOTE 1 – The U-C and U-R interfaces are fully defined in this Recommendation. The V-C and T-R interfaces are defined only in terms of logical functions, not physical. The T/S interface is not defined here.

NOTE 2 – The V-C interface may consist of interface(s) to one or more (STM or ATM) switching systems.

NOTE 3 – Implementation of the V-C and T-R interfaces is optional when interfacing elements are integrated into a common element.

NOTE 4 – One or other of the high-pass filters, which are part of the splitters, may be integrated into the ATU-x; if so, then the U-C 2 and U-R 2 interfaces become the same as the U-C and U-R interfaces, respectively.

NOTE 5 – A digital carrier facility (e.g. SONET extension) may be interposed at the V-C.

NOTE 6 – Due to the asymmetry of the signals on the line, the transmitted signals shall be distinctly specified at the U-R and U-C reference points.

NOTE 7 – The nature of the customer installation distribution and customer premises network (e.g. bus or star, type of media) is for further study.

NOTE 8 – More than one type of T-R interface may be defined, and more than one type of T/S interface may be provided from an ADSL NT (e.g. NT1 or NT2 types of functionalities).

NOTE 9 – A future issue of this Recommendation may deal with customer installation distribution and home network requirements.

NOTE 10 – Specifications for the splitters are given in Annex E.

Figure 1-1/G.992.1 – ADSL system reference model

Id., Fig. 1-1.

314. The ATU-C and ATU-R described in G.992.1 are communications devices

capable of transmitting and receiving. *See, e.g., id.*, i; §§7.4.1.2, 7.7, 10.1.2, 11.2.3, 11.2.6; Fig. 10-5. The transmitter portion and receiver portion of the ADSL transceivers disclosed in G.992.1 share at least some common circuitry.

315. G.992.1 organizes transmitted and received data into data frames. *Id.*, §1. The ADSL transmitter transmits all of the bits in a data frame in the same DMT symbol. *Id.*, §§3.14, 7.4.1.1.

2. G.993.1

316. G.993.1 is entitled “Very high speed digital subscriber line transceivers” and was approved on June 13, 2004 by the ITU-T Study Group 15. G.993.1 at Cover; *id.* at i. I am informed that G.993.1 qualifies as prior art under at least pre-AIA 35 U.S.C. §102(b) because it was publicly available more than one year before the earliest priority date for the Family 9 patents of April 12, 2006. I have also reviewed the ITU website and see that G.993.1 was posted no later than October 24, 2005. I am informed that under this date G.993.1 qualifies as prior art under at least pre-AIA 35 U.S.C. §102(a) because it was described in a printed publication in this or a foreign country before the earliest priority date for the Family 9 patents of April 12, 2006.

317. I also spoke with Nokia's engineers Frank Van der Putten and Danny Van Bruyssel. Mr. Van Bruyssel and Mr. Van der Putten informed me that they were present at the April 2004 meeting where G.993.1 was consented to and the June 2004 meeting where G.993.1 was approved. They informed me that, after approval, the document would undergo no substantive changes. Mr. Van Bruyssel also informed me that, on May 13, 2004, he received an email through an ITU, Study Group 15 email distribution list—tsg15g4@itu.ch. That email pointed to him to the draft version of G.993.1 for consent, which was ultimately approved without comment.

a. Initialization Messaging

318. ITU-T Recommendation G.993.1, sometimes referred to as “VDSL1,” specifies aspects of very-high-speed digital subscriber lines (VDSL) to permit the transmission of asymmetric (downstream greater than upstream) and symmetric (downstream and upstream equal) aggregate data rates up to tens of Mbit/s on twisted pairs. G.993.1 provides for use of a wider bandwidth than is used in ADSL, namely, up to 12 MHz. ITU-T Recommendation G.993.1, Very high speed digital subscriber line transceivers (June 2004) (“G.993.1”), §1.

319. Among other things, G.993.1 specifies the use of FEC and interleaving in the transmitter. Figure 8-1 of G.993.1, copied below, illustrates the defined “slow” and “fast” paths. As shown, the “slow” path includes both FEC and interleaving, whereas the “fast” path includes FEC but not interleaving.

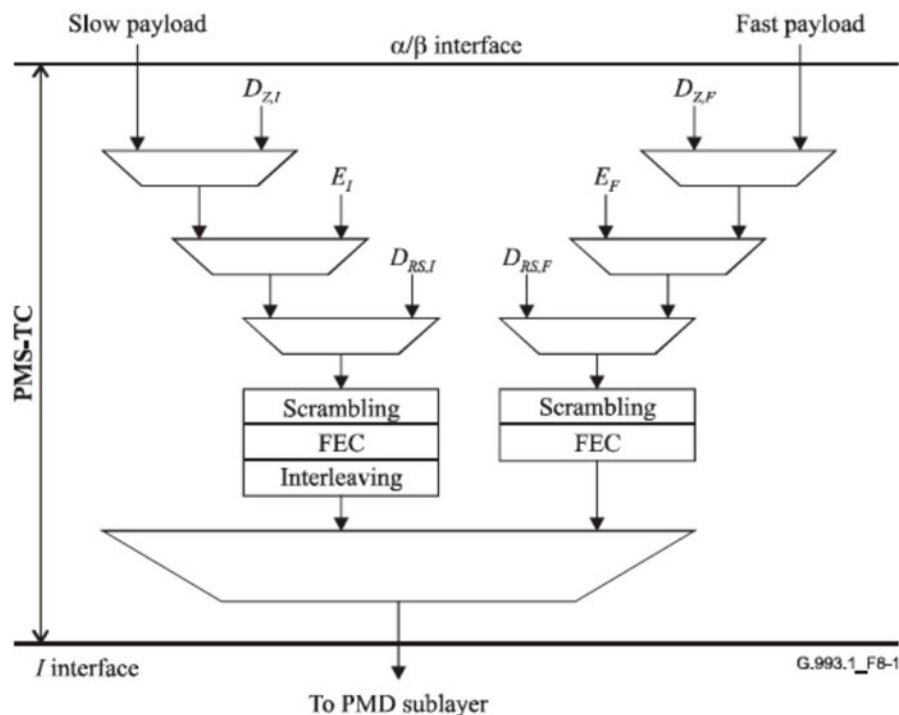


Figure 8-1/G.993.1 – Diagram of PMS-TC sublayer

G.993.1, Fig. 8-1.

320. G.993.1 specifies the use of “a standard byte-oriented Reed-Solomon code . . . to provide protection against random and burst errors” (G.993.1, §8.3) and interleaving “to protect the data against bursts of errors by spreading the errors over a number of Reed-Solomon codewords.” G.993.1, §8.4.1. Specifically, “the codewords shall be interleaved before transmission to increase the immunity of RS [Reed-Solomon] codewords to bursts of errors.” G.993.1, §8.4.1. The interleave depth is programmable up to a maximum depth of 64 codewords when the codeword length is 255 bytes. *Id.* When the codeword is shorter than 255 bytes, the interleave depth can be larger than 64 codewords. *Id.*

321. G.993.1 specifies that “[i]t shall be possible to adjust the interleave depth via the management system to meet latency requirements.” *Id.* The interleaver “uses a memory in which a block of I octets is written while an (interleaved) block of I octets is read.” *Id.* G.993.1 teaches that the receiver requires the same size of memory for deinterleaving as the transmitter uses for interleaving. *Id.*

322. G.993.1 specifies an initialization procedure to allow the VTU-O and VTU-R to, among other things, exchange parameters such as Reed-Solomon settings and interleaver parameters. G.993.1, §12.4.1. Figure 12-7 of G.993.1, copied below, illustrates the timing of messages transmitted by the VTU-O and VTU-R during the channel analysis and exchange phase of VDSL1 initialization.

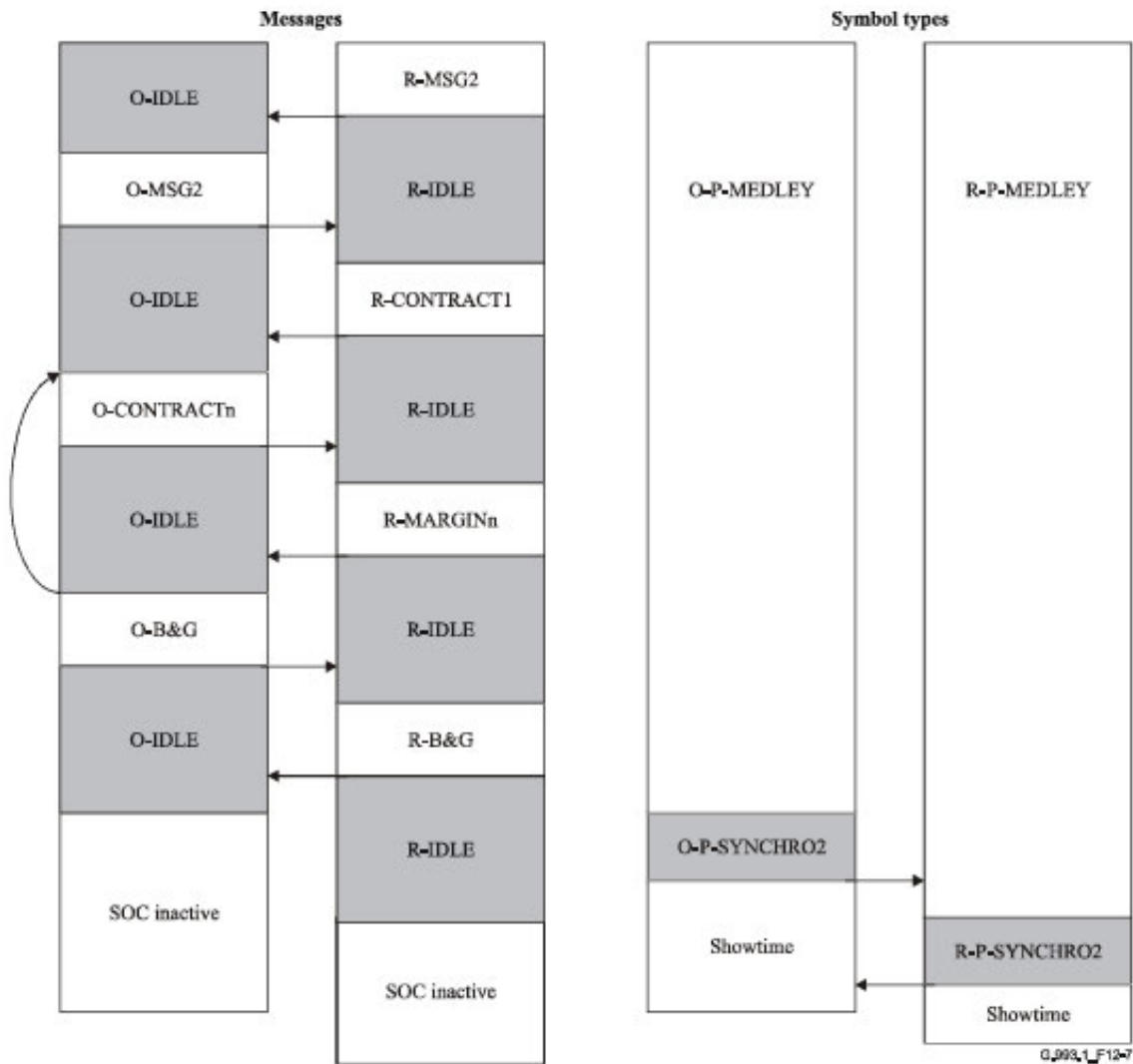


Figure 12-7/G.993.1 – Timeline of the channel analysis and exchange phase

Id., Fig. 12-7.

323. During the channel analysis and exchange phase, the VTU-R sends a message called R-MSG2, which transfers, among other things, the Reed-Solomon capabilities of the VTU-R (e.g., whether it can support only mandatory settings or all settings), the interleaver settings supported by the VTU-R (e.g., whether it can support only mandatory settings, all settings, or a number of additional settings), and the “maximal interleaver memory” in bytes. *Id.*, §12.4.6.1; §12.4.6.3.1.1.

324. After receiving R-MSG2, the VTU-O sends a message called O-MSG2, which

transfers, among other things, the Reed-Solomon capabilities of the VTU-O (e.g., whether it can support only mandatory settings or all settings), the interleaver settings supported by the VTU-O (e.g., whether it can support only mandatory settings, all settings, or a number of additional settings), and the “maximum interleaver delay” in milliseconds. *Id.*, §§12.4.6.1, 12.4.6.2.1.1.

325. After receiving O-MSG2, the VTU-R sends a message called R-CONTRACT1, which contains “the proposed downstream contract based on the maximal number of bits in the slow channel based on the restrictions specified in O-MSG2 (i.e., as if only the slow channel will be used).” *Id.*, §12.4.6.3.1.2. The proposed downstream contract specifies, among other things, the bit rate for the slow channel (a multiple of 64 kbit/s), the Reed-Solomon settings for the slow channel (i.e., the codeword length and number of redundancy bytes), and the interleaver setting (i.e., the interleaver depth and block length). *Id.*, §12.4.6.3.1.2; 12.4.6.2.1.2.

326. After receiving R-CONTRACT1, the VTU-O sends a message called O-CONTRACTn, which contains a proposed upstream and downstream contract that is based on the capabilities of the VTU-O and VTU-R. G.993.1, §12.4.6.2.1.2. Table 12-25 of G.993.1, copied below, defines the O-CONTRACTn message.

Table 12-25/G.993.1 – Description of O-CONTRACTn

Field	Field or macro-field type
Message descriptor	Message code (see Table 12-12)
Downstream contract	Contract descriptor (see Table 12-26)
Upstream contract	Contract descriptor
EOC capacity (number of EOC bytes per frame)	1 byte
VOC capacity (value of V ; see 8.5.5)	1 byte

Id.

327. The “Downstream contract” and “Upstream contract” in O-CONTRACTn are of the type “Contract descriptor.” *Id.* Table 12-26 of G.993.1, copied below, defines the contract

descriptor, which includes information that allows the VTU-R to configure its interleaver (for upstream transmission) and deinterleaver (for downstream reception).

Table 12-26/G.993.1 – Contract descriptor

Field	Field or macro-field type	Remark
Rate in fast channel	2 bytes	In multiples of 64 kbit/s
RS setting in fast channel	2 bytes	B15 → B8: RS overhead B7 → B0: RS codeword length
Rate in slow channel	2 bytes	In multiples of 64 kbit/s
RS setting in slow channel	2 bytes	B15 → B8: RS overhead B7 → B0: RS codeword length
Interleaver setting	2 bytes	B15 → B8: <i>M</i> (Note) B7 → B0: <i>I</i>
NOTE – <i>I</i> must be a divider of the RS codeword length (in the slow channel).		

Id.

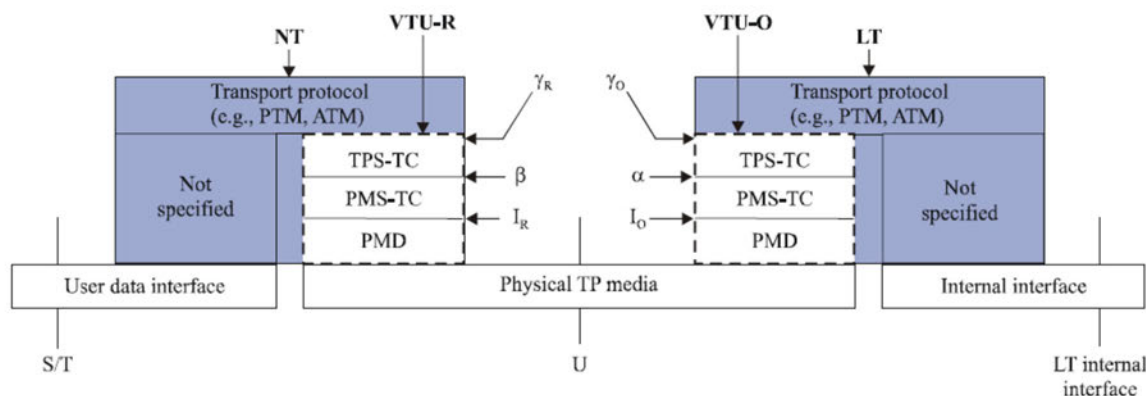
328. The downstream portion of the contract is based on the information provided by the VTU-R in R-CONTRACT1 and, ideally, is the same as the contract the VTU-R proposed in R-CONTRACT1. *Id.* As Table 12-26 indicates, both the upstream and downstream portions of the proposed contract include, among other things, the bit rate for the slow channel (a multiple of 64 kbit/s), the Reed-Solomon settings for the slow channel (i.e., the codeword length and number of redundancy bytes), and the interleaver setting (i.e., the interleaver depth and block length). *Id.*

b. Physical Layer

329. G.993.1 discloses “an access technology that exploits the existing infrastructure of copper wires that were originally deployed for POTS services. *See* G.993.1, 1. G.993.1 “permits the transmission of asymmetric and symmetric aggregate data rates up to tens of Mbit/s on twisted pairs.” *See* G.993.1, i, Summary. G.993.1 “includes worldwide frequency plans that allow asymmetric and symmetric services in the same group of twisted pairs.” *Id.*

330. As the physical layer in an OSI model, an xDSL transceiver can be broken down

into sub-layers, such as a physical medium dependent (“PMD”) sub-layer and a transmission convergence (“TC”) sub-layer. The TC sub-layer is made up of a physical medium specific TC (“PMS-TC”) sub-layer and a transport protocol specific TC (“TPS-TC”) sub-layer. *See* G.993.1, §5.1-5.2, Figs. 5-2, 5-3. A reference model of the physical layer comprising a VTU-O and VTU-R is shown below.



Id. Figure 5-3.

331. As shown above, data is transmitted from OSI layers above the physical layer to a VTU. *See* G.993.1, §5.1-5.2. For example, the VTU-O’s TPS-TC sub-layer receives the incoming data from a higher layer, which is then processed by the TPS-TC sub-layer and communicated to the PMS-TC sub-layer, which in turn processes the received data and communicates it to the PMD sub-layer. *Id.* From there, the PMD sub-layer processes the data received from the PMS-TC sub-layer and communicates it via physical transmission (“TP”) media (e.g., a local loop) to the VTU-R’s PMD sub-layer. *Id.* The VTU-R’s PMD sub-layer processes the received data and communicates it to the VTU-R’s PMS-TC sub-layer, which in turn processes the data and communicates it to the VTU-R’s TPS-TC sub-layer. *Id.* At the VTU-R’s TPS-TC sub-layer, the data is processed and subsequently communicated to the higher OSI layers. *Id.*

332. At the PMS-TC, the data may undergo forward error correction (FEC)

encoding/decoding and interleaving / deinterleaving. *See id.* §§8-8.4. At the PMD, the data is modulated / demodulated to map the data onto a one or more data symbols, such as DMT symbols, or vice versa. *See id.* §§9-9.2. The symbol(s), in the form of a signal, are communicated via the physical transmission medium to another VTU, where the process described above is performed in reverse. *See id.* §§5.1-5.2; Figs. 5-2, 5.3.

c. PTM-TC

333. G.993.1 also discloses the use of packet transfer mode-transmission convergence, or “PTM-TC,” in the context of DSL. For example, Annex H of G.993.1 is dedicated to PTM-TC. Further, “the functional model of packetized data transport is presented in Figure H.1,” which is below. *Id.* at Annex H.

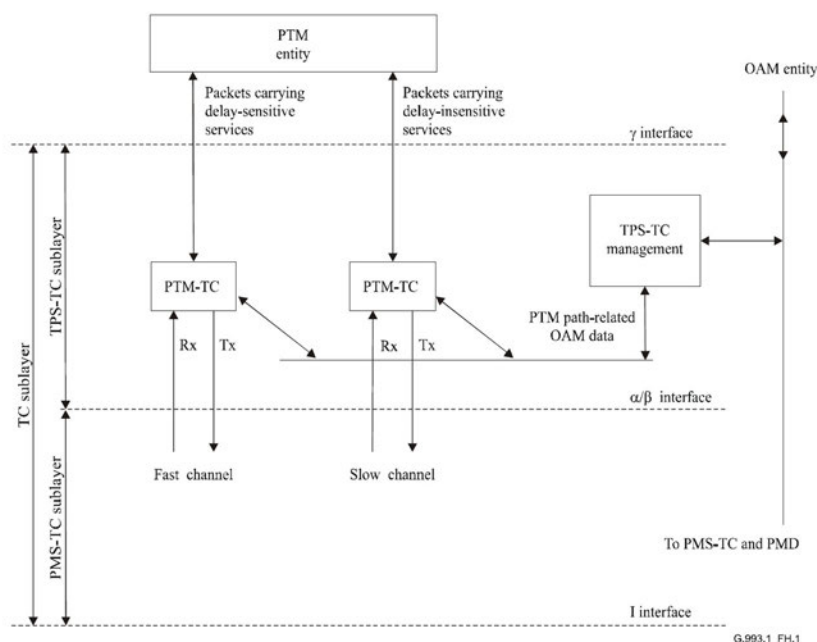


Figure H.1/G.993.1 – Functional model of PTM transport

334. G.993.1 further discloses “the PTM-TC frame format” “shown in Figure H.2,” which is below. *Id.* at Annex H.

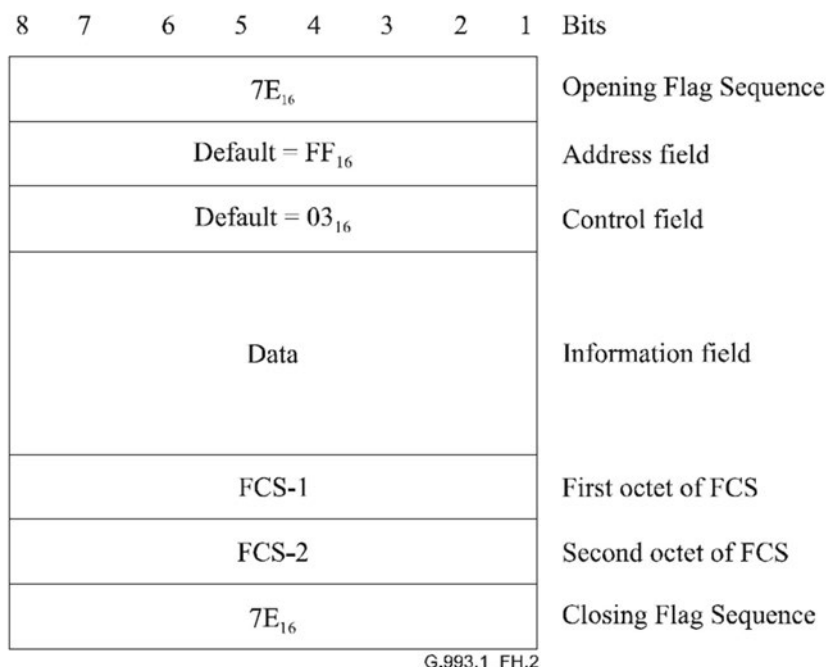


Figure H.2/G.993.1 – PTM-TC frame format

3. BI-089

335. ITU-T Study Group 15 Temporary Document BI-089 (“BI-089”) is titled “G.gen: ARQ for ADSL Transceivers,” and was presented by Joseph Mueller and Vlad Mitlin of 3Com Corp. on October 23-27, 2000 at a meeting of the SG15/Q4 working group held in Goa, India.. BI-089 at 1.

336. BI-089 was made available to SG15/Q4 electronically via the SG15/Q4 document server at least by October 23, 2000.¹⁷ Per the SG15/Q4 operating rules, it should have been uploaded to the document server by at least October 16, 2000. *See, e.g.*, ITU-T SG15/Q4 BI-004, Q4/SG15 Rapporteur Meeting Electronic Document Submission Guidelines (“BI-004”) at §1

¹⁷ *See* ITU-T SG15/Q4 Contribution BI-A18, G.lite.bis: Work Program (Oct. 2000) at Abstract (“This contribution provides the ‘Work Program’ for G.lite.bis based on contributions uploaded and presented as of 23 October, i.e., just after the presentation of papers on the opening day of the India meeting.”); *id.*, §1.2 (listing BI-089 as one contribution uploaded and presented as of October 23, 2000); *id.*, §2 (listing BI-089 in G.lite agenda as addressing issue 1.17, “ARQ”).

(“Contributions for the ITU Rapporteur meeting should be uploaded to the ftp site one week prior to the start of the Rapporteur meeting. Generally, for a Monday Rapporteur meeting start, papers should be submitted by end of day on the prior Monday. If uploaded by that time, only 10 paper copies of the contribution need to be brought to the meeting. Otherwise, 100 paper copies need to be brought to the meeting and the electronic version still uploaded if possible or as a last resort, brought to the meeting. Before presentation of a paper, the electronic version of the paper shall be provided to the Rapporteur.”). Once uploaded to the document server, BI-089 would have been available to SG15/Q4 participants world-wide. *See, e.g., id.* at §1 (“The use of electronic document submission and distribution is a key factor in improving the efficiency of Q4/SG15 operation. The guidelines below will insure that all meeting attendees have advance capability to review contributions presented for Rapporteur meetings. The basic principals [sic] are that documents are posted on the ITU informal WEB site and access to the WEB is available world wide.”).

337. The G.lite.bis issues list available after the Goa meeting, used by SG15/Q4 to track work item status, open questions, and agreements, indicates that BI-089 was presented and discussed at the Goa meeting. *See* ITU-T SG15/Q4 BI-U18R3, G.lite.bis: Issues List at 4 (adding, as item 1.17, question “Should we specify an ARQ protocol?” and listing BI-089 as reference); ITU-T SG15/Q4 BI-U17R3, G.dmt-bis: Issues List at 8 (adding, as item 4.2.9, question “Should G.dmt-bis specify an ARQ protocol in combination with RS FEC?” and listing BI-089 as reference). Marcos Tzannes, named as the inventor on the ’411 patent, attended the Goa meeting and prepared a proposed liaison to the European Telecommunications Standards Institute (ETSI) regarding radio-frequency interference testing. *See* ITU-T SG15/Q4 BI-113, Proposed Liaison to ETSI regarding RFI testing at 1. As of the Goa meeting, Mr. Tzannes served as Associate

Rapporteur for the G.test project of SG15/Q4. *See, e.g.*, SG15/Q4 Oct 2000 (Bangalore, India) Document List at 2.

338. I am informed that BI-089 qualifies as prior art under at least pre-AIA 35 U.S.C. §102(b) because it was publicly available more than one year before the earliest priority date for the Family 9 patents of April 12, 2006.

339. BI-089 discloses a proposal for integrating ARQ into ADSL to improve performance in the presence of impulse noise. BI-089, Abstract. BI-089 discloses that, especially in bursty channels, ARQ has advantages over interleaving:

The complexity of the standard ARQ protocol is trivial; however, the ARQ protocol does require memory at both the transmitter and receiver to buffer frames and this buffering introduces latency. It is proposed that, when ARQ is applied, interleaving be reduced or eliminated thereby freeing memory resources for ARQ as well as to reduce or eliminate the interleaver delay so as to compensate for the delay introduced by ARQ.

ARQ and interleaving are two common approaches to improving performance over a bursty channel. A bursty channel is defined as a channel for which the noise between adjacent samples is correlated. Interleaving attempts to remove the correlation between adjacent samples such that errors are distributed over multiple FEC frames, thereby increasing the likelihood of error correction. On the contrary, ARQ exploits channel correlation resulting in the confinement of burst errors. In other words, retransmitting a FEC frame corrupted by burst errors is preferable over spreading the errors across several adjacent frames and trying to correct them. From the information theoretic point of view, ARQ is the preferred method of burst error correction because of its ability to preserve and exploit the information in the noise correlation.

Id., §5.

340. BI-089 explains that because of these advantages, “when ARQ is applied, interleaving [can] be reduced or eliminated thereby freeing memory resources for ARQ as well as to reduce or eliminate the interleaver delay so as to compensate for the delay introduced by

ARQ.” *Id.* BI-089 explains that in these circumstances, “the memory and delay associated with interleaving can be reapplied to ARQ.” *Id.*

341. Specifically, BI-089 recommends an ARQ protocol as follows:

In a communication protocol with ARQ, the data transmission between two stations consists of exchanging information and acknowledgement frames. The error-controlling algorithm may be a combination of a forward error correction and a cyclic redundancy check (CRC). Each information frame of length N code symbols has an information field of length K code symbols, a CRC field of length S code symbols, and a control field of length R code symbols. The length R depends on the number of errors t that FEC is designed to correct: the larger is t the longer is the control field. Each acknowledgement frame has the length of M code symbols; and typically $M \ll N$.

Any information frame with $\leq t$ errors will be corrected by t -FEC and a positive acknowledgement frame will be sent to the peer. For any frame with $> t$ errors, the CRC will detect the residual errors left after t -FEC, and a negative acknowledgement frame will be sent to the peer. These acknowledgement frames may be sent after every $m \geq 1$ information frames. Then the incorrectable information frame may be retransmitted if the maximum allowed number of transmissions has not been reached for that frame.

BI-089 § 2.

4. Takeuchi

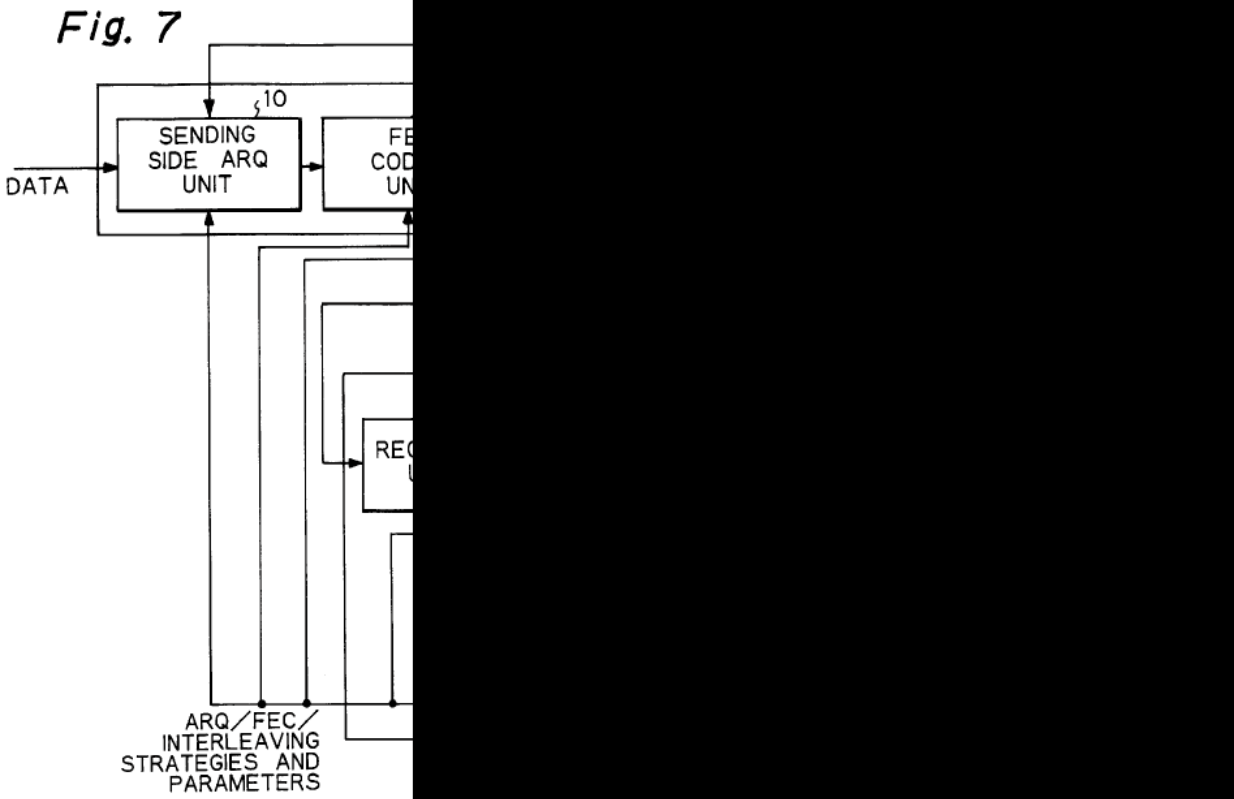
342. U.S. Patent No. 5,907,563 (“Takeuchi”) issued on May 25, 1999 to inventors Yushio Takeuchi, Yoshihiko Ito, and Akira Yamaguchi, based on an application that was filed on March 5, 1997. Takeuchi at Cover. I am informed that Takeuchi qualifies as prior art under at least pre-AIA 35 U.S.C. §102(b) because it issued more than one year before the earliest priority date for the Family 9 patents of April 12, 2006.

343. Takeuchi describes adaptive error control techniques for digital communication systems to allow “an optimum error control strategy and/or parameters” to be used even if channel conditions change. Takeuchi, 2:21-28. Takeuchi describes obtaining “statistical information

including transmission error information at a receiving side,” using the obtained statistical information to “determin[e] an error control strategy and/or a value of at least one parameter of the error control strategy which are/is optimum for transmission path conditions at that time,” and “using the determined error control strategy and/or the at least one parameter for the error control during data communication.” *Id.* at 2:28-39. As a result of the disclosed techniques, “errors can be adaptively controlled by using an optimum error control strategy and/or parameters which are changeable depending upon the variation of transmission path conditions,” so that “when the transmission path conditions are relatively good, the transmission efficiency (throughput) can be increased, whereas when the conditions become somewhat poor, the transmission performance can be maintained or improved.” *Id.* at 2:45-52.

344. Takeuchi describes using forward error correction (FEC) coding (*e.g.*, Reed Solomon coding), interleaving, and/or ARQ for error control. *Id.* at 4:14-19. All three of FEC, interleaving, and ARQ can be used. *Id.* at 12:48-50.

345. FIG. 7 of Takeuchi, copied below, shows a block diagram illustrating one embodiment of the error control system.



Takeuchi discloses that “[t]he sending side device 71 has a sending side ARQ unit 10, the FEC coding unit 11, the interleaving unit 12 and the transmitter unit 13, whereas the receiving side device 72 has the receiver unit 23, the deinterleaving unit 22, the FEC decoding unit 21, a receiving side ARQ unit 20, a transmission path condition detecting unit 724 and a strategy and parameter determining unit 725.” *Id.* at 12:53-59.

346. Takeuchi describes the operation of the FEC coding unit 11 as follows:

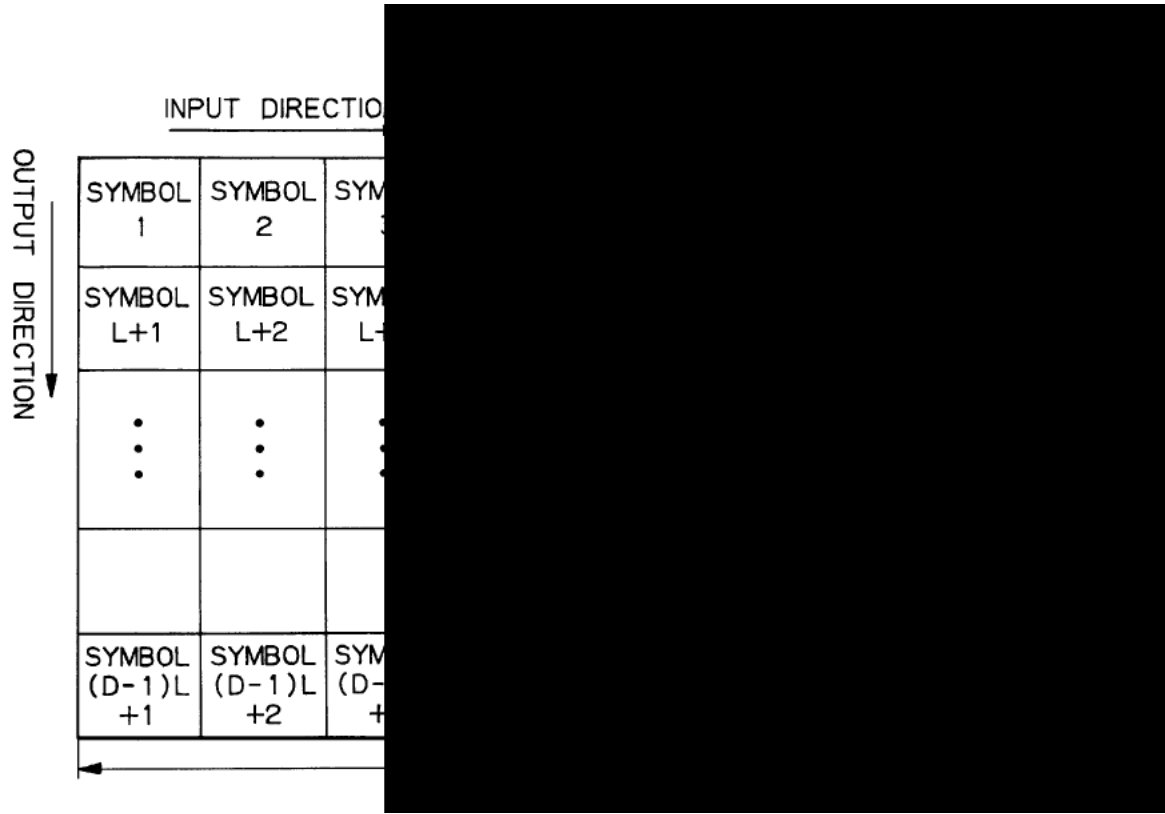
The FEC coding unit 11 in the sending side device 1 codes the input data in accordance with the FEC strategy. In this coding process, either block codes such as BCH codes or RS (Reed Solomon) codes, or convolutional codes, are used as the FEC codes. As for parameters in the block code FEC strategy, there are, for example, a generator polynomial (generator matrix), a block length, an information length in a block (or coding rate) and the number of correctable errors in a block. As for parameters in the convolutional code FEC strategy, there are, for example, a constraint length (generator polynomial), a coding rate, and a truncated path length at the Viterbi decoding. In this embodiment, the FEC strategy and at least one of these parameters can be changed in accordance with

variation of the transmission path conditions, during data communication.

Id. at 5:21-35.

347. Takeuchi explains that “[t]he FEC coding unit 11 is followed by the interleaving unit 12 for interleaving the FEC coded data,” and that because FEC alone is sometimes insufficient to protect the data from errors, interleaving randomizes the errors, “and then the errors are corrected by using the FEC strategy.” *Id.* at 5:36-41.

348. Takeuchi describes how the interleaving unit 12 works with reference to FIG. 2, copied below:



Takeuchi explains that:

FIG. 2 illustrates an example of the interleaving at the interleaving unit 12. In this example, the FEC coded data are interleaved in units of symbols composed of a plurality of bits. As shown in the figure, the FEC coded data are sequentially input in the order of symbols 1, 2, 3, . . . , L, L+1, . . . , and then sequentially output to the

transmitter unit 13 in the order of symbols 1, L+1, 2L+1, . . . , (D+1)·L+1, 2, L+2, . . . , (D-1)·L+2, 3, L+3, . . . , where L denotes an interleaving block length, and D denotes an interleaving depth. The interleaving is executed in unit of every L×D symbols. When using the block codes such as the BCH codes or the RS codes as the FEC codes, L may be typically selected to be equal to the block code length but can be selected to another value. As for parameters of interleaving, there are an interleaving block length and an interleaving depth. In this embodiment, at least one of these parameters can be changed in accordance with variation of the transmission path conditions, during data communication.

Although the FEC coded data are interleaved in units of symbols in this example, it is apparent that the data may be interleaved in units of bits.

Id. at 5:42-62.

349. Takeuchi also provides a detailed explanation of how the ARQ units shown in FIG. 7 operate:

The sending side ARQ unit 10 in the sending side device 71 converts the input data frame into frames which are necessary for ARQ control (ARQ frames) and outputs the converted data to the FEC coding unit 11. The ARQ frame has not only the input data but also additional information necessary for ARQ control such as a transmission frame number and a number of error detecting bits. In this embodiment, any ARQ strategy including a typical Go-Back-N type ARQ strategy, a Selective Repeat type ARQ strategy or other ARQ strategies can be used. As for parameters in the ARQ strategy, there are for example an ARQ frame length, the maximum number of error detecting bits and a modulo number for frame number. In this embodiment, the ARQ strategy and at least one of these parameters can be changed in accordance with variation of the transmission path conditions, during data communication.

...

In the receiving side device 72, the FEC decoded data from the FEC decoding unit 21 are applied to the receiving side ARQ unit 20. This ARQ unit 20 detects an error in accordance with the ARQ control information in the ARQ frame, and executes, depending upon whether an error exists or not, a repeat request process in accordance with the ARQ strategy used. In the case that an error is detected after decoding at the FEC decoding unit 21, it is unnecessary for the ARQ unit 20 to detect an error. In such a case,

the ARQ unit 20 can utilize the error information provided from the FEC decoding unit 21 without executing error detection.

In accordance with the ARQ strategy, information needed for ARQ control (backward ARQ control information) will be returned from the receiving side ARQ unit 20 to the sending side ARQ unit 10 by means of a return path. If the data communication is carried out through a bidirectional transmission link, the above-mentioned backward control information will be returned via this bidirectional link. Otherwise, the information will be returned to the sending side ARQ unit 10 via another transmission link.

In the ARQ receiving process at the receiving side ARQ unit 20, error relating information of the ARQ frame is simultaneously obtained. This obtained information is applied to the transmission path condition detecting unit 724. Thus, the condition detecting unit 724 detects, in a manner similar to that of the condition detecting unit 24 in the embodiment of FIG. 1, the conditions in the transmission link 3 through which the received signals have passed by using the statistical information including transmission error information, which statistical information contains the ARQ frame information (raw information) and its modified information, and outputs the condition parameter values.

Id. at 12:60-13:44.

350. Takeuchi explains that “[d]epending upon the condition parameter values applied from the condition detecting unit 724, the strategy and parameter determining unit 725 determines an optimum FEC strategy and/or an optimum ARQ strategy as well as optimum values of FEC parameters, of interleaving parameters and/or of ARQ parameters at that transmission path conditions. . . .” *Id.* at 12:45-51.

5. Fukushima

351. U.S. Patent No. 7,124,333 (“Fukushima”) issued on October 17, 2006 to inventors Hideaki Fukushima, Seiji Horii, Tatsuya Ohnishi, Makoto Hagai, Yoshinori Matsui, and Akihiro Miyazaki. Fukushima at Cover. Fukushima claims priority to U.S. Application No. 09/450,590, filed on November 30, 1999. *Id.* I am informed that Fukushima qualifies as prior art under at least pre-AIA 35 U.S.C. §102(e) because it issued from an application that was filed before the

earliest priority date for the Family 9 patents of April 12, 2006.

352. Fukushima describes prior art Internet systems for “transmission of video (audio and video) data on the Internet,” and notes that “Internet applications utilizing mobile phones” “include[] a radio transmission section” which generally has a higher bit error rate than the cable transmission section. *See* Fukushima at 1:22-2:13. It states that its invention generally relates to methods of “improv[ing] the transmission quality in a radio section in real-time transmission.” Fukushima at 2:14-20. More specifically, Fukushima describes that:

[I]n the existing real-time transmission method, packet data are transmitted in real time between a distribution server and a terminal unit through a relay server or the like, and additional information (e.g., a sequence number, a time stamp, etc) required for real-time transmission of each packet data is given to the header of the packet. The additional information enables real-time control of packet retransmission.

Fukushima at 13:32-39. Fukushima explains that its invention improves upon prior art systems by allowing for “selective retransmission control for reducing the number of retransmission times by selecting, as packets to be retransmitted, high priority packets amongst the error packets” and “retransmission control with a time limit for reducing excessive retransmission.” *Id.* at 14:28-35.

353. Fukushima discloses a “data transmission apparatus for relaying data transmitted from the transmitting end in *units of packets*.” *Id.*, §(57) (Abstract) (emphasis added). Fukushima also states that “the packet comprises a header section” and “data section” and discloses a “first header information indicating [a] sequence number corresponding to a packet.” *Id.* at 10:54-66, Figs. 6, 9, 17, 21, 22, 31. In successively transmitted data packets (i.e., a packet stream), the sequence number can indicate each data packet’s position relative to the other data packets in the packet stream. *See, e.g., id.*, claims 1-4.

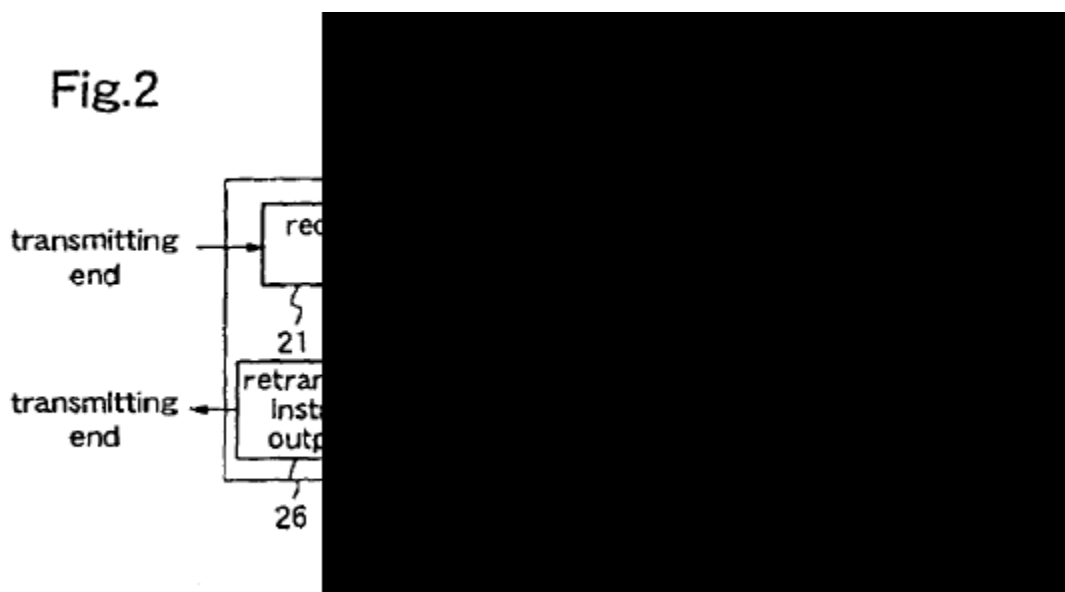
354. Fukushima discloses a “data-receiving apparatus” with components including the following:

The data receiving apparatus **201** includes a receiving unit **21**, an error packet detection unit **22**, and a packet decoding unit **23**. The receiving unit **21** receives the packets transmitted from the relay server (the data transmission apparatus at the transmitting end). The error packet detection unit **22** detects error packets in which errors have occurred during transmission, and outputs normal packets which have been transmitted without transmission errors. The packet decoding unit **23** receives the normal packets and decodes the coded data of the normal packets.

Fukushima at 15:51-60.

355. For packets with errors, the “retransmission instruction output unit **26**” has the capability of “output[ting] a retransmission request to the transmitting end, by indicating the sequence number of this error packet,” which is “received by the retransmission instruction receiving unit” “in the data transmission apparatus.” Fukushima at 17:7-6-17.

356. One embodiment of a “data-receiving apparatus” is depicted in Figure 2 of Fukushima:



Fukushima at Fig. 2.

357. Fukushima’s “data receiving apparatus” can operate using FEC, including a FEC

decoder:

The data receiving apparatus **202** of this second embodiment includes an error correction unit **41**, in addition to the constituents of the data receiving apparatus **201** of the first embodiment. The error correction unit **41** performs an error correction process in which each packet received by the receiving unit **21** is subjected to an error correction process in which the additional information of this packet is subjected to error correction by using the error correction codes given to the packet, and the packet which has been subjected to the error correction process is output to the error packet detection unit **22**. Other constituents of the data receiving apparatus **202** are identical to those of the data receiving apparatus **201** of the first embodiment.

Next, the function and effect will be described.

In the data transmission method according to the second embodiment, at the transmitting end, each packet to be transmitted is given error correction codes for the additional information relating to its sequence number, priority, etc. At the receiving end, the additional information is subjected to error correction according to the error correction codes and, thereafter, a retransmission request for the error packet is made in accordance with the additional information. Thereby, even when the sequence number and the priority information have errors, a retransmission request for the error packet can be correctly performed.

Fukushima at 18:8-33; *see also id.* Fig. 5 (depicting same embodiment).

358. Fukushima discloses an embodiment of the “data receiving apparatus” which consecutively outputs a retransmission request multiple times:

FIG. 33 is a block diagram illustrating a data receiving apparatus 210 in the data transmission system performing real-time data transmission according to the data transmission method of this tenth embodiment.

The data receiving apparatus 210 includes an error packet detection unit 22b, instead of the error packet detection unit 22a of the data receiving apparatus 209 of the ninth embodiment. The error packet detection unit 22b performs the same process as that of the unit 22a and, further, decides the transmission status of the radio section, from the number of the detected error packets.

Further, the data receiving apparatus 210 includes a retransmission instruction output unit 26d. instead of the retransmission instruction output unit 26c of the data receiving apparatus 209. The retransmission instruction output unit 26d performs the same process as that of the unit 26c and, further, outputs the transmitted retransmission request as a control signal.

Further, the data receiving apparatus 210 includes a retransmission instruction consecutive output unit 93 which receives the control signal (retransmission request) output from the retransmission instruction output unit 26d. and consecutively outputs the retransmission request by a predetermined number of times at predetermined intervals. Further, the unit 93 changes the number of output times of retransmission request and the output interval, according to information indicating the transmission status of the radio section, which is output from the error packet detection unit 22b.

Fukushima at 44:32-61; *see also id.* Fig. 33 (illustrating same embodiment).

359. Fukushima describes the purpose of these repeated retransmission requests as follows:

Then, the retransmission instruction consecutive output unit 93 performs a consecutive retransmission process for consecutively transmitting the retransmission request by several times. In this consecutive retransmission process, the number transmission times of the retransmission request and the transmission interval are adjusted on the basis of a predetermined value, according to the transmission status of the radio section which is obtained from the output information of the error packet detection unit 22b.

For example, when many transmission errors occur in the radio section, the number of request transmission times is increased and the output interval is increased. Thereby, the probability of normal transmission of the retransmission request to the transmitting end increases. On the other hand, when not many transmission errors occur in the radio section, the number of request transmission times is decreased, and the output interval is narrowed. Thereby the time required for retransmission is reduced...

As described above, according to the tenth embodiment of the present invention, a retransmission request indicating the high priority sequence number of a desired packet is consecutively transmitted several times, from the receiving end to the transmitting end, against transmission errors. Therefore, when at least one of the

several transmission requests from the receiving end is normally received at the transmitting end, the error packet the priority of which is equal to or higher than a predetermined value can be retransmitted, whereby the transmission quality in the radio section in real-time transmission can be effectively improved.

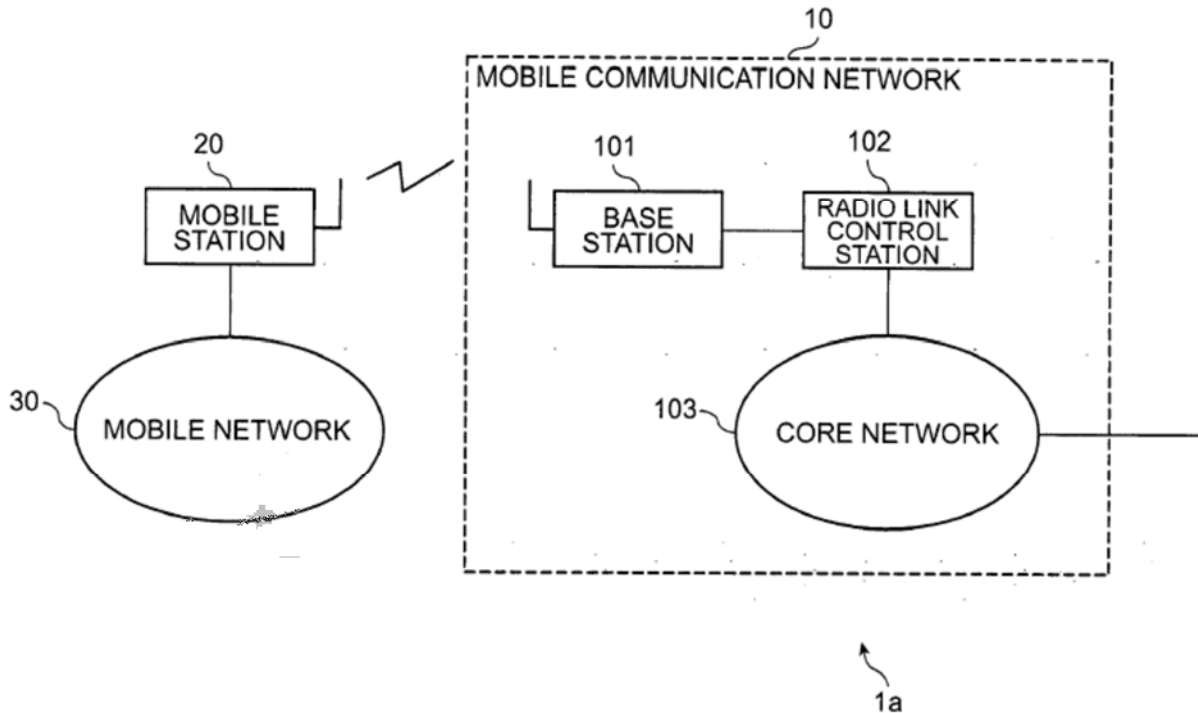
Fukushima at 45:22-39, 45:63-46:6.

6. Kawakami

360. European Patent No. EP 1,507,353 A2 by Kawakami is entitled “Transmission/Reception of Data Flows with Different QoS Requirements.” Kawakami, §(54). Kawakami was published on February 16, 2005. *Id.*, §(43). I am informed that Kawakami qualifies as prior art under 35 U.S.C. §102(b) because it was published more than one year before the priority date of the '055 patent. A related U.S. Publication (U.S. Patent Application Publication No. 2005/0036497) was listed on an Information Disclosure Statement that was considered by the Examiner, but the Examiner did not apply Kawakami in a prior art rejection. *See* '055 prosecution history, 443.

361. Kawakami discloses a mobile communications system including a mobile station and radio link control station, as shown in Figure 1, reproduced below:

Fig.1



As a premise for the description of the present embodiment a network 1a (frame transmission/reception system) will be described using FIG. 1. This network 1a is comprised of a mobile communication network 10, a mobile station 20, and a mobile network 30. The mobile communication network 10 includes a base station 101, a radio link control station 102, and a core network 103. The mobile station 20 has a radio interface to access the mobile communication network 10 and is linked to the mobile network 30 consisting of at least one communication terminal. The base station 101 has a radio interface to the mobile station 20, and an interface to the radio link control station 102. The radio link control station 102 is able to communicate with the exterior of the mobile communication network 10 through the core network 103. In the network 1a of FIG. 1, the base station 101 and the radio link control station 102 are described as separate nodes, but they can also be configured as a single node. The mobile station 20 transfers data flows from many communication terminals of the mobile network 30 through one radio interface to the mobile communication network 10.

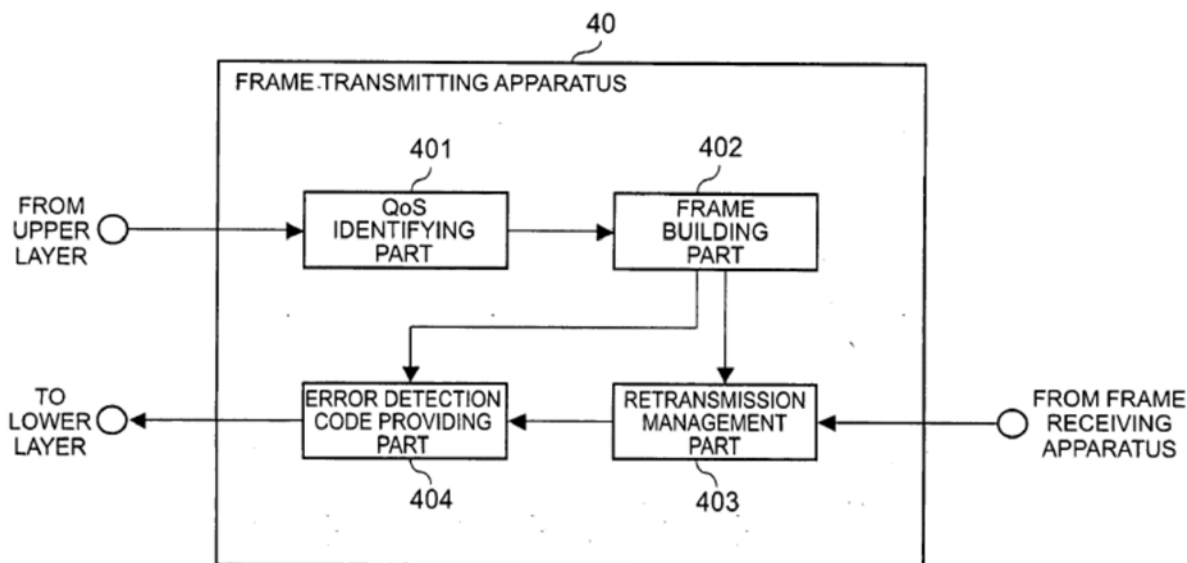
Kawakami, Fig. 1, ¶[0022].

362. Kawakami discloses that the mobile station and control station include a frame transmitting apparatus and a frame receiving apparatus. *Id.*, ¶[0024]. I note that while Kawakami refers to “frames” and “packets” separately, the “frames” in Kawakami are packets under the

construction for “packet” that I have applied in this report (i.e. “a grouping of bytes”).

363. The frame transmitting apparatus includes a number of components, including a frame building part as shown in figure 2, reproduced below:

Fig.2



Id., Fig. 2.

364. Kawakami discloses that the frame transmitting apparatus transmits communications differently according to their Quality of Service (QoS) requirements. *Id.*, ¶[0027]. For example, Kawakami discloses that communications that can tolerate some delay but cannot tolerate errors are transmitted using retransmission; whereas, communications that can tolerate some errors but cannot tolerate delay such as voice communications are transmitted without retransmission. *Id.* Kawakami refers to the first type of communications as acknowledgement type and the second type of communications as unacknowledgement type. *Id.* Kawakami discloses that each message includes a header that identifies whether it is an acknowledgement type or unacknowledgement type message:

The frame building part 402 of the frame transmitting apparatus 40 is a part that divides a data packet, if necessary, to generate radio frames. The frame building part 402 divides a data packet to generate radio frames if the length of the data packet is longer than the maximum load length of radio frame. The frame building part 402 provides a header of each generated radio frame with a QoS identifier according to the QoS information described in the data packet or the QoS information of the connection forming the data flow. In general communication with a QoS level of tolerating some error but being strict on delay like voice communication or the like is handled so as not to perform retransmission. On the other hand, communication with a QoS level of tolerating some delay but not tolerating error like data communication is subjected to error correction by retransmission control. In the description hereinafter, a frame to request retransmission in conjunction with data error or frame loss will be referred to as an acknowledgement type frame, and a frame without retransmission as an unacknowledgement type frame. The frame building part 402 sequentially provides acknowledgement type frames of one radio protocol connection with sequence numbers. The frame building part 402 outputs acknowledgement type frames to the retransmission management part 403 and outputs unacknowledgement type frames to the error detection code providing part 404.

Id.

365. Kawakami discloses that acknowledgement type messages are stored in a retransmission buffer while unacknowledgement type messages are not:

Referring back to FIG. 2, the retransmission management part 403 is a part that buffers an acknowledgement type frame for retransmission and, when receiving a request from the frame receiving apparatus 50, outputs a corresponding acknowledgement type frame to the error detection code providing part 404. The retransmission management part 403 starts a retransmission timer at the same time as transmission of a frame, and buffers the frame for retransmission before receiving an acknowledgement response (ACK) from the frame receiving apparatus. When receiving an ACK, the retransmission management part 403 discards the buffered frame. When detecting a timeout of the retransmission timer or detecting a frame loss from a sequence number of an ACK, the retransmission management part 403 outputs the buffered frame to the error detection code providing part 404.

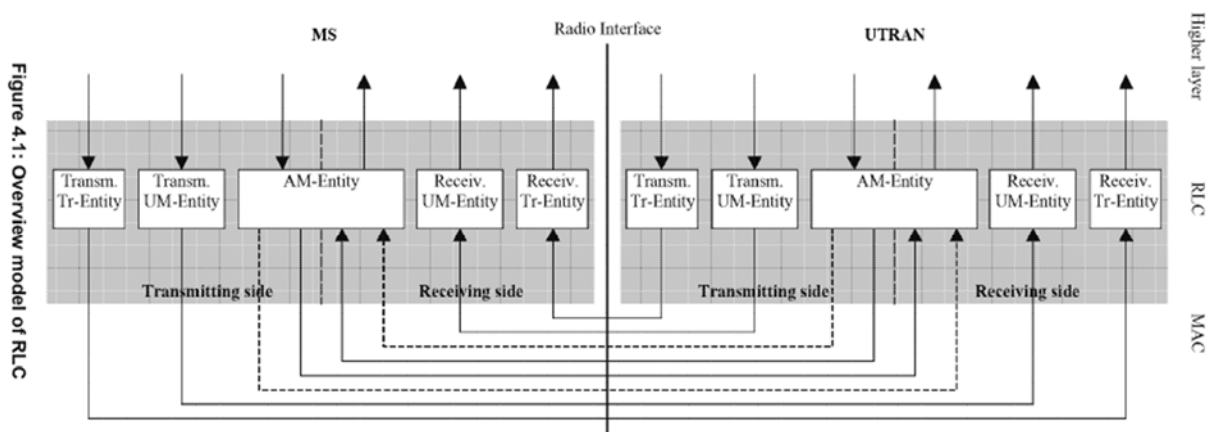
Id., ¶[0029].

7. TS 125 322

366. ETSI TS 125 322 v4.0.0 (2001-03) (“TS 125 322”), titled “Universal Mobile Telecommunications System (UMTS); RLC protocol specification (3Gpp TS 25.322 version 4.0.0 Release 4),” was published as early as March 2001 and not later than April 25, 2001. The

date on the cover of TS 125 322 is March 31, 2001. I have reviewed the 3GPP documentation associated with this standard (TS 25.322 version 4.0.0) and see that it was uploaded to the 3GPP website on March 27, 2001. I have reviewed the ETSI documentation for the publication of TS 125 322 v4.0.0 and see that TS 125 322 was approved on March 23, 2001 and was published by ETSI on April 25, 2001. I am informed that TS 125 322 qualifies as prior art under 35 U.S.C. §102(b) because it was published more than one year before the priority date of the '055 patent.

367. TS 125 322 is directed to the Radio Link Control protocol and architecture. TS 125 322 at 7-8. TS 125 322 discloses a transceiver that is capable of transmitting and receiving packets in an “acknowledged mode” and in an “unacknowledged mode.”



TS 125 322 at 9.

368. The flow of unacknowledged packets is depicted below.

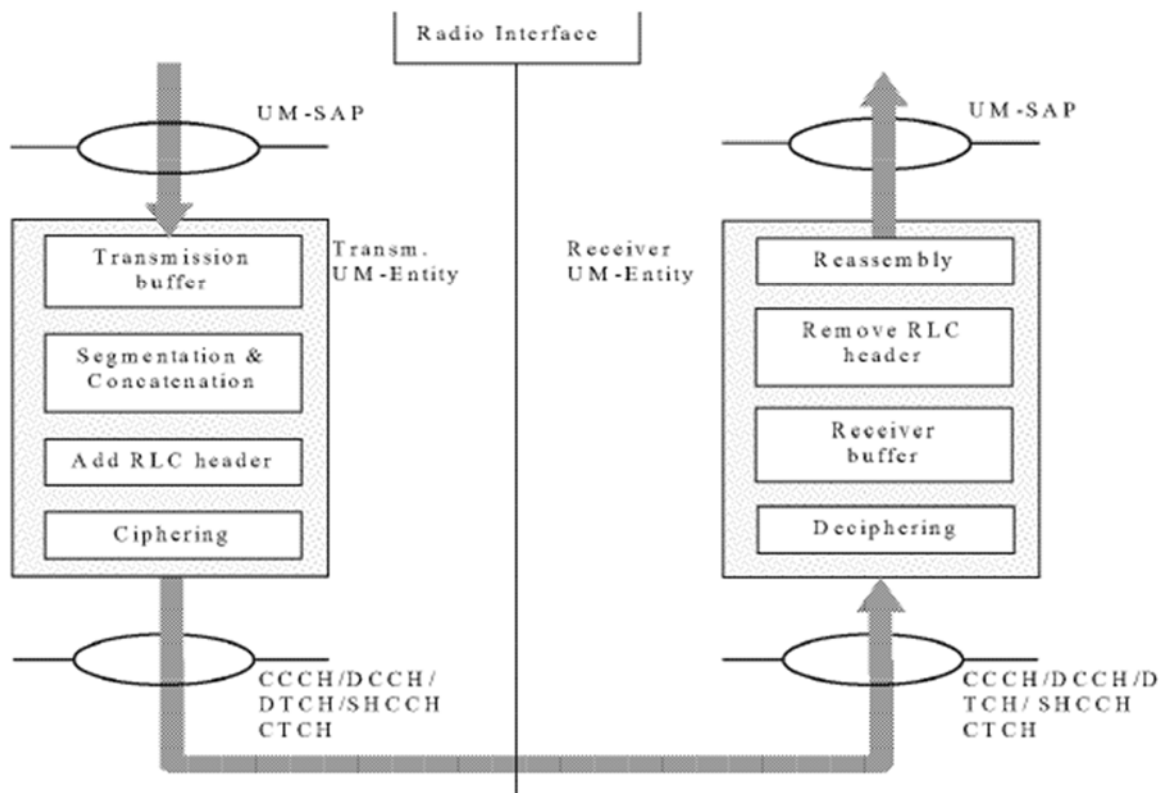


Figure 4.3: Model of two unacknowledged mode peer entities

TS 125 322 at 11. The packet format for unacknowledged packets is shown below.

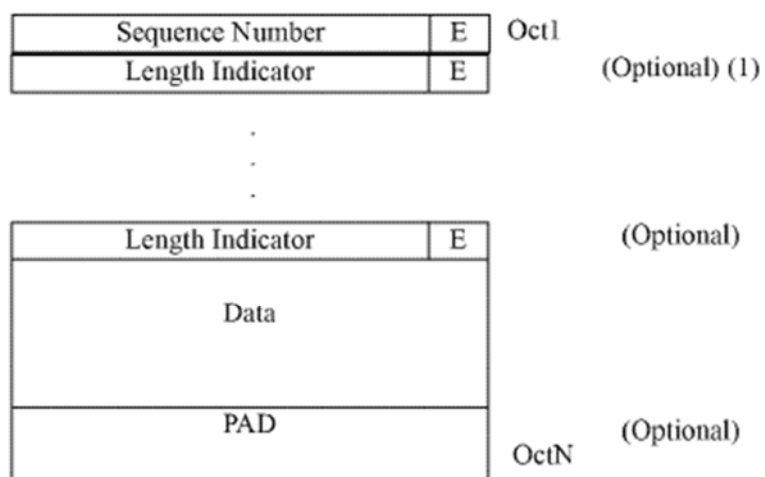


Figure 9.2: UMD PDU

NOTE (1): The Length Indicator may be 15 bits.

TS 125 322 at 20.

369. The flow of acknowledged packets is depicted below.

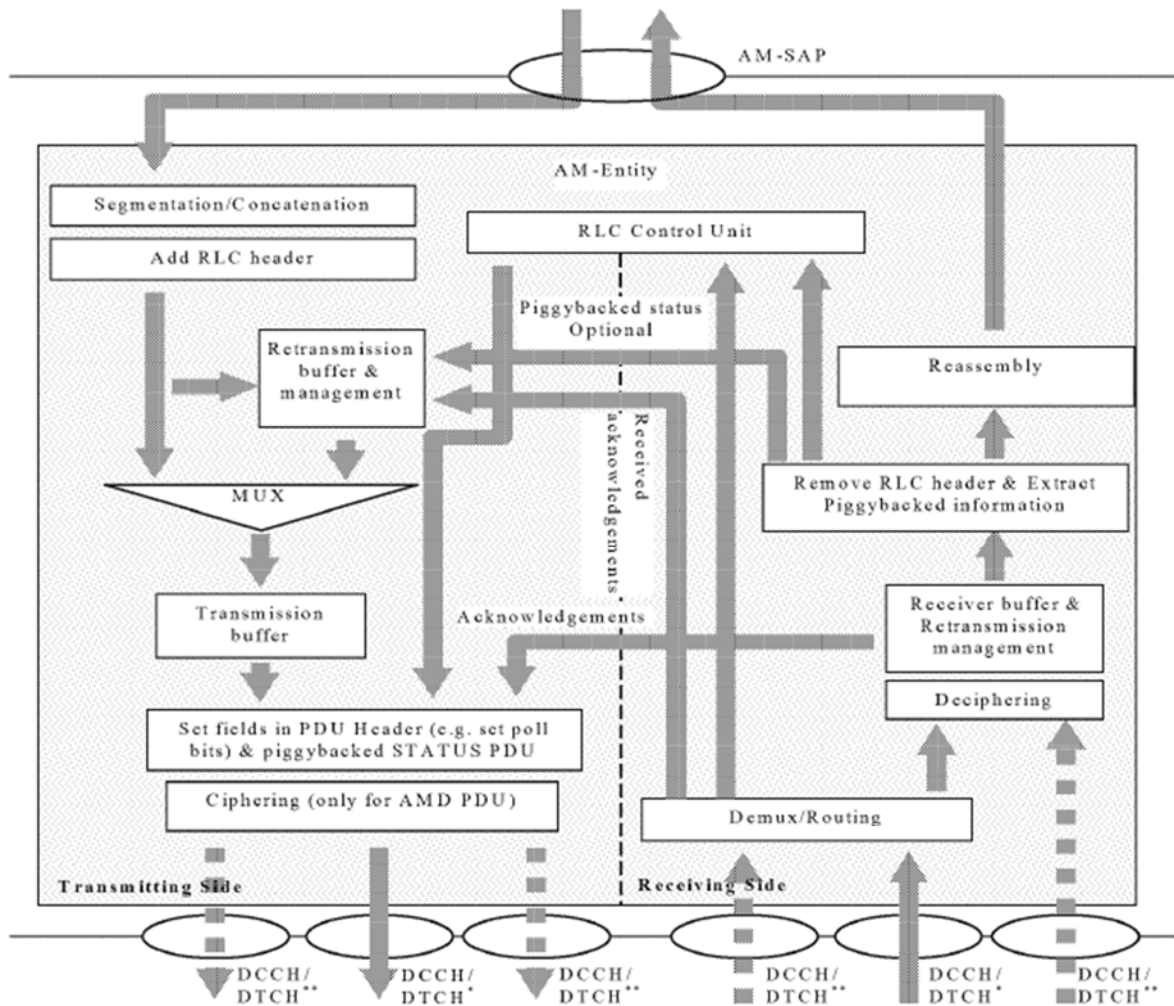
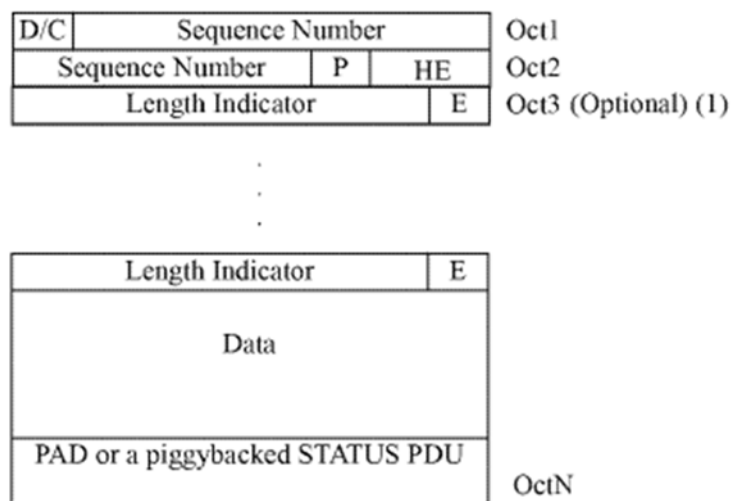


Figure 4.4: Model of an acknowledged mode entity

TS 125 322 at 12. The packet format for acknowledged packets is shown below.



NOTE (1): The Length Indicator may be 15 bits.

Figure 9.3: AMD PDU

TS 125 322 at 20.

B. Application of the Prior Art to the Asserted Claims

1. The '411 Patent

a. G.992.1 in view of BI-089

370. In my opinion, G.992.1 in view of BI-089 discloses each and every limitation of claims 10 and 18 of the '411 patent and therefore renders those claims obvious.

(1) Claim 10

(a) “A transceiver capable of packet retransmission comprising”

371. It is my opinion that G.992.1 in view of BI-089 discloses “[a] transceiver capable of packet retransmission.”

372. A transceiver has been construed as a “communications device capable of transmitting and receiving data wherein the transmitter portion and receiver portion share at least some common circuitry.” D.I. 169, 15.

373. G.992.1, which is entitled “Asymmetric digital subscriber line (ADSL)

transceivers,” discloses transceivers, namely the ATU-O and ATU-R, both of which are capable of transmitting and receiving. *See, e.g.*, G.992.1, i (stating Recommendation “describes Asymmetric Digital Subscriber Line (ADSL) Transceivers on a metallic twisted pair that allows high-speed data transmission between the network operator end (ATU-C) and the customer end (ATU-R).”); *id.*, Figs. 5-1 through 5-4 (providing block diagrams of ATU-O and ATU-R).

374. The ATU-C and ATU-R described in G.992.1 are communications devices capable of transmitting and receiving. *See, e.g., id.*, i (stating Recommendation “describes Asymmetric Digital Subscriber Line (ADSL) Transceivers on a metallic twisted pair that allows high-speed data transmission between the network operator end (ATU-C) and the customer end (ATU-R).”); §7.4.1.2 (describing FEC and interleaving procedures at transmitter and describing characteristics of interleaved data arriving at receiver); §7.7 (“The numbers of bits and the relative gains to be used for every tone shall be calculated in the ATU-R receiver, and sent back to the ATU-C according to a defined protocol. . . . A complementary de-ordering procedure should be performed in the ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit table was originally generated in the ATU-R, and therefore that table has all the information necessary to perform the de-ordering.”); §10.1.2 (“Manufacturers may choose to implement this Recommendation using either frequency-division multiplexing (FDM) or echo cancelling (overlapped spectrum) to separate upstream and downstream signals.”); Fig. 10-5 (showing transmissions from ATU-C to ATU-R and from ATU-R to ATU-C during initialization); §11.2.3 (“The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified.”); §11.2.6 (“The receiver shall start a timeout of 500 ± 20 ms from the moment it sends a bit swap request message. When no acknowledgement has been detected

in this timeout interval, the receiver shall resend a bit swap request message (which shall have the same parameters) and restart the timeout. Only when an acknowledgement has been detected within the timeout interval shall the receiver prepare for a bit swap at the time specified in the acknowledge message. Upon timeout, the bit swap message shall be transmitted.”).

375. The transmitter portion and receiver portion of the ADSL transceivers disclosed in G.992.1 share at least some common circuitry. For example, as would have been understood by a person having ordinary skill in the art, and as shown in Figures 7-1 and 8-1, the ATU-R and ATU-C communicate over a single twisted pair, which means that their respective transmitter and receiver portions share at least an interface to the shared twisted pair. Furthermore, it was common knowledge among skilled artisans that ADSL transceivers included various circuitry shared by the transmitter and receiver, such as, for example, digital signal processors (DSPs), analog front-end components and chips, and clock circuitry.

376. BI-089 discloses a transceiver capable of packet retransmission. BI-089 describes the benefits of using ARQ in “G.dmt.bis and G.lite.bis,” which a person having ordinary skill in the art would have recognized were the names of transceiver standards being developed to allow transceivers to transmit and receive at the same time on the same subscriber line. BI-089, §1. BI-089 refers to transceivers as “stations,” (id., §2), which a person having ordinary skill in the art would have understood to be communications devices capable of transmitting and receiving data wherein the transmitter portion and receiver portion share at least some common circuitry (e.g., an interface to the twisted pair line).

377. BI-089 discloses that “[i]n a communication protocol with ARQ, the data transmission between two stations consists of exchanging information and acknowledgement frames.” BI-089, §2. BI-089 further discloses that “[e]ach information frame of length N code

symbols has an information field of length K code symbols, a CRC field of length S code symbols, and a control field of length R code symbols.” Id. A person having ordinary skill in the art as of the priority date of the ’411 patent would have understood each information frame to be a packet.

378. Accordingly, to the extent it is limiting, G.992.1 in view of BI-089 discloses this limitation.

(b) “a transmitter portion capable of”

379. G.992.1 in view of BI-089 discloses a transmitter portion.

380. G.992.1 discloses that each of the ATU-O and ATU-R also includes a transmitter portion. *See, e.g.*, G.992.1, Fig. 5-1 (“ATU-C transmitter reference model for STM transport”), 5-3 (“ATU-R transmitter reference model for STM transport”).

381. BI-089 also discloses a transmitter portion. BI-089 discloses that “the ARQ protocol does require memory at both the transmitter and receiver to buffer frames and this buffering introduces latency.” BI-089, §5.

382. Therefore, G.992.1 in view of BI-089 discloses this limitation.

(c) “transmitting a plurality of packets”

383. G.992.1 in view of BI-089 discloses transmitting a plurality of packets.

384. G.992.1 discloses that the transmitter portions of the ATU-O and the ATU-R are capable of transmitting a plurality of packets. *See, e.g.*, G.992.1, 1 (“describes the organization of transmitted and received data into frames”); §3.10 (defining data frame as “[a] grouping of bytes from fast and interleaved paths over a single symbol time period after addition of FEC bytes and after interleaving”). A person having ordinary skill in the art would have understood a frame to be a packet.

385. BI-089 also discloses that the transmitter portion is capable of transmitting a plurality of packets. BI-089 describes the benefits of using ARQ in “G.dmt.bis and G.lite.bis,”

which a person having ordinary skill in the art would have recognized were the names of transceiver standards being developed to allow transceivers to transmit data. BI-089, §1. BI-089 refers to transceivers as “stations.” *Id.*, §2. BI-089 discloses that “[i]n a communication protocol with ARQ, the data transmission between two stations consists of exchanging information and acknowledgement frames.” *Id.* BI-089 further discloses that “[e]ach information frame of length N code symbols has an information field of length K code symbols, a CRC field of length S code symbols, and a control field of length R code symbols.” *Id.* A person having ordinary skill in the art as of the priority date of the ’411 patent would have understood each information frame to be a packet.

386. Accordingly, G.992.1 in view of BI-089 discloses claim 10[c].

(d) “identifying at least one packet of the plurality of packets as a packet that should be retransmitted and”

387. BI-089 explains that a receiving station employs a combination of forward error correction (FEC) and a cyclic redundancy check (CRC). BI-089, §2. The FEC algorithm in the station is designed to correct a maximum of t errors. *Id.* If the CRC determines that any frame includes more than t errors, the receiving station will send a negative acknowledgement frame to the transmitting station. *Id.* Thus, the receiving station is capable of identifying at least one packet of the plurality of packets as a packet that should be retransmitted. BI-089 discloses that upon receiving the negative acknowledgement frame, the transmitting station will retransmit the “incorrectable [*sic*] information frame.” *Id.* Accordingly, the transmitting station has a transmitter portion that is capable of identifying at least one packet of the plurality of packets as a packet that should be retransmitted.

388. Therefore, G.992.1 in view of BI-089 discloses this limitation.

- (e) “allocating a memory between a retransmission function and an interleaving and/or deinterleaving function”

389. BI-089 discloses that when ARQ and interleaving are two common approaches to dealing with impulse noise. BI-089, at 3. BI-089 discloses that when ARQ is used the amount of interleaving can be reduced. *Id* (“It is proposed that, when ARQ is applied, interleaving be reduced or eliminated thereby freeing memory resources for ARQ as well as to reduce or eliminate the interleaver delay so as to compensate for the delay introduced by ARQ.”). Therefore, BI-089 discloses that memory that was previously allocated for interleaving can be reapplied to ARQ. BI-089, at 3.

390. Accordingly, a person having ordinary skill in the art would understand BI-089 to disclose allocating a memory between a retransmission function (i.e., ARQ) and an interleaving function.

391. Therefore, G.992.1 in view of BI-089 discloses this limitation.

- (f) “wherein at least a portion of the memory may be allocated to the retransmission function or to the interleaving and/or deinterleaving function at any one particular time, and”

392. BI-089 discloses that both interleaving and ARQ can be used to combat impulse noise. BI-089, at 3 (“It is proposed that, when ARQ is applied, interleaving be reduced or eliminated thereby freeing memory resources for ARQ as well as to reduce or eliminate the interleaver delay so as to compensate for the delay introduced by ARQ.”). BI-089 discloses that under bursty conditions, ARQ has some advantages over interleaving. Thus, a person having ordinary skill in the art would have understood BI-089 to disclose that the amount of memory allocated to ARQ compared to interleaving should increase with the degree of burstiness of the channel.

393. Accordingly, a person having ordinary skill in the art would have understood BI-

089 to disclose that at least a portion of the memory could be allocated to ARQ or to interleaving at any one particular time.

394. Therefore, G.992.1 in view of BI-089 discloses this limitation.

- (g) “wherein a message transmitted during initialization indicates how the memory has been allocated between the retransmission function and the interleaving and/or deinterleaving function in the transceiver.”

395. Although BI-089 does not disclose transmitting a message to indicate how the memory has been allocated, a person having ordinary skill in the art would understand that in ADSL, transceivers need to communicate with each other.

396. For example, G.992.1 discloses that “ADSL transceiver initialization is required in order for a physically connected ATU-R and ATU-C pair to establish a communications link.” G.992.1, §10.11. G.992.1 discloses that during initialization, ATU-R exchanges interleaver settings with ATU-C. *Id.*, §10.9; *see also id.*, §§10.9.2, 10.9.2.7 (R-MSG-RA indicates maximum interleaving depth value, which is either 64, 238, 256, or 512).

397. Therefore, it would have been obvious to a person having ordinary skill in the art to modify the initialization procedure of G.992.1 to include an exchange of how the ATU-R allocated memory between its ARQ and interleaving.

398. Accordingly, G.992.1 in view of BI-089 discloses this limitation.

399. Thus, G.992.1 in view of BI-089 discloses both the structural and non-structural elements of claim 10 and therefore renders claim 10 obvious.

(2) Claim 18

- (a) “A transceiver capable of packet retransmission comprising:”

400. This claim element recites the same claim element set forth in claim 10. Therefore, this element is taught by G.992.1 in view of BI-089 for the reasons explained above for claim

element 10. *Supra* § VIII.B.1.a(1)(a).

401. Therefore, to the extent that it is limiting, G.992.1 in view of BI-089 discloses the preamble of claim 18.

(b) “a receiver portion capable of:”

402. G.992.1 in view of BI-089 discloses a receiver portion.

403. G.992.1 discloses that each of the ATU-O and ATU-R also includes a receiver portion. *See, e.g.*, G.992.1, §7.4.1.2.2 (“At the receiver, the interleaved data buffer will be delayed by $(S \times \text{interleave depth} \times 250)$ μs with respect to the fast data buffer, and data frame 0 (containing the CRC bits for the interleaved data buffer) will appear a fixed number of frames after the beginning of the receiver superframe.”); § 7.7 (“A complementary de-ordering procedure should be performed in the ATU-R receiver.”); §9.5 (“ATN and SNR, as measured by the receivers at both the ATU-C and the ATU-R shall be externally accessible from the ATU-C, but they are not required to be continuously monitored.”); §10.8.9.1 (“During channel analysis the ATU-C receiver estimates the upstream channel gain of each subcarrier in preparation for computing the SNR for each tone; it shall also calculate the average loop attenuation.”); §10.9.8.1 (“During channel analysis the ATU-R receiver estimates the downstream channel gain of each subcarrier in preparation for computing the SNR for each tone; it shall also calculate the average loop attenuation.”).

404. BI-089 also discloses a receiver portion. BI-089 discloses that a receiving station employs a combination of forward error correction (FEC) and a cyclic redundancy check (CRC). BI-089, §2. BI-089 also discloses that “the ARQ protocol does require memory at both the transmitter and receiver to buffer frames and this buffering introduces latency.” *Id.*, §5.

405. Therefore, G.992.1 in view of BI-089 discloses this limitation.

(c) “receiving a plurality of packets,”

406. G.992.1 in view of BI-089 discloses receiving a plurality of packets.

407. G.992.1 discloses that the transmitter portions of the ATU-O and the ATU-R are capable of receiving a plurality of packets. *See, e.g.*, G.992.1, 1 (“describes the organization of transmitted and received data into frames”); §3.10 (defining data frame as “[a] grouping of bytes from fast and interleaved paths over a single symbol time period after addition of FEC bytes and after interleaving”). A person having ordinary skill in the art would have understood a frame to be a packet.

408. BI-089 also discloses that the receiver portion is capable of receiving a plurality of packets. BI-089 describes the benefits of using ARQ in “G.dmt.bis and G.lite.bis,” which a person having ordinary skill in the art would recognize were the names of transceiver standards being developed to transmit and receive data. BI-089, §1. BI-089 refers to transceivers as “stations.” *Id.*, §2. BI-089 discloses that “[i]n a communication protocol with ARQ, the data transmission between two stations consists of exchanging information and acknowledgement frames.” *Id.* BI-089 further discloses that “[e]ach information frame of length N code symbols has an information field of length K code symbols, a CRC field of length S code symbols, and a control field of length R code symbols.” *Id.* A person having ordinary skill in the art as of the priority date of the ’411 patent would have understood each information frame to be a packet.

409. Accordingly, G.992.1 in view of BI-089 discloses this limitation.

(d) “identifying at least one packet of the plurality of packets as a packet that should be retransmitted and”

410. This claim element recites the same claim element set forth in claim 10. Therefore, this element is taught by G.992.1 in view of BI-089 for the reasons explained above for claim element 10.

411. Therefore, G.992.1 in view of BI-089 discloses this limitation.

- (e) “allocating a memory between a retransmission function and an interleaving and/or deinterleaving function,”

412. This claim element recites the same claim element set forth in claim 10. Therefore, this element is taught by G.992.1 in view of BI-089 for the reasons explained above for claim element 10.

413. Therefore, G.992.1 in view of BI-089 discloses this limitation.

- (f) “wherein the memory is allocated between the retransmission function and the interleaving function and/or the deinterleaving function in accordance with a message received during an initialization of the transceiver and”

414. This claim element recites substantively the same claim element set forth in claim 10. Therefore, this element is taught by G.992.1 in view of BI-089 for the reasons explained above for claim element 10.

415. Therefore, G.992.1 in view of BI-089 discloses this limitation.

- (g) “wherein at least a portion of the memory may be allocated between the retransmission function and the interleaving and/or deinterleaving function at any one particular time depending on the message.”

416. This claim element recites substantively the same claim element set forth in claim 10. Therefore, this element is taught by G.992.1 in view of BI-089 for the reasons explained above for claim element 10.

417. Therefore, G.992.1 in view of BI-089 discloses this limitation.

418. Thus, G.992.1 in view of BI-089 discloses both the structural and non-structural elements of claim 18 and therefore renders claim 18 obvious.

(3) Motivation to Combine

419. A person having skill in the art would have been motivated to combine the

teachings of G.992.1 and BI-089 because they are both directed to data transmission systems that utilize similar core concepts. Indeed, both concern ADSL systems operating in environments that suffer from impulse noise. *See, e.g.*, G.992.1 at §§ 9.2.5, F.2.2; BI-089 at §5. Moreover, BI-089 was submitted to the standards body that developed G.992.1, and it proposes to improve ADSL by adding ARQ in “G.dmt-bis,” which a person having ordinary skill in the art would have recognized as the revision of G.992.1. For this reason alone, a person having ordinary skill in the art would have been motivated to combine the disclosures of BI-089 to G.992.1

420. BI-089 teaches that in the context of ADSL, despite the use of a noise margin that should be sufficiently high to eliminate the effects of random errors, “the data . . . occasionally gets corrupted” and that “it must be impulse noise causing burst errors.” BI-089, §3.

421. BI-089 teaches that “ARQ and interleaving are two common approaches to improving performance over a bursty channel,” where “[a] bursty channel is defined as a channel for which the noise between adjacent samples is correlated.” BI-089, §5. Whereas “[i]nterleaving attempts to remove the correlation between adjacent samples such that errors are distributed over multiple FEC frames, thereby increasing the likelihood of error correction,” “ARQ exploits channel correlation resulting in the confinement of burst errors.” *Id.*

422. BI-089 notes that “non-Gaussian bursts of errors can exceed the correction capabilities of FEC methods.” BI-089, §3. BI-089 teaches that “retransmitting a FEC frame corrupted by burst errors is preferable over spreading the errors across several adjacent frames and trying to correct them,” as interleaving does. *Id.*, §5. Thus, relative to interleaving, “[f]rom the information theoretic point of view, ARQ is the preferred method of burst error correction because of its ability to preserve and exploit the information in the noise correlation.” *Id.*, §5. Therefore, BI-089 proposes to add ARQ to ADSL because “ARQ is a natural and convenient

method to fight the impulse noise.” *Id.*, §§3, 6.

423. It would have been straightforward for a person having ordinary skill in the art to add ARQ to G.992.1. Adding ARQ to G.992.1 would merely have combined known methods that, in combination, would perform the same functions as they would separately. Although a person having ordinary skill in the art would have had to modify certain of the G.992.1 initialization messages to accommodate ARQ (e.g., to add fields that would indicate whether to use ARQ or interleaving, to indicate different parameter values for ARQ, etc.), and would have had to define a packet structure, doing so would have been straightforward and well within the level of ordinary skill, as would have been the definition of a return channel for ACKs/NACKs. All of these aspects of ARQ and communication systems were well known and understood as of the priority date. For example, G.992.1 defines an AOC protocol that includes AOC messages with a header and payload as well as a return channel for acknowledgments. A person having ordinary skill in the art would easily have been able to define a packet structure for ARQ that would allow each header to indicate the order of packets being transmitted, and accommodate an ARQ return channel in G.992.1.

424. Adding ARQ to G.992.1 would merely have combined known methods that, in combination, would perform the same functions as they would separately.

425. Moreover, allowing G.992.1 transceivers to use ARQ instead of interleaving in one or both directions of transmission would simply substitute one known method, ARQ, for another known method, interleaving, which is exactly what BI-089 suggests doing. ARQ was known in the art, and its effectiveness in mitigating burst errors was well known and is discussed at length in BI-089. The results of substituting ARQ for interleaving in G.992.1 would have been predictable: improved performance in the presence of impulse noise at a cost of increased delay

jitter.

2. The '055 Patent

a. Takeuchi in view of Fukushima

426. In my opinion, Takeuchi in view of Fukushima discloses each and every limitation of claim 17 of the '055 patent and therefore renders claim 17 obvious. Below, I first show how the combination of Takeuchi and Fukushima discloses the limitations of claim 11 and then show how the combination discloses the limitation added by claim 17.

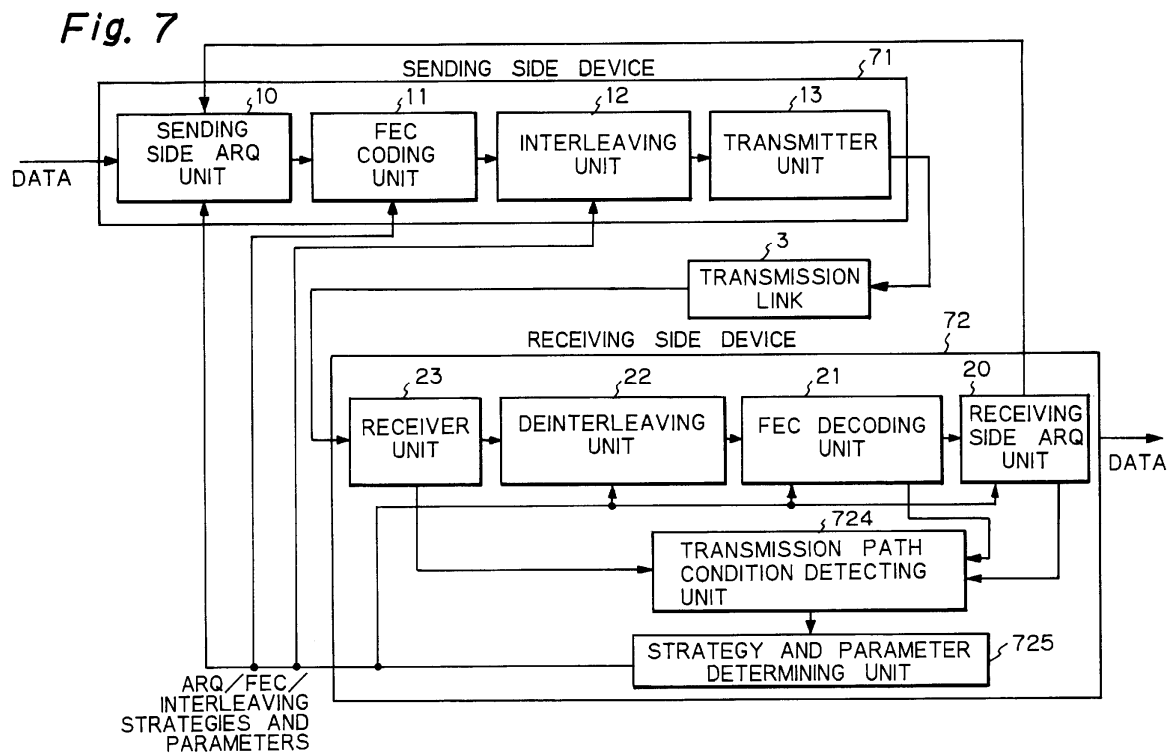
(1) Claim 11

(a) “A transceiver operable to transmit a first type of packet and a second type of packet”

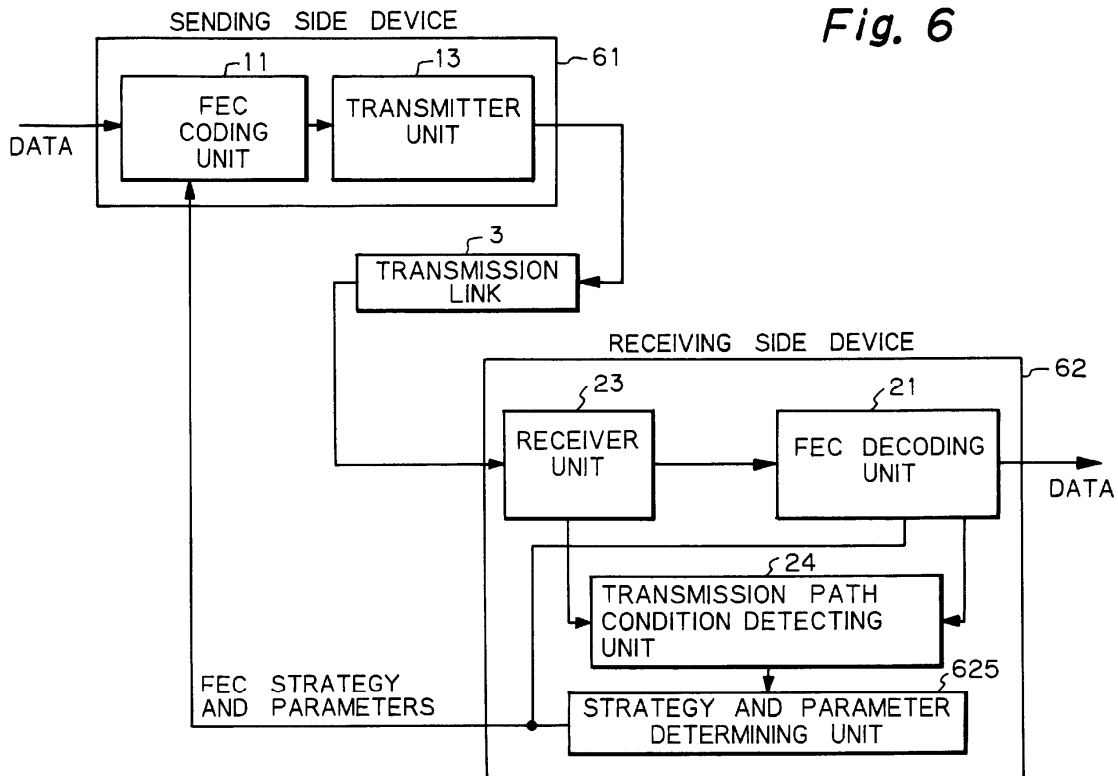
427. Takeuchi discloses a transceiver operable to transmit a first type of packet and a second type of packet.

428. First, Takeuchi discloses a transceiver. *See, e.g.*, Takeuchi, 5:10-13 (“As will be apparent from FIG. 1, the error control system of this embodiment is constituted by a sending side device 1 and a receiving side device 2 connected to each other by a transmission link 3 which includes a radio path.”); 15:16-23 (“FIG. 10 schematically illustrates a further embodiment of an error control system for data transmission over a digital mobile communication system, according to the present invention. In this embodiment, mobile terminals A and B, each of which has both a sending side device and a receiving side device and can be used for bidirectional data communication, have the same constitution as each other and are connected via the transmission link 3.”).

429. Takeuchi also discloses that the transceiver is operable to transmit a first type of packet, i.e., a packet sent using ARQ for error control. *See, e.g., id.*, 12:48-50 (“In the error control system of this embodiment, an ARQ strategy is executed in addition to the FEC strategy and the interleaving strategy.”); Fig. 7.



430. Takeuchi also discloses that the transceiver is operable to transmit a second type of packet, i.e., a packet sent without using ARQ for error control. *See, e.g., id.*, 12:25-26 (“In the error control system of this embodiment, only a FEC strategy is executed without any interleaving strategy.”); Fig. 6.



431. Therefore, to the extent it is limiting, Takeuchi in view of Fukushima discloses this limitation.

- (b) “wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission”

432. Takeuchi does not explicitly disclose that the first type of packet is stored in a retransmission buffer after transmission. However, a person having ordinary skill in the art would understand that in the ARQ strategy used by Takeuchi, the transmitting transceiver storing the packet in a retransmission buffer in the event that the packet needs to be retransmitted because it was not received or was received with uncorrectable errors by the other transceiver is inherent.

433. For example, Fukushima discloses that a first type of packet, i.e. a packet with a

high priority, is stored in a retransmission buffer. Fukushima, 15:11-22 (“Further, the data transmission apparatus 101 includes a buffer 17 for retransmission (hereinafter, referred to as a retransmission buffer 17), a packet priority decision unit 15, and a retransmission buffer management unit 18. The retransmission buffer 17 stores predetermined packets amongst the received packets, as retransmission packets. The packet priority decision unit 15 decides the priorities of the received packets. The retransmission buffer management unit 18 controls the retransmission buffer 17 such that data of packets whose priorities are equal to or higher than a predetermined value are stored in the buffer 17, in accordance with the decided priorities of the packets.”).

434. Similarly, Fukushima discloses that a second type of packet, i.e., a packet with low priority, is not stored in a retransmission buffer. *Id.*, 16:36-39 (“Further, those packets whose priorities are decided as being equal to or higher than the predetermined value are stored in the retransmission buffer 17 under control of the retransmission buffer management unit 17.”).

435. Accordingly, Takeuchi in view of Fukushima discloses this limitation.

(c) “wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet”

436. Takeuchi does not explicitly disclose that the first and second type of packets include a header field that indicate the type of packet. However, a person having ordinary skill in the art would understand that packets generally include headers that include information about the packet. For example, a person having ordinary skill in the art would have understood that a packet that is transmitted with an ARQ strategy includes a sequence identifier in the header field to allow the receiving transceiver to identify the packet and request that it be retransmitted if it is received with too many errors or is not received at all.

437. For example, Fukushima discloses that packets to be retransmitted include sequence identifiers. Fukushima, 15:3-10 (“Each packet transmitted from the transmitting end is composed of a data section containing digital data such as video data, audio data, and text data, and a header section containing additional information other than these digital data. To be specific, the header section of each packet contains additional information relating to its sequence number, priority, and data reproduction time at the receiving end.”). Fukushima explains how the receiving transceiver uses this header information to request retransmission of the first type of packet. *Id.*, 17:6-10 (“With respect to the error packet whose priority is equal to or higher than the predetermined value, the retransmission instruction output unit 26 outputs a retransmission request to the transmitting end, by indicating the sequence number of this error packet.”).

438. A person having ordinary skill in the art would understand that a packet that is transmitted without ARQ, e.g., a second type of packet in Takeuchi, would have no reason to have a header field with a sequence identifier because the sequence identifier is used to identify a packet for retransmission.

439. Accordingly, Takeuchi in view of Fukushima discloses this limitation.

- (d) “wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.”

440. As described above, Fukushima discloses that packets to be retransmitted include a sequence identifier in the header field of the packet. Fukushima does not explicitly disclose that the sequence identifier is incremented each time a packet of this type is transmitted. However, a person having ordinary skill in the art would understand that incrementing the sequence identifier is inherent in any ARQ strategy. This is because a packet may not be received at all by a receiving

transceiver due to such external factors as impulse noise. Therefore, by the receiving transceiver keeping track of which packets were received, the receiving transceiver can determine that a certain packet was not received and request retransmission of that packet. For example, if a receiving transceiver receives packets with sequence identifiers 1001, 1002, 1004, and 1005, the receiving transceiver could determine that packet with sequence identifier 1003 was not received due to external errors, and request that packet 1003 be retransmitted. If sequence identifiers were not incremented but just generated randomly, the receiving transceiver would not be able to determine if a packet was not received and would only be able to request retransmission of a packet that was received but was received with uncorrectable errors.

441. Accordingly, Takeuchi in view of Fukushima discloses this limitation.

442. Thus, Takeuchi in view of Fukushima discloses all elements of claim 11.

(2) Claim 17

443. Claim 17, which depends from claim 11, additionally recites “wherein the first type of packet comprises one or more PTM-TC (Packet Transfer Mode-Transmission Convergence) codewords.”

444. Takeuchi discloses that the first type of packet is transmitted using an FEC strategy as well as an ARQ strategy. Takeuchi, 12:48-50. Takeuchi does not explicitly disclose that the packet includes PTM-TC codewords. However, a person having ordinary skill in the art would understand that any FEC, i.e., forward error correction, strategy would include appending some type of redundancy codewords to the packet. Therefore, a person having ordinary skill in the art would have found it obvious to include PTM-TC codewords in the first type of packet of Takeuchi.

445. Thus, Takeuchi in view of Fukushima disclose both the structural and non-structural elements of claim 17 and therefore render claim 17 obvious.

(3) Motivation to Combine

446. A person having skill in the art would have been motivated to combine the teachings of Takeuchi and Fukushima because they are both directed to data transmission systems that utilize similar core concepts.

447. Takeuchi addresses the problem that error control mechanisms in use are often not well matched to channel conditions. Takeuchi, 1:57-2:18. For example, the error control may be designed conservatively, in which case transmission efficiency is suboptimal, or there may be insufficient error control, leading to bit errors, increased latency, degraded throughput, or disconnection. *Id.* Therefore, Takeuchi seeks to provide an error control method whereby the error control strategy and/or parameters in use for error control are adapted based on real-time observations of channel conditions. *Id.*, 2:21-28.

448. Fukushima seeks to address problems created by the use of communication links that include both wired and wireless portions, and specifically to address the problem that the bit error rate in the wireless section is 10^{-3} , whereas the bit error rate in the wired section is lower (between 10^{-5} and 10^{-7}). Fukushima, 1:64-2:12. Fukushima discloses approaches, including retransmission, that “can improve the transmission quality in a radio section in real-time transmission.” *Id.*, 2:19-21.

449. Both Takeuchi and Fukushima disclose communication systems utilizing retransmission.

450. A person having ordinary skill in the art would have been motivated to combine the adaptive strategies of Takeuchi and the priority-based retransmission of Fukushima in order to improve error performance and efficiency. For example, a person having ordinary skill in the art would have been motivated to add the priority scheme of Fukushima to the transceivers of Takeuchi in order to improve the efficiency of retransmission by only retransmitting packets

having a high enough priority. As another example, a person having ordinary skill in the art would have been motivated to add the adaptive techniques of Takeuchi to the data transmission system of Fukushima in order to better match the error control to the current conditions of the wireless link.

b. BI-089 in view of Fukushima

451. In my opinion, BI-089 in view of Fukushima discloses each and every limitation of claim 17 of the '055 patent and therefore renders claim 17 obvious. Below, I first show how the combination of BI-089 and Fukushima discloses the limitations of claim 11 and then show how the combination discloses the limitation added by claim 17.

(1) Claim 11

(a) “A transceiver operable to transmit a first type of packet and a second type of packet”

452. BI-089 discloses a transceiver operable to transmit a first type of packet and a second type of packet.

453. BI-089 describes the benefits of using ARQ in “G.dmt.bis and G.lite.bis,” which a person having ordinary skill in the art would have recognized were the names of transceiver standards being developed to allow transceivers to transmit and receive at the same time on the same subscriber line. BI-089, §1. BI-089 refers to transceivers as “stations,” (id., §2), which a person having ordinary skill in the art would have understood to be communications devices capable of transmitting and receiving data wherein the transmitter portion and receiver portion share at least some common circuitry (e.g., an interface to the twisted pair line).

454. BI-089 discloses that “[i]n a communication protocol with ARQ, the data transmission between two stations consists of exchanging information and acknowledgement frames.” BI-089, §2. BI-089 further discloses that “[e]ach information frame of length N code

symbols has an information field of length K code symbols, a CRC field of length S code symbols, and a control field of length R code symbols.” *Id.* A person having ordinary skill in the art as of the priority date of the ’055 patent would have understood each information frame to be a packet.

455. BI-089 describes ARQ and interleaving, in conjunction with FEC, as “two common approaches to improving performance over a bursty channel.” BI-089, 3. BI-089 discloses that ARQ has some advantages over interleaving in bursty conditions and therefore “the use of ARQ should reduce or eliminate the need for interleaving” under such conditions. *Id.* Accordingly, a person having ordinary skill in the art would understand BI-089 to disclose a transceiver operable to transmit a first type of packet, i.e., a packet using FEC in conjunction with ARQ for error correction over a bursty channel, and a second type of packet, i.e. a packet using FEC in conjunction with interleaving in non-bursty conditions.

456. Accordingly, to the extent it is limiting, BI-089 in view of Fukushima discloses the preamble of claim 11.

- (b) “wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission”

457. BI-089 discloses that “the ARQ protocol does require memory at both the transmitter and receiver to buffer frames.” BI-089, 3. A person having ordinary skill in the art would understand this to be a disclosure of storing the first type of packet in a retransmission buffer after retransmission because it is inherent in any ARQ protocol that the transmitting transceiver store the packet in a retransmission buffer in the event that the packet needs to be retransmitted because it was not received or was received with uncorrectable errors by the other transceiver. A person having ordinary skill in the art would also understand that a second type of packet, i.e., a packet transmitted using FEC and interleaving, is not stored in a retransmission

buffer because there is no need for the transmitting receiver to save a copy of such a packet.

458. Fukushima also discloses that a first type of packet, i.e. a packet with a high priority, is stored in a retransmission buffer. Fukushima, 15:11-22 (“Further, the data transmission apparatus 101 includes a buffer 17 for retransmission (hereinafter, referred to as a retransmission buffer 17), a packet priority decision unit 15, and a retransmission buffer management unit 18. The retransmission buffer 17 stores predetermined packets amongst the received packets, as retransmission packets. The packet priority decision unit 15 decides the priorities of the received packets. The retransmission buffer management unit 18 controls the retransmission buffer 17 such that data of packets whose priorities are equal to or higher than a predetermined value are stored in the buffer 17, in accordance with the decided priorities of the packets.”).

459. Similarly, Fukushima discloses that a second type of packet, i.e., a packet with low priority, is not stored in a retransmission buffer. *Id.*, 16:36-39 (“Further, those packets whose priorities are decided as being equal to or higher than the predetermined value are stored in the retransmission buffer 17 under control of the retransmission buffer management unit 17.”).

460. Accordingly, BI-089 in view of Fukushima discloses this limitation.

- (c) “wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet”

461. BI-089 does not explicitly disclose that the first and second type of packets include a header field that indicate the type of packet. However, a person having ordinary skill in the art would understand that packets generally include headers that include information about the packet. For example, a person having ordinary skill in the art would have understood that a packet that is transmitted with a retransmission protocol includes a sequence identifier in the header field to allow the receiving transceiver to identify the packet and request that it be retransmitted if it is

received with too many errors or is not received at all.

462. For example, Fukushima discloses that packets to be retransmitted include sequence identifiers. Fukushima, 15:3-10 (“Each packet transmitted from the transmitting end is composed of a data section containing digital data such as video data, audio data, and text data, and a header section containing additional information other than these digital data. To be specific, the header section of each packet contains additional information relating to its sequence number, priority, and data reproduction time at the receiving end.”). Fukushima explains how the receiving transceiver uses this header information to request retransmission of the first type of packet. *Id.*, 17:6-10 (“With respect to the error packet whose priority is equal to or higher than the predetermined value, the retransmission instruction output unit 26 outputs a retransmission request to the transmitting end, by indicating the sequence number of this error packet.”).

463. A person having ordinary skill in the art would understand that a packet that is transmitted without retransmission, e.g., a second type of packet in BI-089, would have no reason to have a header field with a sequence identifier because the sequence identifier is used to identify a packet for retransmission.

464. Accordingly, BI-089 in view of Fukushima discloses this limitation.

- (d) “wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.”

465. As described above, Fukushima discloses that packets to be retransmitted include a sequence identifier in the header field of the packet. Fukushima does not explicitly disclose that the sequence identifier is incremented each time a packet of this type is transmitted. However, a person having ordinary skill in the art would understand that incrementing the sequence identifier

is inherent in any ARQ strategy. This is because a packet may not be received at all by a receiving transceiver due to such external factors as impulse noise. Therefore, by the receiving transceiver keeping track of which packets were received, the receiving transceiver can determine that a certain packet was not received and request retransmission of that packet. For example, if a receiving transceiver receives packets with sequence identifiers 1001, 1002, 1004, and 1005, the receiving transceiver could determine that packet with sequence identifier 1003 was not received due to external errors, and request that packet 1003 be retransmitted. If sequence identifiers were not incremented but just generated randomly, the receiving transceiver would not be able to determine if a packet was not received and would only be able to request retransmission of a packet that was received but was received with uncorrectable errors.

466. Accordingly, BI-089 in view of Fukushima disclose this limitation.

467. Thus, BI-089 in view of Fukushima discloses all elements of claim 11.

(2) Claim 17

468. Claim 17, which depends from claim 11, additionally recites “wherein the first type of packet comprises one or more PTM-TC (Packet Transfer Mode-Transmission Convergence) codewords.”

469. BI-089 discloses that the first type of packet is transmitted using an FEC as well as ARQ. BI-089, 1 (“This contribution discusses the benefits of applying Automatic Repeat Request (ARQ) together with the currently defined Reed-Solomon (RS) forward error correction (FEC) scheme for G.dmt.bis and G.lite.bis.”). BI-089 does not explicitly disclose that the packet includes PTM-TC codewords. However, a person having ordinary skill in the art would understand that any FEC, i.e., forward error correction, strategy would include appending some type of redundancy codewords to the packet. Therefore, a person having ordinary skill in the art would have found it obvious to include PTM-TC codewords in the first type of packet of BI-089.

470. Thus, BI-089 in view of Fukushima discloses all elements of claim 17 and therefore render claim 17 obvious.

(3) Motivation to Combine

471. A person having skill in the art would have been motivated to combine the teachings of BI-089 and Fukushima because they are both directed to data transmission systems that utilize similar core concepts. Although BI-089 is directed to wired communication (ADSL), and Fukushima's focus is on improving transmission quality in a radio section of a communication link, a person having ordinary skill in the art would have recognized that the transmission challenges and need for error protection strategies are common to both types of channels. Accordingly, a person having ordinary skill in the art seeking to improve a DSL system would have considered disclosures related to wireless communication.

472. Both BI-089 and Fukushima disclose communication systems utilizing retransmission. BI-089 teaches that memory is a resource to be managed in an ADSL transceiver, and that retransmission requires memory. *See, e.g.*, BI-089 at 1 ("the use of ARQ will reduce or eliminate the need for interleaving; thus, the memory and delay associated with interleaving can be reapplied to ARQ."); *id.* at 3 ("the ARQ protocol does require memory at both the transmitter and receiver to buffer frames and this buffering introduces latency."). Fukushima describes assigning priorities to packets and using retransmission only for those packets with a priority above a threshold. *See, e.g.*, Fukushima, 10:54-11:4.

473. A person having ordinary skill in the art as of the priority date would have been motivated to add Fukushima's packet priority techniques to the transceivers of BI-089 because doing so would have reduced the amount of memory that would be required to be allocated for retransmission. The person having ordinary skill would have recognized that only sufficiently high-priority packets would have to be stored in memory after transmission, thereby allowing the

amount of memory allocated for retransmission to be reduced (e.g., leaving more memory for interleaving than would be available if all packets were retransmitted).

474. A person having ordinary skill in the art would have found it straightforward to add Fukushima's packet priority technique to the transceivers of BI-089 and would have had a reasonable expectation that the combination would be successful. Fukushima describes in detail how to implement retransmission with packet priorities. It would have been well within the ability of a person having ordinary skill in the art as of the priority date to add Fukushima's retransmission with packet priorities to the transceivers of BI-089.

c. Kawakami in view of G.993.1

475. In my opinion, Kawakami in view of G.993.1 discloses each and every limitation of claim 17 of the '055 patent and therefore renders claim 17 obvious. Below, I first show how the combination of Kawakami and G.993.1 discloses the limitations of claim 11 and then show how the combination discloses the limitation added by claim 17.

(1) Claim 11

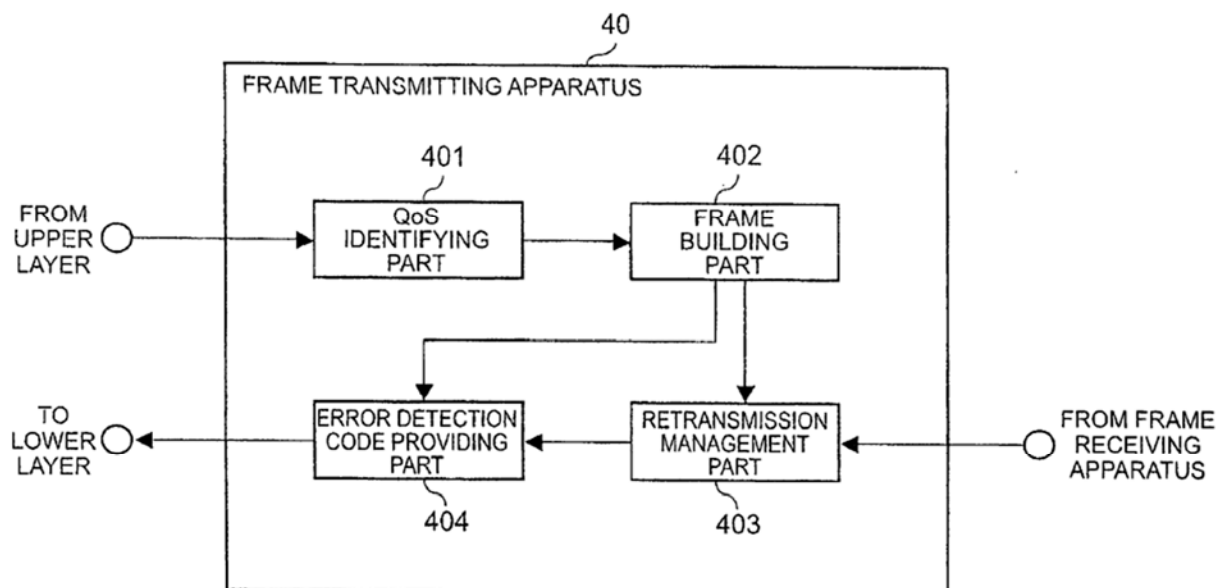
(a) "A transceiver operable to transmit a first type of packet and a second type of packet"

476. Kawakami discloses a transceiver operable to transmit a first type of packet and a second type of packet.

477. Kawakami discloses a transceiver, namely that mobile station 20 and control station 102 are each capable of transmitting and receiving data. For example, Kawakami discloses that "frame transmitting apparatus 40 and the frame receiving apparatus 50 of the present embodiment are installed in each of the mobile station 20 and the radio link control station 102 so as to terminate a radio protocol." *Id.*, ¶[0024]. In other words, each of the mobile station 20 and the control station 102 contain a transceiver comprised of the frame transmitting apparatus

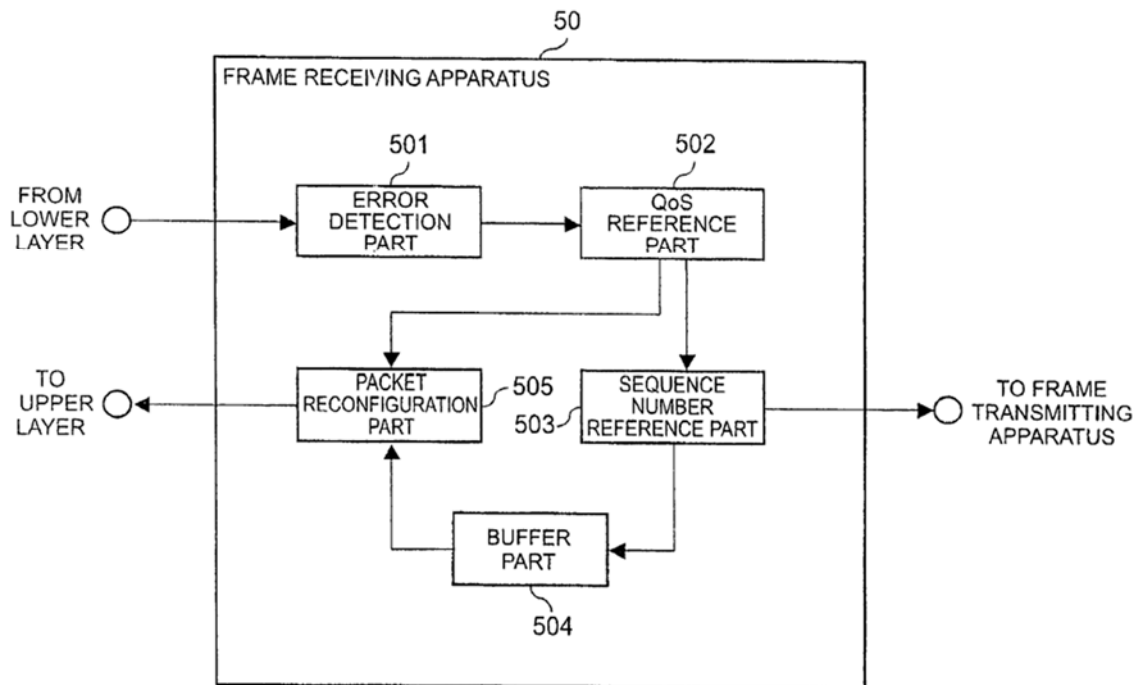
40 and the frame receiving apparatus 50.

478. Kawakami illustrates the frame transmitting apparatus of the transceiver in Figure 2:



Id., Fig. 2.

479. Kawakami illustrates the frame receiving apparatus of the transceiver in Figure 3:



Id., Fig. 3.

480. Kawakami discloses that this transceiver is used to transmit packets, including whether a packet is an acknowledgement type or an unacknowledgement type. *Id.* ¶[0007].

481. Kawakami further discloses that the frame transmitting apparatus 40 and the frame receiving apparatus 50 share common circuitry as they are connected to each other and transmit communications between each other. *Id.*, ¶[0029] (“the retransmission management part 403 is a part that buffers an acknowledgement type frame for retransmission and, when receiving a request from the frame receiving apparatus 50, outputs a corresponding acknowledgement type frame to the error detection code providing part 404.”), ¶[0034] (“the sequence number reference part 503 is a part that refers to a sequence number of each acknowledgement type frame and that transmits an ACK with the sequence number to the frame transmitting apparatus 40.”).

482. Further, one embodiment of the transceiver in Kawakami is a radio transceiver. ¶[0022] (“The mobile station 20 has a radio interface to access the mobile communication

network 10 . . . The base station 101 has a radio interface to the mobile station 20.”). I understand that TQ Delta took the position during claim construction that one definition that is consistent with the Court’s construction of “transceiver” is “a radio transmitter-receiver that uses many of the same components for both transmission and reception”) from the 1998 Merriam Webster Dictionary. TQ Delta Opening Claim Construction Brief at 2-3. A POSA would understand Kawakami to be disclosing such a radio transceiver that uses common components, such as an antenna or other circuitry, for transmission and reception. Additionally, the transmitting apparatus and receiving apparatus are both shown in Figs. 2 and 3 to connect to the same shared lower layer, which would include common circuitry known to POSAs that is used in transceivers to physically transmit and receive signals.

483. To the extent this limitation is not explicitly disclosed in Kawakami, it would have been obvious to a POSA to use the transmitting apparatus and receiving apparatus of Kawakami in an arrangement where the two portions share some common circuitry. There is a known desire to use as few components as possible in a given device, such as a transceiver, and therefore there is a natural motivation for the receiving and transmitting portions to share at least some circuitry.

484. Further, to the extent this limitation is not explicitly disclosed in, or obvious in view of, Kawakami, it is obvious in view of Kawakami and G.993.1. G.993.1 explicitly discloses the use of transceivers as it is directed to “Very high speed digital subscriber line transceivers.” G.993.1 at Title Page. Further, the figure below from G.993.1 “defines VDSL transceiver functionality between the I_O (I_R) and U2_O (U2_R) reference points, respectively.” G.993.1 at 157.

have reasonably expected the use of common shared circuitry in a transceiver to be a successful design choice.

485. Accordingly, Kawakami or Kawakami in view of G.993.1 discloses and renders obvious this limitation.

- (b) “wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission”

486. Kawakami discloses that the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission.

487. Kawakami discloses transmitting different types of packets according to their Quality of Service (QoS). *See, e.g.*, Kawakami, ¶¶ [0012]-[0019] (describing a “frame transmitting apparatus used in a frame transmission/reception system for transferring a data packet on a connection established prior to communication” which transmits “frames” (*i.e.*, packets) which contain “a QoS identifier... with information for determining whether the frame is an acknowledgement type frame” and transmit it to a “frame receiving apparatus”). Kawakami explains that a first type of packet is an “acknowledgement type frame,” *i.e.*, a packet with a “QoS level of tolerating some delay but not tolerating error like data communication.” *Id.*, ¶[0027].

488. Kawakami explains that a packet with a “QoS level of tolerating some delay but not tolerating error like data communication is subjected to error correction by retransmission control.” *Id.*, ¶[0027]. Kawakami also explains that a packet with a “QoS level of tolerating some error but being strict on delay like voice communication or the like is handled so as not to perform retransmission.” *Id.*, ¶[0027]. Kawakami refers to the first type of packet as an “acknowledgement type” packet and the second type of packet as an “unacknowledgement type” packet. *Id.*

Kawakami discloses that acknowledgement type packets are stored in a retransmission buffer and that unacknowledgement type packets are not. *Id.*, ¶[0029] (“Referring back to FIG. 2, the retransmission management part 403 is a part that buffers an acknowledgement type frame for retransmission and, when receiving a request from the frame receiving apparatus 50, outputs a corresponding acknowledgement type frame to the error detection code providing part 404. The retransmission management part 403 starts a retransmission timer at the same time as transmission of a frame, and buffers the frame for retransmission before receiving an acknowledgement response (ACK) from the frame receiving apparatus.”); ¶[0027] (“The frame building part 402 outputs acknowledgement type frames to the retransmission management part 403 and outputs unacknowledgement type frames to the error detection code providing part 404.”).

489. Accordingly, Kawakami discloses this limitation.

- (c) “wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet”

490. Kawakami discloses that the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet.

491. Kawakami discloses and renders obvious that an acknowledgement type packet (first type of packet) and an unacknowledgement type packet (second type of packets) each include a header field that indicates the type of packet.

492. Kawakami discloses that acknowledgement type packets and unacknowledgement type packets include a header that indicates the type of packet. *See, e.g.*, Kawakami, ¶[0027] (“The frame building part 402 provides a header of each generated radio frame with a QoS identifier according to the QoS information described in the data packet or the QoS information of the connection forming the data flow.”); ¶[0028] (“In the example of FIG. 4

(a), the QoS identifier of ‘0’ indicates an unacknowledgement type frame, and the QoS identifier of ‘1’ an acknowledgement type frame.”). The header of Kawakami’s packets therefore contains a header field that indicates whether the transmitted packet is the first type of packet (acknowledgement type frame) or the second type of packet (unacknowledgement type frame): a QoS identifier in the header which is 0 for unacknowledgement type frames, and which is 1 for acknowledgement type frames. *See id.*

493. Accordingly, Kawakami discloses this limitation.

- (d) “wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.”

494. Kawakami discloses that the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.

495. Kawakami discloses and renders obvious that the header field of an acknowledgement type packet (first type of packet) includes a sequence identifier (SID) that is incremented after the acknowledgement type packet is transmitted and that the header field of an unacknowledgement type packet (second type of packet) does not include the sequence identifier of the acknowledgement packet. Kawakami discloses that the header of an acknowledgement type packet includes a sequence number (SID) that is incremented after transmission. Kawakami at Abstract (“In order to achieve this object, a frame receiving apparatus has a QoS reference part for identifying whether a frame is an acknowledgement type frame, based on a QoS identifier provided for each frame, and a sequence number reference part for determining whether a frame is lost, only for each acknowledgement type frame, and requesting retransmission of a lost

frame.”); ¶[0012] (“Preferably, the frame transmitting apparatus of the present invention comprises number providing means for providing each acknowledgement type frame with a sequence number for each established connection. Since acknowledgement type frames are provided with their respective sequence numbers, for example, a frame receiving apparatus is able to acknowledge a loss of an acknowledgement type frame from discontinuity of the sequence numbers.”); ¶[0027] (“The frame building part 402 sequentially provides acknowledgement type frames of one radio protocol connection with sequence numbers.”); ¶[0034] (emphasis added) (“The sequence number reference part 503 is a part that refers to a sequence number of each acknowledgement type frame and that transmits an ACK with the sequence number to the frame transmitting apparatus 40. The sequence number reference part 503 also outputs an acknowledgement type frame outputted from the QoS reference part 502, to the buffer part 504. Furthermore, the sequence number Reference part 503 refers to a sequence number of each acknowledgement type frame and, when detecting a frame loss with a sequence number drop, instructs the buffer part 504 to buffer an acknowledgement type frame received thereafter.”).

496. A person having ordinary skill in the art would have understood that the sequence number disclosed by Kawakami is a “SID that is incremented” after transmission. In order for the sequence number to correspond to the correct frame, the sequence number must necessarily be incremented after each transmitted frame. A person having ordinary skill in the art would have also understood that the header field of an unacknowledgement type packet does not include the SID of the acknowledgement type since Kawakami only discloses providing acknowledgement type frames with a SID and explains that the SID is used to “determine[e] whether a frame is lost, only for each acknowledgement type frame.” Kawakami at abstract, ¶[0027]. Thus, appending a SID on an unacknowledgement type frame would serve no purpose and would disrupt the

sequencing of the SID of the acknowledge type frames.

497. To the extent that Kawakami does not explicitly disclose that the header field of an acknowledgement type frame includes a SID that is “incremented” after the frame is transmitted, it would have been obvious to a person having ordinary skill in the art to do so. Appending a SID to a packet that is incremented after transmission is a fundamental part of all selective repeat retransmission systems that allows a receiving transceiver to determine if a frame was lost due to error, request that the frame be retransmitted, and then put the frames in the correct order after receiving the retransmitted frame.

498. Accordingly, Kawakami discloses and renders obvious this limitation.

(2) Claim 17

499. Claim 17, which depends from claim 11, additionally recites “wherein the first type of packet comprises one or more PTM-TC (Packet Transfer Mode-Transmission Convergence) codewords.”

500. The '055 Patent admits that PTM-TC codewords were known in the art prior to the alleged invention. '055 Patent at 10:25-31 (“For reference, ‘Annex A’ which is of record in the identified provisional filing and incorporated by reference herein contains the PTM-TC of ADSL2 and VDSL2 systems as specified in the ITU-T G.992.3 ADSL2 standard.”); *see* TQD_TX-00001572-1584.

501. Kawakami discloses that the packets transferred in its system can comprise Internet Protocol packets. *Id.* ¶[0026] (Conceivable examples of the QoS information described in a data packet include Differentiated Services Code Point (DSCP) in Internet Protocol (IP) packet and others). A person having skill in the art would know that packet transfer mode-transmission convergence (and therefore PTM-TC codewords) can be utilized, and is often advantageous, in systems utilizing IP packets. Further, As explained above, various DSL

standards as of the priority date required the use of PTM-TC codewords. See G.993.1, 143 (“In the transmit direction... [t]he corresponding TPS-TC (PTM-TC) receives the packet from the γ interface, encapsulates it into a special frame (PTM-TC frame) and maps into the PMS-TC frame (transmission frame) for transmission over the VDSL link”). Therefore, a person having ordinary skill in the art would have found it obvious to include PTM-TC codewords in the first type of packet of Kawakami.

502. A person having skill in the art would have been motivated to combine the teachings of Kawakami and G.993.1 because they are both directed to data transmission systems that utilize similar core concepts. While Kawakami is directed to a RF physical layer and G.993.1 is directed to a copper physical layer, a person having ordinary skill in the art would be motivated to look to a variety of data transmissions systems in order to build a transceiver. Additionally, a person having skill in the art would have been motivated to look to G.993.1 to understand the types of packets that may be transmitted by the transceiver. The teachings of G.993.1 evidence that PTM-TC codewords were well-known in the art well before the date of the alleged invention of Claim 17. Additionally, a person having ordinary skill in the art at the relevant time would have been motivated to ensure that a transceiver could transmit a variety of types of packets. A person having ordinary skill in the art would have reasonably expected the use of PTM-TC codewords with the transceiver of Kawakami to be a successful design choice.

503. Thus, Kawakami in view of G.993.1 renders claim 17 obvious.

d. TS 125 322 in view of G.993.1

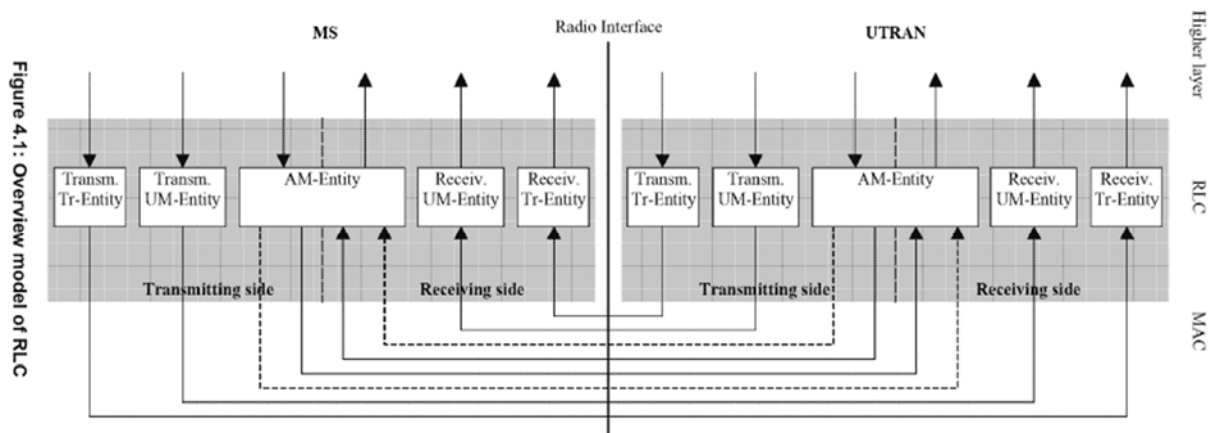
504. In my opinion, TS 125 322 in view of G.993.1 discloses each and every limitation of claim 17 of the '055 patent and therefore renders claim 17 obvious. Below, I first show how the combination of TS 125 322 and G.993.1 discloses the limitations of claim 11 and then show how the combination discloses the limitation added by claim 17.

(1) Claim 11

(a) “A transceiver operable to transmit a first type of packet and a second type of packet”

505. TS 125 322 discloses a transceiver operable to transmit a first type of packet and a second type of packet.

506. TS 125 322 discloses a transceiver, namely that a UE and a base station in a mobile network utilize transceivers to communicate. For example, TS 125 322 discloses a transceiver that is capable of transmitting and receiving packets in an “acknowledged mode” and in an “unacknowledged mode.”



TS 125 322 at 9.

507. The flow of unacknowledged packets is depicted below.

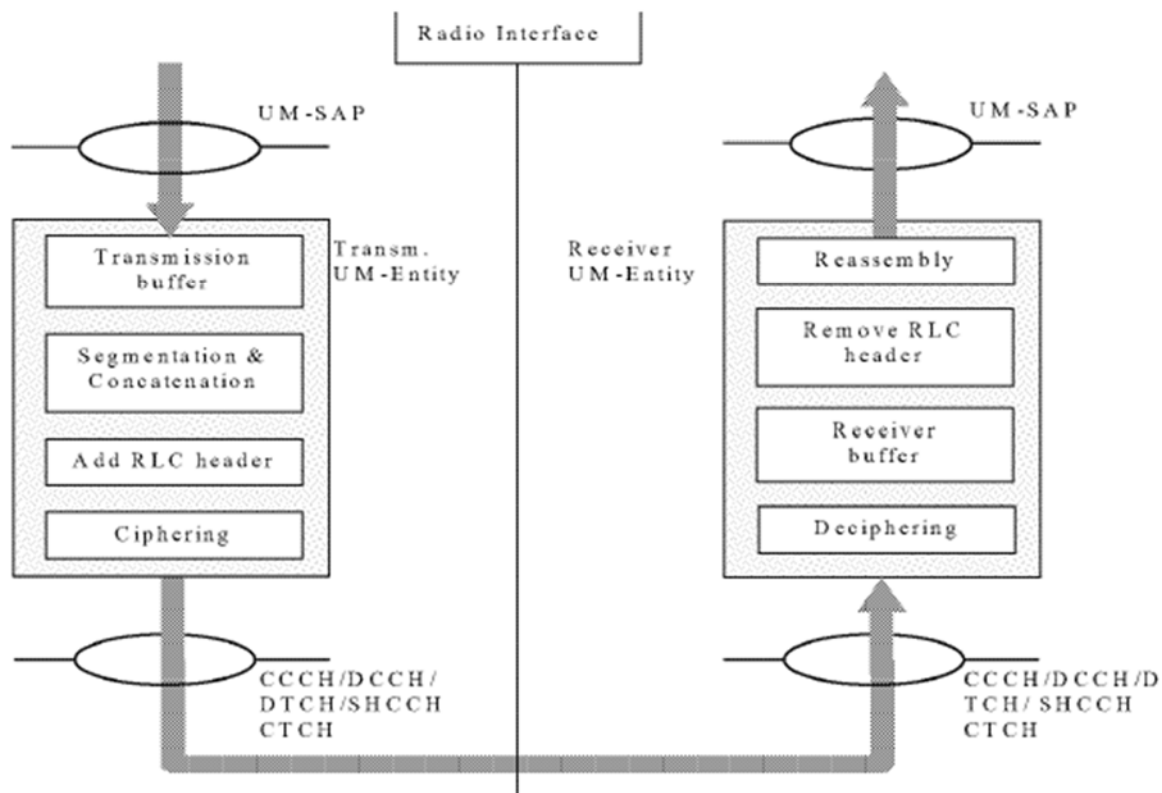


Figure 4.3: Model of two unacknowledged mode peer entities

TS 125 322 at 11.

508. The flow of acknowledged packets is depicted below.

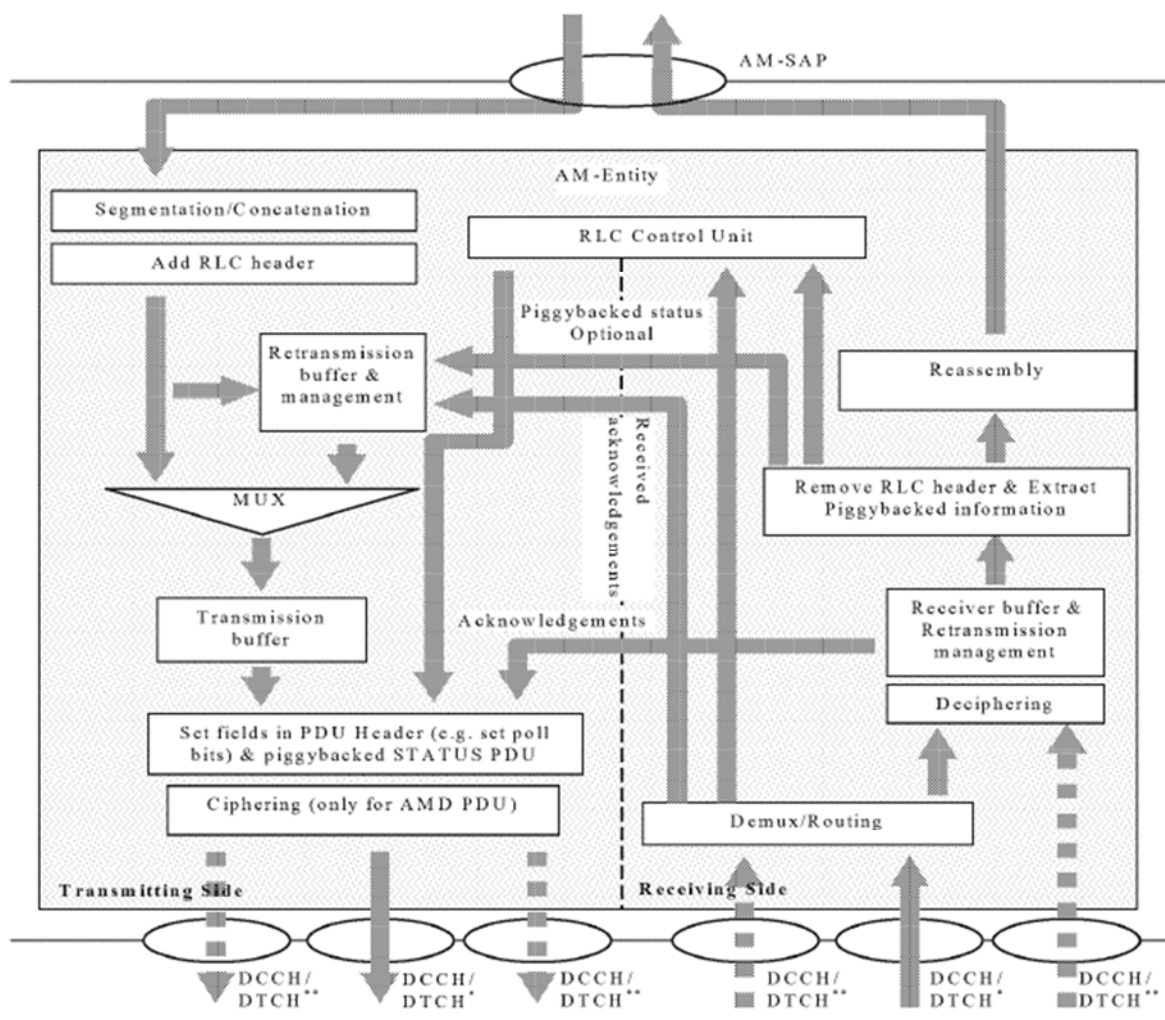


Figure 4.4: Model of an acknowledged mode entity

TS 125 322 at 12.

509. A person of skill in the art would understand, and readily know, that a UE and/or base station would necessarily have a transceiver capable of transmitting and receiving data. Such a transceiver is depicted in Fig. 4.1 and expanded upon in Fig. 4.4.

510. TS 125 322 further discloses that the transmitting and receiving portions of the transceiver share common circuitry as they are connected to each other and transmit communications between each other. *Id.*, at Fig. 4.4. Additionally, as shown in Fig. 4.4, the transmitting and receiving portions of the transceiver share the RLC control unit.

511. Further, one embodiment of the transceiver in TS 125 322 is a radio transceiver. I understand that TQ Delta took the position during claim construction that one definition that is consistent with the Court's construction of "transceiver" is "a radio transmitter-receiver that uses many of the same components for both transmission and reception") from the 1998 Merriam Webster Dictionary. TQ Delta Opening Claim Construction Brief at 2-3. A POSA would understand TS 125 322 to be disclosing such a radio transceiver that uses common components, such as an antenna or other circuitry, for transmission and reception. Additionally, the transmitting apparatus and receiving apparatus both connect to the same shared lower layer, which would include common circuitry known to POSAs that is used in transceivers to physically transmit and receive signals.

512. To the extent this limitation is not explicitly disclosed in TS 125 322, it would have been obvious to a POSA to use the transmitting apparatus and receiving apparatus of TS 125 322 in an arrangement where the two portions share some common circuitry. There is a known desire to use as few components as possible in a given device, such as a transceiver, and therefore there is a natural motivation for the receiving and transmitting portions to share at least some circuitry.

513. Further, extent this limitation is not explicitly disclosed in, or obvious in view of, TS 125 322, it is obvious in view of TS 125 322 and G.993.1. G.993.1 explicitly discloses the use of transceivers as it is directed to "Very high speed digital subscriber line transceivers." G.993.1 at Title Page. Further, the figure below from G.993.1 "defines VDSL transceiver functionality between the I_O (I_R) and U2_O (U2_R) reference points, respectively." G.993.1 at 157.

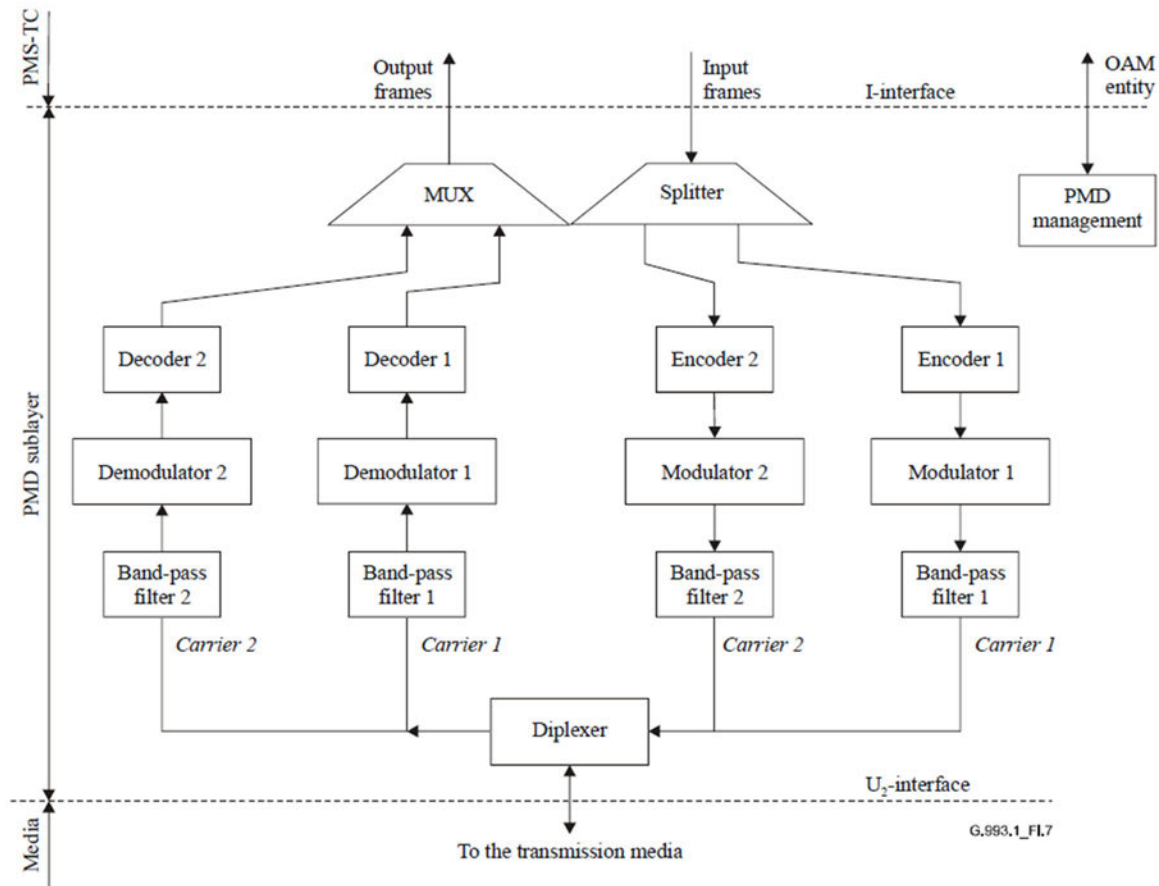


Figure I.7/G.993.1 – VTU PMD sublayer functional model

G.993.1 at 158. This figure teaches the use of a common diplexer in a VDSL transceiver.

A person having ordinary skill in the art would have been motivated to combine G.993.1's teaching of the use of common shared circuitry in a transceiver with the transceiver of TS 125 322. For example, a person having ordinary skill in the art would have known that the use of common shared circuitry in transceivers is a common design choice that is ubiquitous in transceivers. G.993.1 confirms this fact. Additionally, a person having ordinary skill in the art at the relevant time would have been motivated to use as few components as possible to design a transceiver and, therefore, would have looked to reuse as many components as possible, particularly in a common and known device such as transceiver. A person having ordinary skill

in the art would have reasonably expected the use of common shared circuitry in a transceiver to be a successful design choice.

514. Accordingly, TS 125 322 or TS 125 322 in view of G.993.1 and renders obvious discloses this limitation.

- (b) “wherein the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission”

515. TS 125 322 discloses that the first type of packet is stored in a retransmission buffer after transmission and the second type of packet is not stored in a retransmission buffer after transmission.

516. TS 125 322 discloses transmitting different types of packets according to whether an acknowledgement (an ACK/NACK) is required. TS 125 322 explains that a first type of packet is transmitted in an “acknowledged” mode and a second type of packet is transmitted in an unacknowledged mode. *Id.*, 43-44.

517. The flow of acknowledged packets is depicted in the figure below, which shows that acknowledgement packets are sent and stored in the retransmission buffer.

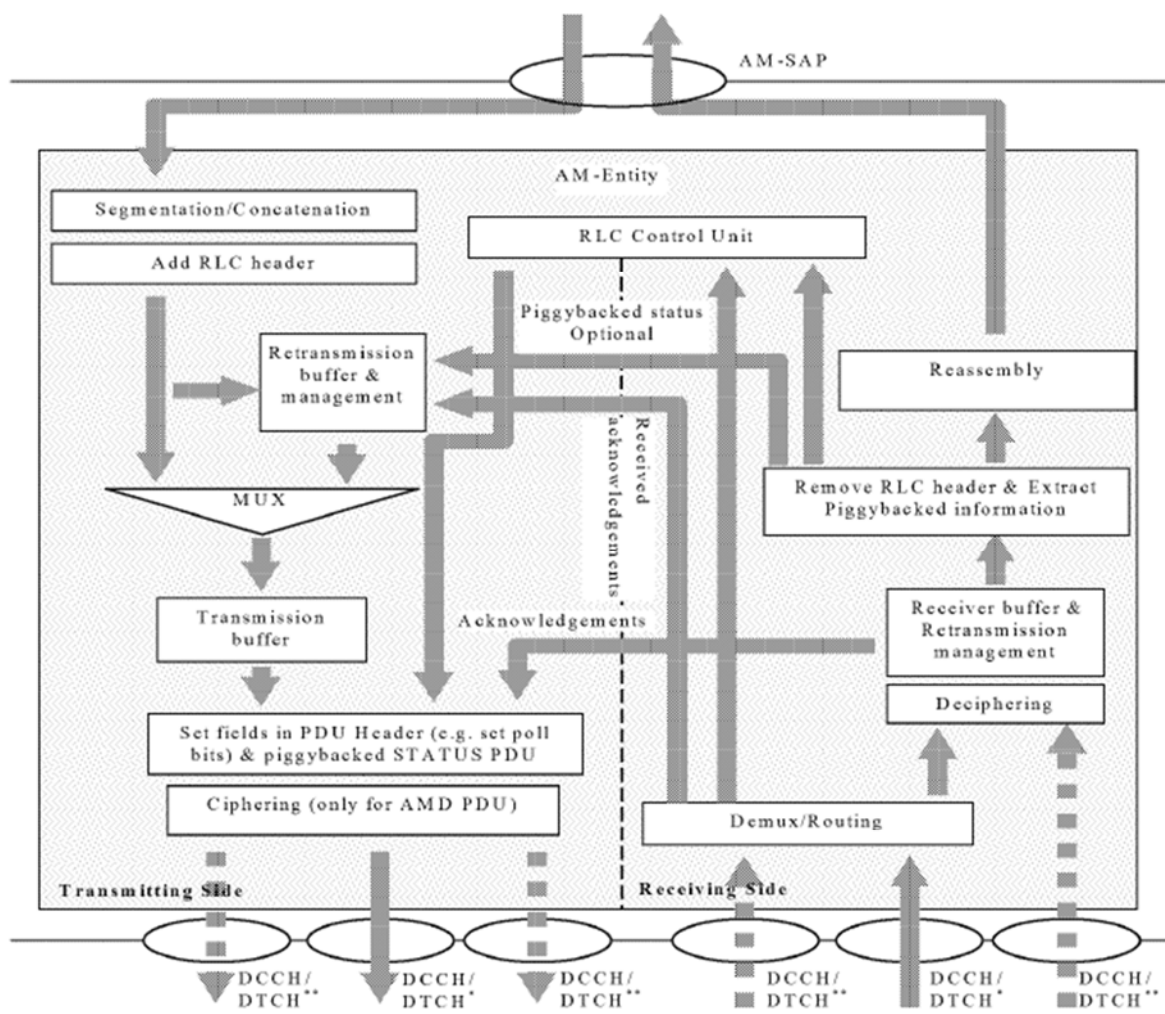


Figure 4.4: Model of an acknowledged mode entity

TS 125 322 at 12 (“After that the PDUs are placed in the retransmission buffer and the transmission buffer.”).

518. TS 125 322 also discloses that “the retransmission buffer also receives acknowledgements from the receiving side, which are used to indicate retransmissions of PDUs and when to delete a PDU from the retransmission buffer.” *Id.*

519. Figure 4.3 (reproduced below) shows that unacknowledged packets are not stored in the retransmission buffer.

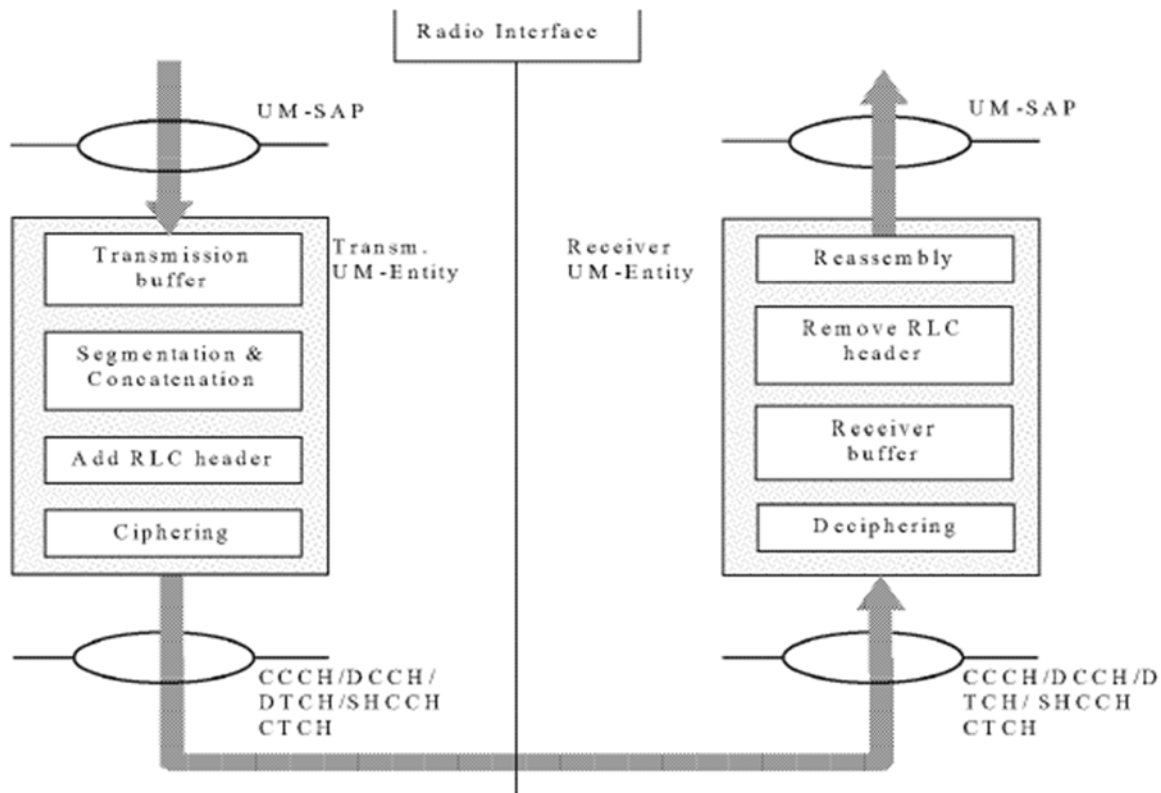


Figure 4.3: Model of two unacknowledged mode peer entities

TS 125 322 at 11.

520. Accordingly, TS 125 322 discloses this limitation.

- (c) “wherein the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet”

521. TS 125 322 discloses that the first and second types of packet comprise a header field that indicates whether a transmitted packet is a first type of packet or a second type of packet.

522. TS 125 322 discloses and renders obvious that an acknowledgement type packet (first type of packet) and an unacknowledgement type packet (second type of packets) each include a header field that indicates the type of packet.

523. TS 125 322 discloses that acknowledged packets and unacknowledged packets include different headers that indicates the type of packet. *See, e.g.,* TS 125 322, 19-21.

524. The header for unacknowledged packets is shown below.

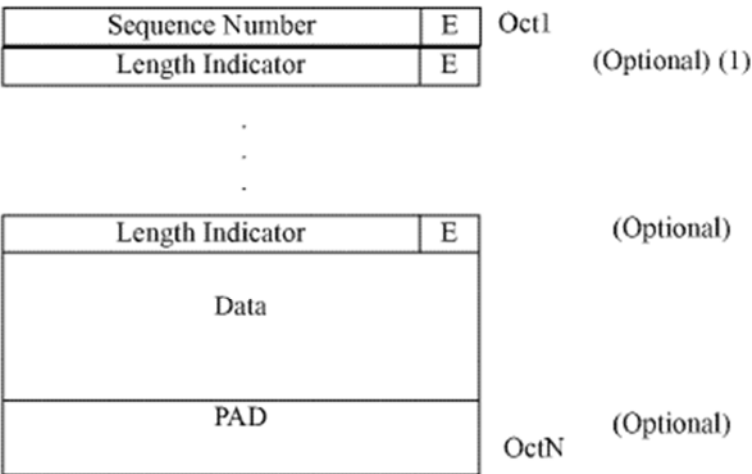
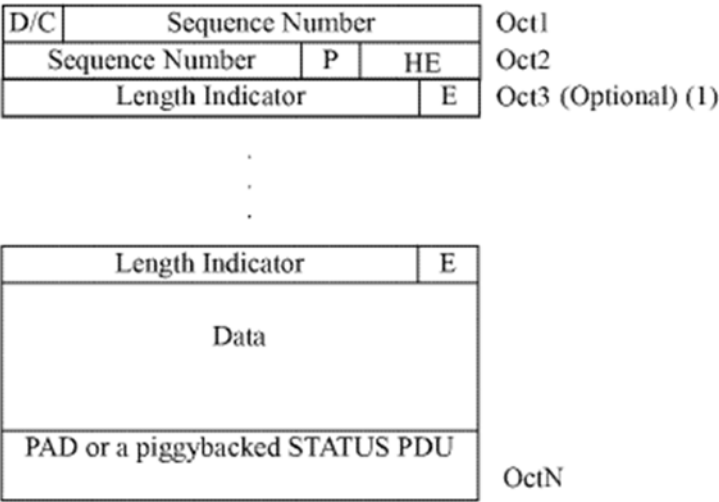


Figure 9.2: UMD PDU

NOTE (1): The Length Indicator may be 15 bits.

TS 125 322 at 20.

525. The header for acknowledged packets is shown below.



NOTE (1): The Length Indicator may be 15 bits.

Figure 9.3: AMD PDU

TS 125 322 at 20. The acknowledged packet headers contain additional information that identifies the packet as an acknowledged packet. For example, TS 125 322 teaches that the

presence of the D/C field indicates that a packet is an acknowledged packet.

9.2.2.1 D/C field

Length: 1bit.

The D/C field indicates the type of an acknowledged mode PDU. It can be either data or control PDU.

Bit	Description
0	Control PDU
1	Acknowledged mode data PDU

TS 125 322 at 22.

526. TS 125 322 also teaches that the acknowledged packets a polling bit data field, but the unacknowledged packets do not.

9.2.2.4 Polling bit (P)

Length: 1bit.

This field is used to request a status report (one or several STATUS PDUs) from the receiver RLC.

Bit	Description
0	Status report not requested
1	Request a status report

TS 125 322 at 23.

527. TS 125 322 also teaches that the acknowledged packets and unacknowledged packets have different sequence number (SN) lengths.

PDU type	Length	Notes
AMD PDU	12 bits	Used for retransmission and reassembly
UMD PDU	7 bits	Used for reassembly

TS 125 322 at 22-23.

528. Accordingly, TS 125 322 discloses this limitation.

- (d) “wherein the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.”

529. TS 125 322 discloses that the header field of the first type of packet comprises a sequence identifier (SID) that is incremented after the first type of packet is transmitted and the header field of the second type of packet does not comprise the SID of the first type of packet.

530. TS 125 322 discloses and renders obvious that the header field of an acknowledgement type packet (first type of packet) includes a sequence identifier (SID) that is incremented after the acknowledged packet is transmitted and that the header field of an unacknowledged packet (second type of packet) does not include the sequence identifier of the acknowledgement packet. TS 125 322 discloses that the acknowledged packets and unacknowledged packets have different sequence numbers (SN).

PDU type	Length	Notes
AMD PDU	12 bits	Used for retransmission and reassembly
UMD PDU	7 bits	Used for reassembly

TS 125 322 at 22-23. TS 125 322 teaches that the SN are used for (at least) reassembly of the acknowledged packets.

531. A person having ordinary skill in the art would have understood that the acknowledged packet sequence number disclosed by TS 125 322 is a “SID that is incremented” after transmission. In order for the sequence number to correspond to the correct packet, the sequence number must necessarily be incremented after each transmitted frame.

532. To the extent that TS 125 322 does not explicitly disclose that the SN of an acknowledged packet includes a SID that is “incremented” after the frame is transmitted, it would have been obvious to a person having ordinary skill in the art to do so. Appending a SN to a

packet that is incremented after transmission is a fundamental part of all selective repeat retransmission systems that allows a receiving transceiver to determine if a frame was lost due to error, request that the frame be retransmitted, and then put the frames in the correct order after receiving the retransmitted frame.

533. Accordingly, TS 125 322 discloses this limitation.

(2) Claim 17

534. Claim 17, which depends from claim 11, additionally recites “wherein the first type of packet comprises one or more PTM-TC (Packet Transfer Mode-Transmission Convergence) codewords.”

535. The '055 Patent admits that PTM-TC codewords were known in the art prior to the alleged invention. '055 Patent at 10:25-31 (“For reference, ‘Annex A’ which is of record in the identified provisional filing and incorporated by reference herein contains the PTM-TC of ADSL2 and VDSL2 systems as specified in the ITU-T G.992.3 ADSL2 standard.”); *see* TQD_TX-00001572-1584.

536. TS 125 322 discloses that the packets transferred in its system can comprise data packets. Additionally, a person having skill in the art would know that a cellular system such as the one of which TS 125 322 is a part can be used to transmit IP packets. A person having skill in the art would know that packet transfer mode-transmission convergence (and therefore PTM-TC codewords) can be utilized, and is often advantageous, in systems utilizing IP packets. Further, As explained above, various DSL standards as of the priority date required the use of PTM-TC codewords. See G.993.1, 143 (“In the transmit direction... [t]he corresponding TPS-TC (PTM-TC) receives the packet from the γ interface, encapsulates it into a special frame (PTM-TC frame) and maps into the PMS-TC frame (transmission frame) for transmission over the VDSL link”). Therefore, a person having ordinary skill in the art would have found it obvious to include

PTM-TC codewords in the first type of packet of TS 125 322.

537. A person having skill in the art would have been motivated to combine the teachings of TS 125 322 and G.993.1 because they are both standards that are directed to data transmission systems.

538. A person having skill in the art would have been motivated to combine the teachings of TS 125 322 and G.993.1 because they are both directed to data transmission systems that utilize similar core concepts. While TS 125 322 is directed to a RF physical layer and G.993.1 is directed to a copper physical layer, a person having ordinary skill in the art would be motivated to look to a variety of data transmissions systems in order to build a transceiver. Additionally, a person having skill in the art would have been motivated to look to G.993.1 to understand the types of packets that may be transmitted by the transceiver. The teachings of G.993.1 evidence that PTM-TC codewords were well-known in the art well before the date of the alleged invention of Claim 17. Additionally, a person having ordinary skill in the art at the relevant time would have been motivated to ensure that a transceiver could transmit a variety of types of packets. A person having ordinary skill in the art would have reasonably expected the use of PTM-TC codewords with the transceiver of TS 125 322 to be a successful design choice.

539. Thus, TS 125 322 in view of G.993.1 renders claim 17 obvious.

3. The '348 Patent

a. BI-089 in view of the knowledge of a POSA

(1) Independent Claim 9

(a) “An apparatus comprising:”

540. To the extent the preamble is limiting, this claim element is disclosed. BI-089 is entitled “ARQ for ADSL Transceivers.” BI-089 at 1. A POSA would have understood as of the '348 patent's priority date that ADSL transceivers are apparatuses.

(b) “a multicarrier transceiver including a processor and memory operable to:”

541. BI-089 is entitled “ARQ for ADSL Transceivers.” BI-089 at 1. A POSA would have understood as of the ’348 patent’s priority date that ADSL transceivers are multicarrier transceivers relying on discrete multitone (DMT) modulation, a form of multicarrier modulation. *See, e.g.*, G.992.1 at § 7.4.1 (“Up to four downstream simplet data channels and up to three duplex data channels shall be synchronized to the 4 kHz DMT frame rate, and multiplexed into two separate data buffers (fast and interleaved).”); *id.* at § 7.4.1.1 (“Each superframe is composed of 68 data frames, numbered from 0 to 67, which are encoded and modulated into DMT symbols...”).

542. A POSA would have understood that ADSL transceivers were communications devices capable of transmitting and receiving data wherein the transmitter portion and receiver portion shared at least some common circuitry. A POSA would have understood that the transmitter and receiver portion of an ADSL transceiver necessarily shared (at a minimum) an interface to the shared twisted pair over which communication took place. Additionally, it was common knowledge in the art that ADSL transceivers included shared circuitry between the transmitter and receiver, including for instance digital signal processors, analog front-end components and chips, and clock circuitry.

543. A POSA would have understood that the ADSL transceivers referenced in BI-089 included a processor. To the extent this element is not explicitly disclosed by BI-089, it would have been obvious to a POSA. In my experience, all ADSL transceivers include a processor. For instance, a POSA would have known that conventional modems, such as those in ADSL as well as wireless and analog modems, have long relied on digital signal processors. *See, e.g.*, Jacobsen, §11.6 (stating that “*DSL technology is becoming more and more based on software*

implementations on digital signal processors” (emphasis added)); Ayre, §2 (disclosing different types of modems capable of digital signal processing).

544. BI-089 discloses that the ADSL transceivers include memory. See, e.g., BI-089 at 1 (“the use of ARQ will reduce or eliminate the need for interleaving; thus, the memory and delay associated with interleaving can be reapplied to ARQ.”); *id.* at 3 (“the ARQ protocol does require memory at both the transmitter and receiver to buffer frames and this buffering introduces latency.”).

- (c) “receive a packet using a forward error correction decoder and a deinterleaver,”

545. BI-089 discloses the use of Reed-Solomon FEC in ADSL transceivers, and specifically in G.992.1 and G.992.1 transceivers. See, e.g., BI-089 at 1 (“The FEC scheme presently used in G.dmt and G.lite is based on the Reed-Solomon method.”). BI-089 also discloses ADSL transceivers capable of interleaving, and specifically that the use of ARQ can “reduce or eliminate the need for interleaving.” *Id.* at 1. Accordingly, BI-089 discloses that the ADSL transceivers are operable to receive a packet using a forward error correction decoder and a deinterleaver.

- (d) “wherein the packet comprises a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords, and”

- (i) “a header field”:

546. BI-089 describes an ARQ protocol which “require[s] memory at both the transmitter and receiver to buffer frames.” *Id.* at 3. A POSA would understand from this disclosure that the ARQ in BI-089 is a form of sliding-window ARQ: the transmitter sends a steady stream of packets and stores each transmit packet in memory until it receives an ACK for each one—i.e., that it is not of the stop-and-wait variety (which would require only a small amount

of memory for buffering an individual frame, not multiple frames). *See supra* § VII.D.3.a. Standard ARQ protocols of this variety had been known in the art since at least the 1980s. *See, e.g.,* Lin at 6-7; RFC 3366 at 7-8.

547. It is inherent in the ARQ described by BI-089 that each packet would necessarily comprise overhead information to allow the transmitter and receiver to identify which packets had been acknowledged and which had not. It was known in the art that in these kinds of ARQ approaches, each packet needed to include overhead information—specifically, a sequence ID—so that the transmitter and receiver could track which packets had been successfully received/ACKed and which had not, and so the receiver could put the packets back into the correct order. *See, e.g.,* Lin at 7 (noting that codewords must be identified by number for go-back-N or selective-repeat ARQ); RFC 3366 at 7-8 (“A protocol using sliding-window link ARQ... numbers every frame with a unique sequence number, according to a modulus... The modulus numbering space determines the size of the frame header sequence number field.”)

548. It was conventional in the art to put overhead information, including sequence IDs, into a header field. *See, e.g.,* G.992.1 (referred to by BI-089 as G.dmt), § 11.1.1 (describing AOC message header); RFC 3366 at 7-8; Fukushima at 10:54-66. Accordingly, a POSA would understand BI-089 to disclose that its packets include a header field, and would have found this limitation obvious to the extent not explicitly disclosed.

- (ii) *“a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords”:*

549. A POSA would have understood that at least the packets of BI-089 sent in the downstream direction would include a plurality of ATM cells. BI-089 references and presents its disclosures in the context of, among other things, G.992.1 (G.dmt), which defines ATM transport protocol specific functionalities. G.992.1, §§ 7.2, 8.2. A POSA would have understood as of the

priority date that ATM cells are 53 bytes long, which equates to 424 bits. A POSA would also have known that G.992.1 supports bit rates up to 6.144 Mbit/s, or 1536 bits per DMT symbol, in the downstream direction. G.992.1, § 6.2.

550. Accordingly, a POSA would have known that the G.992.1 ATU-C transmitters referred to in BI-089 would be operable to carry a plurality of ATM cells in each DMT symbol and, therefore, in each packet (referred to as “information frames” in BI-089). Likewise, a POSA would have known that the G.992.1 ATU-R receivers referred to in BI-089 would be operable to receive a packet comprising a header field and a plurality of ATM cells. Similarly, ADSL transceivers used Reed-Solomon codewords (*see, e.g.*, G.992.1 at § 7.6.1), and a POSA would therefore understand that the packets of BI-089 could include “a plurality of Reed-Solomon codewords.”

- (e) “wherein the header field comprises a sequence identifier (SID); and”

551. For the same reasons discussed above with respect to the “header field” limitation, a POSA would have understood a header field comprising a sequence identifier (SID) to be inherently disclosed by BI-089, or would have found it obvious in view of the knowledge in the art to the extent not disclosed.

- (f) “transmit a plurality of messages using a forward error correction encoder and without using an interleaver,”

552. BI-089 discloses the use of Reed-Solomon FEC in ADSL transceivers, and specifically in G.992.1 and G.992.2 transceivers. *See, e.g.*, BI-089 at 1 (“The FEC scheme presently used in G.dmt and G.lite is based on the Reed-Solomon method.”). As a POSA would have understood, G.992.1 transceivers are necessarily capable of using multiple framing modes, including framing structures 0 and 1, which are mandatory for ATM transport. *See* G.992.1 at §

6.2. As a POSA would also have understood, framing structures 0 and 1 provide both a fast path (FEC coding but no interleaving) and an interleaved path (FEC coding plus interleaving).

553. Accordingly, BI-089 inherently discloses ADSL transceivers that are both operable to transmit a plurality of messages using a forward error correction encoder and without using an interleaver, via the fast path included in all G.992.1 transceivers. To the extent not inherently disclosed, a POSA would have found this functionality to be obvious, as it was a standard functionality in ADSL transceivers (as G.992.1 is the relevant standard for ADSL transceivers).

(g) “wherein each message of the plurality of messages is transmitted in a different DMT symbol and”

554. A POSA would have understood that a G.dmt transceiver (e.g., an ATU-R), such as those disclosed in BI-089, would inherently be operable to transmit a plurality of messages in the upstream direction, wherein each message of the plurality of messages is transmitted in a different DMT symbol. A POSA would have understood that ATU-Rs operating in a conventional manner transmit a variety of messages in the upstream direction, and that, in operating in the ordinary and customary way, would transmit each message of some plurality of messages in a different DMT symbol. *See, e.g.*, G.992.1 at 7.4.1 (“Up to four downstream simplex data channels and up to three duplex data channels shall be synchronized to the 4 kHz ADSL DMT frame rate, and multiplexed into two separate data buffers (fast and interleaved)... The two data streams shall then be tone ordered as defined in 7.7, and combined into a data symbol that is input to the constellation encoder.”); *id.* at § 7.4.1.1 (“Each superframe is composed of 68 data frames, numbered from 0 to 67, which are encoded and modulated into DMT symbols...”); *id.* § 8.4.1 (“The ATU-R transmitter is functionally similar to the ATU-C transmitter, as specified in 7.4.1, except that up to three duplex data channels are synchronized to the 4 kHz ADSL DMT

symbol rate (instead of up to four simplex and three duplex channels as is the case for the ATU-C) and multiplexed into the two separate buffers (fast and interleaved).”); *id.* at 8.4.1.2 (“Each data frame shall be encoded into a DMT symbol” for the ATU-R); *id.* § 8.6 (showing parameter of “DMT symbols per RS codeword” for upstream transmission of ATU-R).

555. Accordingly, BI-089 inherently discloses this limitation. To the extent not disclosed, a POSA would have found it obvious, as this functionality was standard in G.dmt transceivers such as those referenced in BI-089.

- (h) “wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.”

556. BI-089 discloses that at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet. *See, e.g.*, BI-089 at 1 (“Any information frame with $\leq t$ errors will be corrected by t -FEC and a positive acknowledgement frame will be sent to the peer. For any frame with $> t$ errors, the CRC will detect the residual errors left after t -FEC, and a negative acknowledgement frame will be sent to the peer. These acknowledgement frames may be sent after every $m \geq 1$ information frames. Then the incorrectable information frame may be retransmitted if the maximum allowed number of transmissions has not been reached for that frame.”). A POSA would have recognized that the acknowledgement frames of BI-089 would be sent via the fast path of a G.dmt transceiver in order to reduce latency of the transmitter receiving it and thereby mitigate the potential for memory overrun.

557. In summary, BI-089 in view of the general knowledge of a POSA discloses each and every element of claim 9 and renders claim 9 obvious as a result.

(2) Dependent Claim 10

558. Claim 10 depends from claim 9 and further recites “wherein the transmitted messages have a higher immunity to noise than the received packet.”

559. The phrase “a higher immunity to noise” does not appear in the ’348 Patent’s specification or Figures. This phrase only appears in claims 2, 10, 18, and 24 at column 16, the ’348 Patent states: “the messages would have a higher immunity to *channel* noise.” *See* ’348 Patent, 16:04-08 (emphasis added). Accordingly, a POSA would understand that “higher immunity to noise” recited in claims 2, 8, 10, and 24 refers at least to channel noise, which is one of the categories of noise I discuss above. I understand that this Court has construed “higher immunity to noise” to have its plain meaning, and has not limited it to any specific feature of a particular disclosed embodiment in the ’348 patent. D.I. 169 at 97.

560. The ’348 patent’s specification recites:

The ACK and NAK messages sent back to the transmitting modem can be transmitted over the same physical channel i.e., phone line, in the opposite direction as the received packets. *Since the channel has a limited data rate and is not necessarily error-free, it is important to make sure that these messages are as robust as possible and consume the least amount of data rate. . . . There are several ways these requirements can be addressed.*

See ’348 Patent, 15:18-28 (emphasis added); *see also id.* 15:29-16:08.

561. A POSA would understand, from the preceding disclosures of the ’348 Patent, that the messages having a “higher immunity to noise” than the packet means the messages should be “as robust as possible” because the channel “is not necessarily error-free”, where the errors can occur due to channel noise. *Id.* The ’348 Patent’s “several ways” to provide higher immunity to noise include “repeating transmission of each message a number of times,” *see id.* 15:33-15, sending repeated message across several DMT symbols, *see id.* 15:39-41, sending a single message for multiple packets “using multiple packet count values,” *see id.* 15:62-64, and

increasing a margin of signal-to-noise ratio of the DMT sub carriers used for modulating the messages above six decibels (“dB”), or any combination thereof. *See id.*, 16:4-8.

562. It would have been obvious to a POSA that the control signals conveying the ACK and NACK messages of BI-089 would have a “higher immunity to noise” than the data packets transmitted. First, a POSA would understand that the control signals conveying ACK and NACK messages would necessarily have to be better protected than the messages that they are protecting, or the protocol would be pointless—in order to correct for errors in data packets caused by noise, the ACK and NACK messages must get through successfully, and therefore must have a higher immunity to noise. A POSA would be aware of multiple potential mechanisms of accomplishing this.

563. First, the ACK and NACK messages would likely have an intrinsically higher noise resistance simply because of their format. A POSA would understand that the ACK and NACK messages in BI-089’s multi-packet ARQ protocol would convey only a short field of information, rather than the large amount of information contained in a data packet. The chances of a short string being corrupted by a short noise burst is intrinsically much less than a long string being corrupted, so the ACK/NACK messages in BI-089 would inherently possess “higher immunity to noise” than the data packets being transmitted.

564. If this level of noise immunity proved insufficient, a POSA would be motivated to implement any standard method of increasing noise resistance for the ACK/NACK messages, such as transmitting constellation symbols with a greater distance from decision boundaries, transmitting the shorter messages with increased redundancy or with more error coding, or even with higher transmit power levels., and would have had a reasonable expectation of successfully creating a “higher immunity to noise” for the ACK/NACK messages.

565. In summary, BI-089 in view of the general knowledge of a POSA discloses each and every element of claim 10 and renders claim 10 obvious as a result.

b. G.993.1 and BI-089 in view of the knowledge of a POSA

(1) Motivation to Combine G.993.1 and BI-089

566. As of April 12, 2006, a POSA would have been motivated to incorporate the ARQ techniques disclosed in BI-089 into G.993.1 VDSL transceivers to provide those transceivers with an additional tool to combat impulse noise, which has been known to be problematic for DSL systems since the mid-1990s. The POSA would have recognized that, as taught by BI-089, for some connections, and for some kinds of services, ARQ could be used instead of interleaving, in one or both transmission directions, to provide better impulse noise immunity. BI-089 at § 5; *see supra* § VII.D.3.c. Because it was known in the art that ARQ introduces delay jitter, which some types of services cannot tolerate, the person having ordinary skill in the art would have added ARQ to G.993.1 as an additional technique, but not as a wholesale replacement for interleaving. *See, e.g.*, PF-042, §1.1; BI-066 at 2. Instead, to provide the flexibility to choose the right tool to combat burst errors caused by impulse noise, a POSA would have made ARQ one of the tools the transceivers could choose to use to combat impulse noise.

567. G.993.1 was developed to provide reliable, high-speed transmission at rates up to tens of Mbit/s under a wide variety of conditions. For example, it could be deployed from a central office or from a cabinet near subscriber premises. It was designed to allow both symmetric and asymmetric bit rates to be provided to subscribers, and it was expected to be able to “overcome many types of ingress interference from radio and other transmission techniques that occur in the same frequencies” used by VDSL. G.993.1, §1.

568. G.993.1 recognizes that impulse noise is a significant concern for VDSL. Specifically, G.993.1 states that “deep interleaving will be required to provide adequate protection

against impulse noise.” G.993.1, §5.1; *see also id.*, §11.3 (“G.993.1 systems shall provide protection against disturbance from impulse noise.”); *id.*, §14.2.6 (specifying an impulse noise model for testing of VDSL transceiver performance and stating that “[t]he impulse noise generator is required to prove the burst noise immunity of the VDSL transceiver.”).

569. BI-089 teaches that in the context of ADSL, despite the use of a noise margin that should be sufficiently high to eliminate the effects of random errors, “the data . . . occasionally gets corrupted” and that “it must be impulse noise causing burst errors.” BI-089, §3.

570. BI-089 teaches that “ARQ and interleaving are two common approaches to improving performance over a bursty channel,” where “[a] bursty channel is defined as a channel for which the noise between adjacent samples is correlated.” BI-089, §5. Whereas “[i]nterleaving attempts to remove the correlation between adjacent samples such that errors are distributed over multiple FEC frames, thereby increasing the likelihood of error correction,” “ARQ exploits channel correlation resulting in the confinement of burst errors.” *Id.*

571. BI-089 notes that “non-Gaussian bursts of errors can exceed the correction capabilities of FEC methods.” BI-089, §3. BI-089 teaches that “retransmitting a FEC frame corrupted by burst errors is preferable over spreading the errors across several adjacent frames and trying to correct them,” as interleaving does. *Id.*, §5. Thus, relative to interleaving, “[f]rom the information theoretic point of view, ARQ is the preferred method of burst error correction because of its ability to preserve and exploit the information in the noise correlation.” *Id.*, §5. Therefore, BI-089 proposes to add ARQ to ADSL because “ARQ is a natural and convenient method to fight the impulse noise.” *Id.*, §§3, 6.

572. A POSA as of the priority date would have recognized that the rationale in BI-089, described in the context of ADSL, would also apply to VDSL, which is a higher-speed version of

DSL that has many commonalities with ADSL.

573. Furthermore, a POSA as of the priority date would have understood that, as taught by BI-089, ARQ is an alternative to interleaving, and that, from an information theoretic point of view, ARQ is superior to interleaving in the presence of burst errors.

574. Thus, a POSA would have been motivated, based on the disclosures of BI-089, to include ARQ in the VDSL systems of G.993.1 in order to improve their performance in the presence of burst errors and impulse noise.

575. It was well known in the art as of the priority date that impulse noise is frequency-dependent, and therefore affects some frequencies more than others. *See, e.g.*, W. Henkel and T. Kessler, “A Wideband Impulsive Noise Survey in the German Telephone Network: Statistical Description and Modeling,” AEÜ, Vol. 48, 1994, No. 6, pp. 277-88 (“Henkel”) (survey of impulse noise at frequencies below 5 MHz); C.F. Valenti and K. Kerpez, “Analysis of wideband noise measurements and implications for signal processing in ADSL environments,” Proceedings of the IEEE International Conference on Communications, pp. 826 – 832, May 1994 (“Valenti”) (survey of impulse noise at frequencies below 1 MHz); K.J. Kerpez and A.M. Gottlieb, “The Error Performance of Digital Subscriber Lines in the Presence of Impulse Noise,” IEEE Trans. On Comms., Vol. 43, No. 5, pp. 1902-05, May 1995 (“Kerpez”) (survey of impulse noise at frequencies below 2 MHz). To my knowledge, as of the priority date, there was no survey data characterizing impulse noise at the higher frequency bands available to VDSL transceivers (e.g., up to 12 MHz). Therefore, as of the priority date, impulse noise remained a problematic impairment that was not well characterized in much of the bandwidth in which G.993.1 transceivers could operate (e.g., bandwidth up to 12 MHz). G.993.1, §1.

576. Therefore, a person having ordinary skill in the art would have been motivated to

provide, in G.993.1 VDSL transceivers, as much flexibility as possible and as many tools as possible to combat impulse noise. Based on the disclosures of BI-089, a person having ordinary skill in the art would have been motivated to add ARQ to the G.993.1 VDSL transceivers' suite of tools that could be used when appropriate to combat impulse noise.

577. It would have been straightforward for a person having ordinary skill in the art to add ARQ to G.993.1 VDSL transceivers. Adding ARQ to G.993.1 VDSL transceivers would merely have combined known methods that, in combination, would perform the same functions as they would separately. Although a POSA would likely have had to modify certain of the G.993.1 initialization messages to accommodate ARQ (e.g., to add fields that would indicate ARQ or interleaving, to indicate different parameter values, etc.), doing so would have been straightforward and well within the level of ordinary skill. A POSA would have been motivated to use the address field and/or control field in the G.993.1 PTM TPS-TC frame structure to indicate the order of packets being transmitted. Annex H.4.1.1

578. Moreover, allowing G.993.1 VDSL transceivers to use ARQ instead of interleaving in one or both directions of transmission would simply substitute one known method, ARQ, for another known method, interleaving, which is exactly what BI-089 suggests doing. BI-089 § 5. (noting that “[f]rom the information theoretic point of view, ARQ is the preferred method of burst error correction because of its ability to preserve and exploit the information in the noise correlation” and that “when ARQ is applied, interleaving [can] be reduced or eliminated thereby freeing memory resources for ARQ as well as to reduce or eliminate the interleaver delay so as to compensate for the delay introduced by ARQ”). ARQ was known in the art, and its effectiveness in mitigating burst errors was well known and is discussed at length in BI-089. *See id.*; *see also*, e.g., Lin at 6-7; RFC 3366 at 7-8. The results of substituting ARQ for interleaving

in G.993.1 VDSL transceivers would have been utterly predictable: improved performance in the presence of impulse noise at a cost of increased delay jitter, which would be a desirable trade-off for certain applications (e.g. for non-streaming applications such as email, text, or web browsing, where delay jitter would not cause any problems).

(2) Independent Claim 9

(a) “An apparatus comprising:”

579. To the extent the preamble is limiting, this claim element is disclosed and rendered obvious by the combination of G.993.1 and BI-089.

580. As discussed above, BI-089 discloses an “apparatus” in the form of ADSL transceivers. *Supra* § VIII.B.3.a.(1).(a).

581. G.993.1 also discloses an “apparatus.” Specifically, G.993.1 is entitled “Very high speed digital subscriber line transceivers,” and discloses multicarrier VDSL transceivers, which a POSA would understand to be an “apparatus.” G.993.1 at cover; § 8.5.1 (“A frame is a set of bytes carried by one DMT symbol.”); § 9.2.2 (“All transceivers shall start transmission of DMT frames at the same time.”).

(b) “a multicarrier transceiver including a processor and memory operable to:”

582. The combination of G.993.1 and BI-089 discloses “a multicarrier transceiver including a processor and memory,” and would render this limitation obvious to a POSA.

583. As discussed above, BI-089 discloses this limitation and/or renders it obvious. *Supra* § VIII.B.3.a.(1).(b).

584. G.993.1 also discloses “a multicarrier transceiver.” *See, e.g.*, G.993.1, § 8.5.1 (“A frame is a set of bytes carried by one DMT symbol.”); *id.* at § 9.2.2 (“All transceivers shall start transmission of DMT frames at the same time.”). As would have been recognized by a POSA,

DMT is a type of multicarrier modulation; accordingly, a G.993.1 transceiver that supports DMT is a multicarrier transceiver.

585. A POSA would have understood that DSL transceivers such as those described in G.993.1 were communications devices capable of transmitting and receiving data wherein the transmitter portion and receiver portion shared at least some common circuitry. A POSA would have understood that the transmitter and receiver portion of an DSL transceiver necessarily shared (at a minimum) an interface to the shared twisted pair over which communication took place. This interface is known as a “hybrid” or “hybrid transformer.” Additionally, it was common knowledge in the art that DSL transceivers included shared circuitry between the transmitter and receiver, including for instance digital signal processors, analog front-end components and chips, and clock circuitry.

586. G.993.1 discloses that its multicarrier transceivers include a processor. *See, e.g.*, G.993.1, § 7.2.2 (“transmit and receive timing signals (eoc_tx_clk, eoc_rx_clk): both asserted by the eoc processor;”); *id.* at § 10.3.2.3.3 (“Hold State (HOLD, 01): This message tells the VME-R to maintain the VTU-R eoc processor and any active VDSL eoc-controlled operations (such as latching commands) in their present state; Return to Normal (Idle Code) (RTN, F0): This message releases all outstanding eoc-controlled operations (latched conditions) at the VTU-R and returns the VDSL eoc processor to its initial state”).

587. In my experience, all ADSL and VDSL transceivers include a processor. To the extent this element is not explicitly disclosed by BI-089 or G.993.1, it would have been obvious to a POSA. For instance, a POSA would have known that conventional modems, such as those in ADSL and VDSL as well as wireless and analog modems, have long relied on digital signal processors. *See, e.g.*, Jacobsen, §11.6 (stating that “*DSL technology is becoming more and more*

based on software implementations on digital signal processors” (emphasis added)); Ayre, §2 (disclosing different types of modems capable of digital signal processing).

588. G.993.1 discloses that its multicarrier transceivers also include memory. *See, e.g.*, G.993.1, § 8.4.1 (“The convolutional interleaver uses a memory in which a block of I octets is written while an (interleaved) block of I octets is read. Details of the implementation are given in 8.4.2. The same size interleaving memory (see Table 8-1) is needed for interleaving at the transmitter and de-interleaving at the receiver.”); *id.* at Table 12-32 (“Maximal interleaver memory”).

(c) “receive a packet using a forward error correction decoder and a deinterleaver,”

589. The combination of G.993.1 and BI-089 discloses a transceiver operable to “receive a packet using a forward error correction decoder and a deinterleaver,” and would render this limitation obvious to a POSA.

590. As discussed above, BI-089 discloses this limitation and/or renders it obvious. *Supra* § VIII.B.3.a.(1).(c).

591. G.993.1 also discloses that the multicarrier transceivers are operable to receive a packet using a forward error correction decoder and a deinterleaver. *See, e.g.*, G.993.1, §§ 8.3, 8.4, FIG. 8-1 (slow path).

(d) “wherein the packet comprises a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords, and”

592. The combination of G.993.1 and BI-089 discloses a “packet compris[ing] a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords,” and would render this limitation obvious to a POSA.

593. As discussed above, BI-089 discloses this limitation and/or renders it obvious.

Supra § VIII.B.3.a.(1).(d).

594. G.993.1 also discloses and/or renders obvious that the packet comprises a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords.

595. G.993.1 discloses a PTM-TC for packetized data transport. *See, e.g.*, G.992.1, Annex H. The PTM-TC accepts packets from a PTM entity. *Id.* at § H.1.1. The PTM-TC encapsulates the packet into a special frame, called a PTM-TC frame and maps it into a PMC-TC frame for transmission over a VDSL link. *Id.* As would be understood by a POSA, the packet received from the PTM entity could include any payload, including, for example, a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords. *See, e.g.*, G.993.1 § 8.3 (recommending use of “a standard byte-oriented Reed-Solomon code” in PMS-TC sublayer); G.993.1 § 7 (“The physical layer shall be able to transport at least one of ATM or PTM signals”); G.993.1 Annex G.4.1.1 (data flow for ATM-TC in G.993.1 “consists of two streams of 53 octet ATM cells each (Tx_ATM, Tx_ATM) with independent rates flowing in opposite directions”).

596. G.993.1 discloses a PTM-TC frame format for use in both the downstream and upstream directions. G.993.1, § H.4. The frame format includes an information field that “shall be filled with the transported data packet” received from the PTM entity. *Id.* at § H.4.1.1. The PTM-TC frame format includes opening and closing Flag Sequences that identify the start and end of the frame, and “Address and Control octets . . . intended for auxiliary information.” *Id.* A POSA would recognize that the opening flag sequence, the address field, and the control field are a header field.

(e) “wherein the header field comprises a sequence identifier (SID); and”

597. The combination of G.993.1 and BI-089 discloses a “header field compris[ing] a sequence identifier (SID),” and would render this limitation obvious to a POSA.

598. As discussed above, BI-089 discloses this limitation and/or renders it obvious—its ARQ system inherently requires a sequence identifier, and the conventional place to include this information would have been in a header field. *Supra* § VIII.B.3.a.(1).(d).

599. Additionally, G.993.1 discloses that “Address and Control octets are intended for auxiliary information.” G.993.1, § H.4.1.1. As noted above, a POSA would recognize that the opening flag sequence, the address field, and the control field are a header field. A POSA would have recognized that the Address and/or Control fields in the PTM-TC frame structure of G.993.1 could be used for the sequence identifier (SID) inherently required by the ARQ described in BI-089. *See, e.g.*, G.993.1, § H.4.1.1 (“The Address and Control octets are intended for auxiliary information.”).

600. As such, a POSA would find it obvious based on G.993.1 and BI-089 to include a “header field compris[ing] a sequence identifier (SID).”

(f) “transmit a plurality of messages using a forward error correction encoder and without using an interleaver,”

601. The combination of G.993.1 and BI-089 discloses a transceiver operable to “transmit a plurality of messages using a forward error correction encoder and without using an interleaver,” and would render this limitation obvious to a POSA.

602. As discussed above, BI-089 discloses this limitation and/or renders it obvious. *Supra* § VIII.B.3.a.(1).(f).

603. G.993.1 also discloses this limitation. G.993.1 discloses that the PTM-TC

functionality can be used over the slow channel or the fast channel. *See, e.g.*, G.993.1, § H.1.1; *see also id.* at § H.2 (“The PTM transport could be arranged using either Slow channel or Fast channel or both. . . . The mandatory configuration for packet transport shall include one PTM-TC (either Fast or Slow). the second PTM-TC is optional.”); *id.* at § 10.5.2.3 (“The PTM transport anomalies, defects and failures shall be supported by the PTM-TC. If both the Fast and Slow PTM channels are established, the two corresponding PTM-TC shall be represented by two equal and independent sets of anomalies, defects and failure.”).

604. The slow channel includes both forward error correction (FEC) coding and interleaving, and the fast channel includes FEC coding and no interleaving. *Id.*, §§ 8.3, 8.4.1. Accordingly, G.993.1 discloses that the transceiver is operable to transmit a plurality of messages using a forward error correction encoder and without using an interleaver.

(g) “wherein each message of the plurality of messages is transmitted in a different DMT symbol and”

605. The combination of G.993.1 and BI-089 discloses the limitation “wherein each message of the plurality of messages is transmitted in a different DMT symbol,” and would render this limitation obvious to a POSA.

606. As discussed above, BI-089 discloses this limitation and/or renders it obvious. *Supra* § VIII.B.3.a.(1).(g).

607. Additionally, a POSA would have understood that a G.993.1 VTU-R transceiver would be operable to transmit a plurality of messages in the upstream direction, wherein each message of the plurality of messages is transmitted in a different DMT symbol and, likewise, that a G.993.1 VTU-O transceiver would be operable to transmit a plurality of messages in the downstream direction, wherein each message of the plurality of messages is transmitted in a different DMT symbol. A POSA would have understood that VTU-Os and VTU-Rs operating in

a conventional manner transmit a variety of messages, and that, in operating in the ordinary and customary way, would transmit each message of some plurality of messages in a different DMT symbol.

- (h) “wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.”

608. The combination of G.993.1 and BI-089 discloses a transceiver operable to transmit messages “wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet,” and would render this limitation obvious to a POSA.

609. As discussed above, BI-089 discloses this limitation and/or renders it obvious—it discloses a system requiring transmission of positive and negative acknowledgement frames. *Supra* § VIII.B.3.a.(1).(h); BI-089 at 1. A POSA would have recognized that the acknowledgement frames of BI-089 would be sent via the fast path of a G.993.1 transceiver in order to reduce latency of the transmitter receiving it and thereby mitigate the potential for memory overrun.

610. In summary, the combination of G.993.1 and BI-089, in view of the knowledge of a POSA, discloses each and every element of claim 9 and renders claim 9 obvious as a result.

(3) Dependent Claim 10

611. Claim 10 depends from claim 9 and further recites “wherein the transmitted messages have a higher immunity to noise than the received packet.”

612. As I discuss above, I understand that this Court has construed “higher immunity to noise” to have its plain meaning, and has not limited it to any specific feature of a particular disclosed embodiment in the ’348 patent. D.I. 169 at 97.

613. For the same reasons discussed above, it would have been obvious to a POSA that the control signals conveying the ACK and NACK messages of BI-089 would have a “higher immunity to noise” than the data packets transmitted, and a POSA would have known how to accomplish this. *Supra* § VIII.B.3.a.(2).

614. In summary, G.993.1 and BI-089 in view of the general knowledge of a POSA discloses each and every element of claim 10 and renders claim 10 obvious as a result.

c. Fukushima and G.993.1

(1) Motivation to Combine Fukushima and G.993.1

615. As of April 12, 2006, a POSA would have been motivated to combine G.993.1 with Fukushima so as to improve G.993.1’s communication protocol. These two references are in the same or closely related fields. In particular, G.993.1 discloses that it “permits the transmission of asymmetric and symmetric aggregate data rates up to tens of Mbit/s on twisted pairs.” G.993.1 at i (Summary). In a closely related field, Fukushima discloses “data transmission methods, data transmission apparatuses, data receiving apparatuses, and a packet data structure.” Fukushima, 1:14-20.

616. G.993.1 discloses a model of “packetized data transport,” PTM-TC (G.993.1 § H.1.1), with packets (“frames”) containing a header and a payload. G.993.1 at 146, § H.4.1.1. Similarly, Fukushima explicitly states that “[e]ach packet transmitted from the transmitting end is composed of a data section containing digital data such as video data, audio data, and text data, and *a header section containing additional information other than these digital data.*” Fukushima, 15:02-10 (emphasis added).

617. Fukushima addresses the more difficult problem of communications over a wireless network, but is based on extending the backbone Internet over that wireless access network. *See, e.g.* Fukushima at 1:22-2:20, 13:32-39, 14:28-35. G.993.1 similarly extends

backbone Internet connections over a DSL (specifically VDSL) access network. A POSA interested in dealing with the problems of communications reliability would have been motivated to see how Fukushima solved the harder wireless problem, where the rapidly changing fading and impulse noise environment create more severe problems than the far more benign DSL environment, and incorporate its disclosures into a DSL system to improve noise resistance.

618. Further, Fukushima refers to an Internet connection between a distribution server and a terminal using a modem, ISDN, or LAN. Fukushima at 1:46. A POSA would recognize that the modem referred to in Fukushima could be a cable modem, an analog modem, or a DSL modem (including a VDSL modem), and would look to G.993.1 for an understanding of how the systems of Fukushima would work in conjunction with a VDSL modem.

619. A POSA would have been motivated to combine G.993.1 and Fukushima, both of which disclose similar data communication techniques and systems for data communication, because a POSA would have readily recognized the predictable benefits of the combination, such as providing improvements such as use of user data acknowledgements, and packets with message counts and/or sequence IDs. For example, to the extent that G.993.1 may not explicitly disclose requests for user data retransmission, a POSA would have understood that G.993.1's communication protocol could be improved using Fukushima's retransmission requests.

620. To a POSA, this combination would have been nothing more than combining prior art elements according to known methods (information transmission using acknowledgement messages and packets) to obtain the predictable results described above. A POSA would have also understood this combination to be the use of a known technique (multi-carrier DMT transmission) to improve a similar process (G.993.1's) in the same way as Fukushima describes, or applying a known technique (e.g., use of packets and retransmission requests that Fukushima

discloses) to a known process (G.993.1's) that is ready for improvement, or a simple substitution (of G.993.1's generic packets, to the extent they lack headers, with Fukushima's packets having specific headers), to yield predictable results described above.

621. Additionally, one of ordinary skill in the art would have understood that these predictable, beneficial results can be obtained without requiring substantial changes or modifications to G.993.1's or Fukushima's techniques, and without adversely affecting the data communication performed according to these techniques. A POSA would have also been able to apply known, conventional data communication techniques, such as back and forth transmission and reception of signals between two connected devices, to perform the necessary modifications. As such, a POSA would have expected the combination of Fukushima and G.993.1 to succeed. For these reasons, it would have been obvious to a POSA to combine G.993.1 and Fukushima.

(2) Independent Claim 9

(a) "An apparatus comprising:"

622. To the extent the preamble is limiting, this claim element is disclosed and rendered obvious by the combination of Fukushima and G.993.1.

623. As discussed above, G.993.1 discloses an "apparatus," specifically multicarrier VDSL transceivers. *Supra* § VIII.B.3.b.(2).(a).

624. Fukushima also discloses this limitation. Specifically, Fukushima discloses a "data transmission apparatus"—such as a "distribution server"—that receives data, "encodes the data and outputs the coded data in packet units." *See* Fukushima, 14:41-15:50.

(b) "a multicarrier transceiver including a processor and memory operable to:"

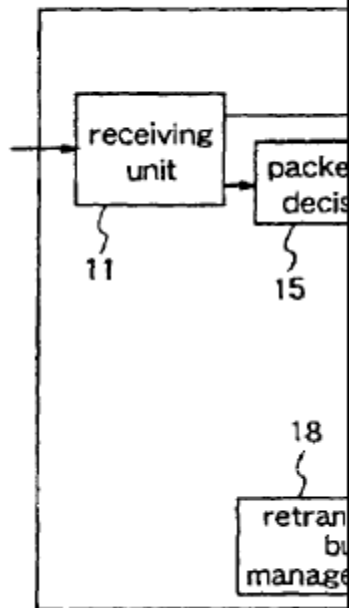
625. The combination of Fukushima and G.993.1 discloses "a multicarrier transceiver including a processor and memory," and would render this limitation obvious to a POSA.

626. As discussed above, G.993.1 discloses “a multicarrier transceiver including a processor and memory,” specifically a VDSL transceiver. *Supra* § VIII.B.3.b.(2).(b).

627. Fukushima also discloses this limitation. First, describes the prior art as including standard Internet modems, which a POSA would understand could include multicarrier transceivers such as DSL transceivers. *See* Fukushima at 1:43-48; *id.* at Fig. 28(a). A POSA would have understood that DSL transceivers were communications devices capable of transmitting and receiving data wherein the transmitter portion and receiver portion shared at least some common circuitry, for the same reasons described above with respect to G.993.1. *Supra* § VIII.B.3.b.(2).(b).

628. Fukushima describes its invention as including “data transmission apparatuses” capable of transmitting and receiving data. *See* Fukushima at 11:32-35; *id.* at Fig. 1. Fig. 1(a) illustrates that the “data transmission apparatus” can both transmit data (through “the transmission unit”) and receive data (through the “retransmission instruction receiving unit”):

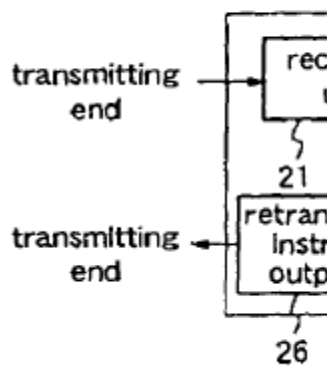
Fig.1 (a)



Id. Fig. 1(a).

629. Fukushima further describes a “data receiving apparatus,” which is also capable of transmitting and receiving data. *See, e.g.*, Fukushima 15:51-16:5 (“data receiving apparatus” “includes a receiving unit” and a “retransmission instruction output unit” which “outputs a request for retransmitting..., toward the transmitting end”). Fukushima depicts an example of a “data receiving apparatus” in Figure 2:

Fig.2



Fukushima Fig. 2.

630. A POSA would have understood that the “data transmission apparatus” in Fukushima contained shared circuitry between the transmitter portion and receiver portion, and would have found this limitation obvious to the extent not explicitly disclosed. For instance, Fukushima describes the application of its invention to wireless WCDMA networks. Fukushima at 1:57-2:6. A POSA would understand that the practical implementation of wireless devices, such as WCDMA devices, involved the design of radio transceivers, incorporating shared circuitry between the transmitter and receiver sections of the devices. For instance, these shared circuits would typically include power supplies, clock and frequency generations circuits, user interfaces, and shielding, filtering, and other circuits. A POSA would also have found it obvious that the apparatus of Fukushima could be implemented within a DSL transceiver, which was understood to include shared circuitry as discussed above.

631. A POSA would have understood that the “data transmission apparatus” in Fukushima to include a processor, and would have found this limitation obvious to the extent not explicitly disclosed. In my experience, all DSL transceivers include a processor. For instance, a POSA would have known that conventional modems, such as those in ADSL as well as wireless

and analog modems, have long relied on digital signal processors. *See, e.g.,* Jacobsen, §11.6 (stating that “*DSL technology is becoming more and more based on software implementations on digital signal processors*” (emphasis added)); Ayre, §2 (disclosing different types of modems capable of digital signal processing). Fukushima refers to the use of standard modems, and it would have been obvious to implement Fukushima’s apparatus within a modem, which would involve the use of a digital signal processor.

(c) “receive a packet using a forward error correction decoder and a deinterleaver.”

632. The combination of Fukushima and G.993.1 discloses a transceiver operable to “receive a packet using a forward error correction decoder and a deinterleaver,” and would render this limitation obvious to a POSA.

633. As discussed above, G.993.1 discloses multicarrier transceivers operable to receive a packet using a forward error correction decoder and a deinterleaver. *Supra* § VIII.B.3.b.(2).(c).

634. Fukushima also discloses that its transceivers are operable to transmit and receive packets using FEC. Specifically, Fukushima discloses that, “at the transmitting end, each packet to be transmitted is given *error correction codes* for the additional information relating to its sequence number, priority, etc.” *Id.* Furthermore, “[a]t the receiving end, the additional information is subjected to *error correction according to the error correction codes* and, thereafter, *a retransmission request for the error packet is made in accordance with the additional information.*” (emphasis added). *See id.* 17:59-18:32. More specifically, each packet’s additional information is “*required for real-time transmission of each packet data.*” *See id.* 13:32-39 (emphasis added); *see also, e.g.,* Fukushima, 26:45-28:34 (indicating that at least two of CRC coding, FEC, and retransmission may be used together).

635. To the extent Fukushima does not explicitly disclose interleaving, a POSA would find it obvious to use interleaving in any DSL system incorporating Fukushima's methods. Interleaving has been standard functionality in all DSL systems since the inception of DSL, including in G.993.1, and a POSA would have found it obvious to include in any DSL system. G.993.1 §§ 8.3, 8.4, Fig. 8-1; *see also supra* § VIII.B.3.b.(2).(c).

- (d) “wherein the packet comprises a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords, and”

636. The combination of Fukushima and G.993.1 discloses a “packet compris[ing] a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords,” and would render this limitation obvious to a POSA.

637. As discussed above, G.993.1 discloses and/or renders obvious packets comprising a header field and a plurality of PTM-TC codewords, a plurality of ATM cells or a plurality of Reed-Solomon codewords. *Supra* § VIII.B.3.b.(2).(d).

638. Fukushima also discloses packets comprising a “header field.” Specifically, Fukushima discloses that “[e]ach packet transmitted from the transmitting end is composed of a data section containing digital data such as video data, audio data, and text data, and *a header section containing additional information other than these digital data.*” *See* Fukushima, 15:02-10 (emphasis added). A POSA would understand that the Fukushima's header section constitutes or is equivalent to the “header field” set forth by this claim element.

- (a) “wherein the header field comprises a sequence identifier (SID); and”

639. The combination of Fukushima and G.993.1 discloses a “header field compris[ing] a sequence identifier (SID),” and would render this limitation obvious to a POSA.

640. Fukushima discloses this claim element. Fukushima discloses that “[e]ach packet

transmitted from the transmitting end is composed of a data section containing digital data such as video data, audio data, and text data, and *a header section* containing additional information other than these digital data.” *See* Fukushima, 15:2-10 (emphasis added). Fukushima further discloses that “*the header section of each packet contains additional information relating to its sequence number, priority, and data reproduction time at the receiving end.*” *See id.* (emphasis added). A POSA would understand that Fukushima’s “sequence number” in a packet’s “header section” constitutes or is equivalent to a “header field compris[ing] a sequence identifier (SID),” as set forth by this claim element.

641. As discussed above, G.993.1 discloses the Address and Control fields “intended for auxiliary information,” and a POSA would have known that a sequence identifier could be included in those fields. *Supra* § VIII.B.3.b.(2).(e).

642. As such, a POSA would have found it obvious based on G.993.1 and Fukushima to include a “header field compris[ing] a sequence identifier (SID).”

(b) “transmit a plurality of messages using a forward error correction encoder and without using an interleaver,”

643. The combination of Fukushima and G.993.1 discloses a transceiver operable to “transmit a plurality of messages using a forward error correction encoder and without using an interleaver,” and would render this limitation obvious to a POSA.

644. As discussed above, G.993.1 discloses systems that can transmit a plurality of messages using FEC but not interleaving, including the slow channel for PTM-TC. *Supra* § VIII.B.3.b.(2).(f).

645. Fukushima discloses various “data-receiving apparatus[es]” containing a “retransmission instruction output unit,” which send retransmission request messages to the transmitting apparatus. *See, e.g.,* Fukushima at 15:61-16:5 (“[T]he data receiving apparatus...

includes... a retransmission instruction output unit” which “outputs a request for retransmitting [an] error packet... toward the transmitting end, by indicating the sequence number of the error packet”). A POSA implementing Fukushima’s methods in a DSL system such as G.993.1 would have found it obvious to include the capability of transmitting messages using FEC but not interleaving, such as the slow channel in G.993.1. In particular and as detailed above, interleaving spreads burst errors across a longer time interval, which improving the chances that FEC can correct the resulting isolated errors but also increases latency. The hostile radio channel that Fukushima addresses is subject to noise bursts and potentially very slow random fading, which would require a very, very high interleaver latency. A POSA would recognize that where latency is a limiting factor, interleaving would need to be minimized or avoided, requiring other techniques to insure robust performance.

- (c) “wherein each message of the plurality of messages is transmitted in a different DMT symbol and”

646. The combination of Fukushima and G.993.1 discloses the limitation “wherein each message of the plurality of messages is transmitted in a different DMT symbol,” and would render this limitation obvious to a POSA.

647. As discussed above, G.993.1 discloses this limitation. *Supra* § VIII.B.3.b.(2).(g). A POSA implementing Fukushima’s methods in a DSL system such as G.993.1 would have found it obvious to include the capability of transmitting messages, where each message is transmitted in a different DMT symbol. For example, depending on the number and sizes of messages, a POSA would have recognized that it might be impossible to fit them all in a single DMT symbol. In addition, a POSA would have understood that separate DMT symbols would provide diversity in time and frequency, which would mitigate the impact of noise or interference that are time and frequency bound, and thereby enhance the chances of successful transmission.

- (d) “wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.”

648. The combination of Fukushima and G.993.1 discloses a transceiver operable to transmit messages “wherein at least one message of the plurality of messages includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet,” and would render this limitation obvious to a POSA.

649. As discussed above, Fukushima discloses various “data-receiving apparatus[es]” containing a “retransmission instruction output unit,” which send retransmission request messages to the transmitting apparatus. *See, e.g.*, Fukushima at 15:61-16:5 (“[T]he data receiving apparatus... includes... a retransmission instruction output unit” which “outputs a request for retransmitting [an] error packet... toward the transmitting end, by indicating the sequence number of the error packet”). A POSA would understand the “retransmission request” messages in Fukushima to be a negative acknowledgement (NACK) of the received packet, as these messages indicate to the transmitting system that the packet was not successfully received.

650. In summary, G.993.1 and Fukushima in view of the general knowledge of a POSA disclose each and every element of claim 9 and render claim 9 obvious as a result.

(3) Dependent Claim 10

651. Claim 10 depends from claim 9 and further recites “wherein the transmitted messages have a higher immunity to noise than the received packet.” The combination of Fukushima and G.993.1 discloses this limitation, and would render the limitation obvious to a POSA.

652. As I discuss above, I understand that this Court has construed “higher immunity to noise” to have its plain meaning, and has not limited it to any specific feature of a particular

disclosed embodiment in the '348 patent. D.I. 169 at 97; *supra* § VIII.B.3.b.(3).

653. For the same reasons discussed above with respect to BI-089, it would have been obvious to a POSA that the control signals conveying the NACK messages of Fukushima (i.e., its retransmission requests) would have a “higher immunity to noise” than the data packets transmitted, and a POSA would have known how to accomplish this. *Supra* § VIII.B.3.a.(2).

654. Additionally, Fukushima gives an example of how to increase the noise resistance of its NACK messages. Fukushima discloses embodiments where its transmitted messages, or “retransmission requests,” are consecutively transmitted multiple times to increase their immunity to noise. Fukushima at 45:22-39 (“[T]he retransmission instruction consecutive output unit **93** performs a consecutive retransmission process for consecutively transmitting the retransmission request by several times... [W]hen many transmission errors occur in the radio section, the number of request transmission times is increased. Thereby, the probability of normal transmission of the retransmission request to the transmitting end increases.”); *see id.* at 45:63-46:6. A POSA would understand that these transmitted messages in Fukushima would have a higher immunity to noise than the received packets in Fukushima.

655. In summary, G.993.1 and Fukushima in view of the general knowledge of a POSA disclose each and every element of claim 10 and render claim 10 obvious as a result.

4. The '809 Patent

a. G.993.1 and BI-089 in view of the knowledge of a POSA

(1) Motivation to Combine

656. For the same reasons discussed above with respect to the '348 patent, a POSA would have been motivated to combine the disclosures of G.993.1 and BI-089 by adding BI-089's proposed ARQ functionality as an option to the G.993.1 standard, and would have expected success in doing so. *Supra* § VIII.B.3.b.(1).

(2) Independent Claim 8

(a) “An apparatus comprising:”

657. As I discuss above with respect to the '348 patent, the combination of G.993.1 and BI-089 discloses an “apparatus,” and renders this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(a).

(b) “a multicarrier transceiver including a processor and memory capable of:”

658. As I discuss above with respect to the '348 patent, the combination of G.993.1 and BI-089 discloses a “multicarrier transceiver including a processor and memory,” and renders this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(b).

(c) “receiving a packet using forward error correction decoding and deinterleaving,”

659. As I discuss above with respect to the '348 patent, the combination of G.993.1 and BI-089 discloses multicarrier transceivers that can receive packets using forward error correction decoding and deinterleaving. *Supra* § VIII.B.3.b.(2)(c).

660. The combination of G.993.1 and BI-089 therefore discloses a multicarrier transceiver “capable of receiving a packet using forward error correction decoding and deinterleaving” and renders this limitation obvious to a POSA.

(d) “wherein the packet comprises a header field and a plurality of Reed-Solomon codewords, and”

661. The combination of G.993.1 and BI-089 discloses and/or renders this limitation obvious. Specifically, G.993.1 discloses and/or renders obvious that the packet comprises a header field and a plurality of Reed-Solomon codewords.

662. G.993.1 discloses a PTM-TC for packetized data transport. *See, e.g.*, G.992.1, Annex H. The PTM-TC accepts packets from a PTM entity. *Id.* at § H.1.1. The PTM-TC encapsulates the packet into a special frame, called a PTM-TC frame and maps it into a PTM-TC

frame for transmission over a VDSL link. *Id.* As would be understood by a POSA, the packet received from the PTM entity could include any payload, including, for example, a plurality of Reed-Solomon codewords. *See, e.g.,* G.993.1 § 8.3 (recommending use of “a standard byte-oriented Reed-Solomon code” in PMS-TC sublayer).

663. G.993.1 discloses a PTM-TC frame format for use in both the downstream and upstream directions. G.993.1, § H.4. The frame format includes an information field that “shall be filled with the transported data packet” received from the PTM entity. *Id.* at § H.4.1.1. The PTM-TC frame format includes opening and closing Flag Sequences that identify the start and end of the frame, and “Address and Control octets . . . intended for auxiliary information.” *Id.* A POSA would recognize that the opening flag sequence, the address field, and the control field are a header field.

(e) “wherein the header field comprises a sequence identifier (SID); and”

664. As I discuss above with respect to the ’348 patent, the combination of G.993.1 and BI-089 discloses a “header field compris[ing] a sequence identifier (SID),” and would render this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(e).

(f) “transmitting a message using forward error correction encoding and without using interleaving,”

665. As I discuss above with respect to the ’348 patent, the combination of G.993.1 and BI-089 discloses multicarrier transceivers capable of transmitting messages using forward error correction and without using interleaving. *Supra* § VIII.B.3.b.(1)(f). BI-089 and G.993.1 therefore disclose the limitation of “transmitting a message using forward error correction encoding and without using interleaving,” and render this limitation obvious to a POSA.

(g) “wherein the message is transmitted in a single DMT symbol and”

666. BI-089 and G.993.1 disclose the limitation “wherein the message is transmitted in a single DMT symbol,” and render this limitation obvious to a POSA.

667. As I discuss above with respect to the ’348 patent, BI-089 and G.993.1 disclose transceivers that can transmit messages in a single DMT symbol. *Supra* § VIII.B.3.b.(1)(g). This limitation is therefore obvious.

(h) “wherein the message includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.”

668. As I discuss above with respect to the ’348 patent, the combination of G.993.1 and BI-089 discloses a “message include[ing] an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet,” and would render this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(h).

669. In summary, the combination of G.993.1 and BI-089 discloses each and every element of claim 8, and renders claim 8 obvious as a result.

(3) Dependent Claim 11

670. Claim 11 further recites:

11. The apparatus of claim 8, wherein a physical layer of the transceiver is capable of generating the packet and the message.

671. The ’809 patent does not explain what it means by “generating the packet and the message.” However, I understand that Plaintiffs have taken the position that the retransmission function of the PMS-TC sub-layer in the ITU-T G.9701 G.fast Standard and/or the “physical layer retransmission method” in the ITU-T G.998.4 G.inp Standard meet the limitation that “a physical layer of the transceiver is capable of generating the packet and the message.” Plaintiffs’ Claim Chart for U.S. Patent No. 10,833,809 (G.9701) at 52-54; Plaintiffs’ Claim Chart for U.S. Patent

No. 10,833,809 (G.998.4) at 57.

672. I take no position in this Report as to whether these functionalities in G.9701 or G.998.4 meet this limitation, and reserve the right to respond to any infringement opinions put forth in Plaintiffs' forthcoming expert reports on infringement. However, to the extent that the identified functionalities in G.9701 or G.998.4 meet this limitation, this limitation would have been obvious to a POSA in view of G.993.1, BI-089, and the general knowledge of a POSA.

673. Like G.9701, G.993.1 contains a PMS-TC layer, where data may undergo forward error correction (FEC) encoding/decoding and interleaving / deinterleaving. *See* G.993.1 §§8-8.4. Both the "packet" and the "message" in independent claim 8 use forward error correction coding, a process which "generates" the final set of bits to be transmitted in the packet and the message (i.e., by adding FEC bits). *See* '809 packet claim 8. In this sense, the PMS-TC layer of G.993.1 is a "physical layer" that "generates" the packet and the message, in the same sense that Plaintiffs seem to use the term for the purpose of their infringement contentions, and therefore renders this limitation obvious.

674. In summary, G.993.1 and BI-089 in view of the general knowledge of a POSA disclose each and every element of claim 11 and render claim 11 obvious as a result.

(4) Dependent Claim 13

675. Claim 13 depends from claim 9, which depends from claim 8. Claims 9 and 13 recite:

9. The apparatus of claim 8, wherein the transmitted message has a higher immunity to noise than the received packet.

13. The apparatus of claim 9, wherein a physical layer of the transceiver is capable of generating the packet and the message.

676. The "higher immunity to noise" limitation would have been obvious over G.993.1 and BI-089 for the same reasons discussed above with respect to the identical limitation in claim

10 of the '348 patent. *Supra* § VIII.B.3.b.(3). The “physical layer” limitation would have been obvious over G.993.1 and BI-089 for the same reasons discussed above with respect to the identical limitation in claim 11 of the '809 patent. *Supra* § VIII.B.4.a.(3).

677. In summary, G.993.1 and BI-089 in view of the general knowledge of a POSA disclose each and every element of claim 13 and render claim 13 obvious as a result.

b. G.993.1 and Fukushima in view of the knowledge of a POSA

(1) Motivation to Combine

678. For the same reasons discussed above with respect to the '348 patent, a POSA would have been motivated to combine the disclosures of G.993.1 and Fukushima, and would have expected success in doing so. *Supra* § VIII.B.3.b.(1).

(2) Independent Claim 8

(a) “An apparatus comprising:”

679. As I discuss above with respect to the '348 patent, the combination of G.993.1 and Fukushima discloses an “apparatus,” and renders this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(a).

(b) “a multicarrier transceiver including a processor and memory capable of:”

680. As I discuss above with respect to the '348 patent, the combination of G.993.1 and Fukushima discloses a “multicarrier transceiver including a processor and memory,” and renders this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(b).

(c) “receiving a packet using forward error correction decoding and deinterleaving,”

681. As I discuss above with respect to the '348 patent, the combination of G.993.1 and Fukushima discloses multicarrier transceivers that can receive packets using forward error correction decoding and deinterleaving. *Supra* § VIII.B.3.b.(2)(c).

682. The combination of G.993.1 and Fukushima therefore discloses a multicarrier transceiver “capable of receiving a packet using forward error correction decoding and deinterleaving” and renders this limitation obvious to a POSA.

(d) “wherein the packet comprises a header field and a plurality of Reed-Solomon codewords, and”

683. The combination of G.993.1 and Fukushima discloses and/or renders this limitation obvious. Specifically, as I discuss above with respect to claim 8 of the ’809 patent in view of G.993.1 and BI-089, G.993.1 discloses and/or renders obvious that the packet comprises a header field and a plurality of Reed-Solomon codewords. *Supra* § VIII.B.4.a.(2)(d).

(e) “wherein the header field comprises a sequence identifier (SID); and”

684. As I discuss above with respect to the ’348 patent, the combination of G.993.1 and Fukushima discloses a “header field compris[ing] a sequence identifier (SID),” and would render this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(e).

(f) “transmitting a message using forward error correction encoding and without using interleaving,”

685. As I discuss above with respect to the ’348 patent, the combination of G.993.1 and Fukushima discloses multicarrier transceivers capable of transmitting messages using forward error correction and without using interleaving. *Supra* § VIII.B.3.b.(2)(f). Fukushima and G.993.1 therefore disclose the limitation of “transmitting a message using forward error correction encoding and without using interleaving,” and render this limitation obvious to a POSA.

(g) “wherein the message is transmitted in a single DMT symbol and”

686. Fukushima and G.993.1 disclose the limitation “wherein the message is transmitted in a single DMT symbol,” and render this limitation obvious to a POSA.

687. As I discuss above with respect to the '348 patent, Fukushima and G.993.1 disclose transceivers that can transmit messages in a single DMT symbol. *Supra* § VIII.B.3.b.(2)(g).

(h) “wherein the message includes an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet.”

688. As I discuss above with respect to the '348 patent, the combination of G.993.1 and Fukushima discloses a “message include[ing] an acknowledgement (ACK) or a negative acknowledgement (NACK) of the received packet,” and would render this limitation obvious to a POSA. *Supra* § VIII.B.3.b.(2)(h).

689. In summary, the combination of G.993.1 and Fukushima discloses each and every element of claim 8, and renders claim 8 obvious as a result.

(3) Dependent Claim 11

690. Claim 11 further recites:

11. The apparatus of claim 8, wherein a physical layer of the transceiver is capable of generating the packet and the message.

691. For the same reasons discussed above with respect to the combination of G.993.1 and BI-089, G.993.1 discloses this obvious and renders it obvious. *Supra* § VIII.B.4.a.(3).

692. In summary, G.993.1 and Fukushima in view of the general knowledge of a POSA disclose each and every element of claim 11 and render claim 11 obvious as a result.

(4) Dependent Claim 13

693. Claim 13 depends from claim 9, which depends from claim 8. Claims 9 and 13 recite:

9. The apparatus of claim 8, wherein the transmitted message has a higher immunity to noise than the received packet.

13. The apparatus of claim 9, wherein a physical layer of the transceiver is capable of generating the packet and the message.

694. The “higher immunity to noise” limitation would have been obvious over G.993.1 and Fukushima for the same reasons discussed above with respect to the identical limitation in claim 10 of the ’348 patent. *Supra* § VIII.B.3.b.(3). The “physical layer” limitation would have been obvious over G.993.1 and Fukushima for the same reasons discussed above with respect to the identical limitation in claim 11 of the ’809 patent. *Supra* § VIII.B.4.b.(3).

695. In summary, G.993.1 and Fukushima in view of the general knowledge of a POSA disclose each and every element of claim 13 and render claim 13 obvious as a result.

IX. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

696. I understand that TQ Delta and its experts may present evidence relating to secondary considerations of non-obviousness, for example, while contending that the references described above in my report do not render obvious the Asserted Family 9 Claims. I have reviewed TQ Delta’s Response to CommScope’s Interrogatory No. 17 and TQ Delta’s Response to Nokia’s Interrogatory No. 6, each of which relate to secondary considerations of non-obviousness. None of the “secondary considerations” identified in TQ Delta’s responses to either interrogatory change my conclusion that the Asserted Family 9 Claims would have been obvious, including because TQ Delta has not identified any nexus between any identified secondary consideration and the features of the Asserted Family 9 Claims. Despite TQ Delta’s claims that “the ITU-T has adopted the DSL standards that have incorporated the inventions of many of the Asserted Patents into them,” TQ Delta has not presented any evidence to show a nexus between this statement and the asserted claims of the Family 9 patents.¹⁸ Further, I have seen no evidence

¹⁸ In response to CommScope’s Interrogatory No. 5 and Nokia’s Interrogatory No. 28, TQ Delta asserts generally that “the ’348 and ’809 patents are essential to G.inp and G.fast” and that “the

that the ITU has adopted any standard based on any contribution of Aware or TQ Delta related to any alleged invention of Asserted Family 9 Claims.

697. If TQ Delta should present evidence regarding secondary considerations of non-obviousness in support of the non-obviousness of the Asserted Family 9 Claims, whether in its responsive expert reports, or at a later date, I reserve the right to address this evidence in my reply report, or any supplemental reports thereafter.

X. CONCLUSION

698. In my opinion, based on my review of the Family 9 patents, the materials referenced herein, and my knowledge of what a person of ordinary skill in the art would have known at and before the priority date of the Family 9 patents about the technology at issue, it is my opinion that one of ordinary skill in the art would have understood all of Asserted Family 9 Claims to be invalid for the reasons discussed above.

699. I reserve the right to supplement my opinions in the future to respond to any arguments or positions that TQ Delta or its experts may raise, taking account of new information as it becomes available to me.

'055 patent is essential to the G.fast standard.” These statements do not evidence any essentiality of the individual asserted claims of the Family 9 patents themselves.

Executed in Holmdel , NJ

Date: August 29, 2022

A handwritten signature in blue ink, appearing to read "Bruce McNair", written over a horizontal line.

Bruce McNair

APPENDIX A

Bruce McNair

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1-732-264-5244

Career Summary	• Fifty years engineering research, design, development, systems engineering experience in communications systems (including extensive background in wireless communications and system/network security) • Twenty four years as a well-rated member of one of world's most highly respected R&D organizations, recognized for breadth, depth and practicality of expertise • Extensive experience teaching technical short courses for premiere educational programs over a fourteen year period • Full time university educator for fifteen years with experience teaching a broad set of courses focusing on practical engineering approach • On-line university educator for eighteen years teaching well-attended graduate courses in wireless and security technologies
Research interests	• High speed wireless data networking • System/network security • Geolocation technology • Real-time digital signal processing • Software-Defined Radio technology • Broadband Powerline (BPL) technology
Present Organizations	• Stevens Institute of Technology, • Novidesic Communications, LLC
Job Titles	• Distinguished Service Professor of Electrical and Computer Engineering • Founder, Chief Technology Officer
Education	• M.E., E.E., Stevens Institute of Technology, 1974 • B.E. (with Honor), Stevens Institute of Technology, 1971 • Completed qualifiers and course work for PhD in Computer Science at Stevens

Relevant Experience

January 2003 – present – on-line teaching professor – Electrical and Computer Engineering, Stevens Institute of Technology, Hoboken, NJ;
Teach several well-enrolled on-line graduate courses in wireless security, information systems security and physical design of wireless communications systems.

August 2002 – December 2017 (retired) – Distinguished Service Professor of Electrical and Computer Engineering, Program Director, Computer Engineering graduate program, Stevens Institute of Technology, Hoboken, NJ;

Design and manage the Senior Design Project, a two-semester program that forms a substantial portion of the senior year in the engineering program. This project comprises a large fraction of the seniors' efforts and serves to provide real-world engineering design experiences for the student. Teach a large number of well-enrolled graduate and undergraduate core and elective courses. Conduct research in wireless systems, geolocation services, and broadband powerline (BPL) systems, particularly security needs and solutions. Member of Stevens Intellectual Property Review Board, Stevens Honor Board Advisory Council, Stevens' Schaeffer School of Engineering and Science Promotion and Tenure Committee, and the Senior Design Coordinator Committee.

February 2002 – present – CTO, Novidesic Communications, LLC, Holmdel, NJ;

Founded a technical consulting company, providing expert witness support and testimony, telecommunications, wireless networking, security, software, computing, product evaluation, proof-of-concept prototyping, and web site design guidance to individuals and small businesses. Clients include health care facilities, patent attorneys, major telecommunications providers, venture capitalists, major component manufacturing company, start-up hardware and concept development companies. Supported technology needs of small local business leading to Phase I and Phase II SBIR funding in the area of RFID with patented technology. Provide IP portfolio evaluation. Expert witness in patent litigation with experience testifying at deposition and trial as well as preparing USPTO IPR declarations.

August 2011 – February 2012 – Part-time consultant, Lockheed-Martin, Moorestown, NJ;

Support development of advanced radar systems and interactions with other wireless systems.

2010 – 2015 (part-time, on an as-needed basis) – Senior Systems Engineer consultant, AT&T Government Solutions, Columbia, MD;

Support AT&T's projects with the US Government customers on defense and intelligence-related systems, drawing on previous knowledge and experience in signal processing, wireless systems, telephone and computer networks, and secure system design.

**Relevant
Experience**
(continued)

May 1994 to February 2002 (retired) -- Wireless Systems Research Department, AT&T Bell Labs/ AT&T Labs - Research, Holmdel/Red Bank/Middletown, NJ

Member of Technical Staff/Research Staff Member/Principal Technical Staff Member/Technology Consultant; Investigating high-speed, high-mobility wireless data communications systems for untethered access to high speed global networks. Proposed and investigated IEEE 802.11(a & b) physical and MAC layer extensions to outdoor, high mobility environment. Efforts involved system architecture, system control, real-time DSP programming in C, high-speed hardware design, RF design, analog, RF interfacing, Matlab/SIMULINK simulation and experimental investigations. Responsible for complete design, implementation and characterization of a multiple TMS320C40-based 384 kb/s OFDM transmission system and definition/design of advanced signal processing platforms. Recent research extended results to 5-40 Mb/s with TMS320C62/FPGA-based platform and incorporated 802.11a and DVB-T technology. Previous research involved speech quality/data rate enhancements to IS-136, the North American TDMA cellular standard.

November 1987 to April 1994 -- Security and System Reliability Architecture Group, AT&T Bell Labs, Holmdel, NJ

Technical Manager; Created, staffed, and led a group of security, systems reliability and fraud control experts to assess security/quality of products, services, operations systems, communications networks, operating systems, and work centers and to recommend, specify, and prototype cost effective improvements. Created corporate process to build security into the development process. Transformed small (2 person) corporate-funded activity into well-staffed (multi million dollar), successful business unit supported program. Served as security technologies subject matter expert for AT&T Corporate Security and other (AT&T and outside) organizations

May 1982 to October 1987 -- various AT&T Bell Labs organizations, MTS - Supervisor; System Design, Exploratory Development, Applied Research, and Final Product Development of secure voice terminals, modems, speech recognition and speaker verification systems, security chips, encryption devices, and network management systems

June 1978 to April 1982 -- various AT&T Bell Labs organizations, Member of Technical Staff, System design, digital hardware design and simulation of wide area (X.25) data communications networks and high-speed data transmission techniques for voiceband modems. Led \$1M IR&D secure voice terminal initiative, ultimately resulting in promotion to MTS-Supervisor and laying groundwork for AT&T's breakthrough success in NSA's STU-3 program.

Relevant Experience (continued)	June 1971 to February 1973, January 1974 to June 1978 -- U.S Army Communications R&D Command, Fort Monmouth, NJ. GS-7, 9, 11 & 12 Electronic Engineer (GS-0855) Development of tactical military radio communications equipment, specializing in modulation, data transmission, communications security and electronic warfare (frequency hopping and direct sequence spread spectrum) for the SINCGARS VHF-FM radio system. March 1973 to December 1973 -- ITT Defense Communications Division, Nutley, NJ. Junior Member of Technical Staff; Designed, developed and tested software and digital hardware for portable satellite terminals for use by White House and the world's first hardware implementation of a 2400 bps Linear Predictive Coder (LPC) secure speech transmission system.
Patents, Presentations and Publications	Twenty six U.S. patents and nineteen international patents granted (several pending) in areas such as data transmission, cryptographic techniques, speech processing, video processing, security systems, user authentication, fraud control, synchronization, dynamic channel assignment, localization techniques, hazardous voltage detection, RFID, biomedical applications, vibration energy harvesting, solar energy harvesting for portable devices, etc. Presented numerous well-rated short courses in Digital Communications, Digital Telephony, Digital Signal Processing, and Wireless Communications, & Security. Course sponsors included: Bell Labs In-hours Continuing Education Program, George Washington University, University of Maryland, UCLA Extension, Johns Hopkins University – Organizational Effectiveness Institute, Berlin (Germany) Continuing Engineering Education Program, Monmouth University, and the Fort Monmouth Education Center. Several papers presented at IEEE Vehicular Technology and other Conferences and published in AT&T Technical Journal, IEEE Transactions on Wireless Communications, and IEEE Communications Magazine on various topics in wireless systems and security.
Skills	System/network architecture, communications system design, digital hardware design, RF design, signal processing, real-time DSP programming, software design and coding, proof-of-concept prototyping, designing and conducting laboratory research experiments, OFDM, TDMA/IS-136, FPGA, encryption, computer network security, threat assessment, data communications protocols, computer architecture, digital and analog video systems, system & link-level simulation, UNIX/Linux, Windows, C/C++, Matlab/Simulink, MathCad, PASCAL, Algol, SNOBOL, Verilog, VHDL, FORTRAN. Recruitment, development and management of highly effective technical staff. Highly effective technical presentations and training sessions to any level audience. Well-developed technical writing skills. Preparation, deposition, and testifying regarding expert report for patent infringement/non-infringement/validity/invalidity and other litigation matters. Assist in claim construction and prior art research for patent litigation.

**Other
information**

U.S. Citizen. Held Top Secret - Sensitive Compartmented Information (TS/SCI) clearance with full scope polygraph until October 2015.

Selected as one of twenty-six finalists among 490 entrants in the 2014 Bell Labs Prize competition for proposal "High-precision, low-cost, low-power indoor geolocation techniques."

Stevens Institute of Technology, Henry Morton Distinguished Teaching Professor, 2013-2014.

Named to New Jersey Inventors Hall of Fame, Inventor of the Year (2012) for "Patented/Innovative Research and Entrepreneurial Leadership Related to: Groundbreaking modem development and next generation wireless data communications systems"

Mentored two AT&T Labs Fellowship Program (ALFP) participants, three students in the MentorNet program, 5 Bell Labs Early Career Advisory Program (ECAP) participants, numerous summer students (graduate and undergraduate), several new employees, and all of the staff in groups I have managed.

Advised a significant fraction of ECE Senior Design groups, numerous graduate students; participation in thesis committees of several Stevens PhD students in various departments, including Physics, Computer Science, Mechanical Engineering, and ECE. Consult with non-ECE students on ECE aspects of their Senior Design projects

Mentor summer students at Stevens in NSF-funded Research Experience for Undergraduates (co-PI).

Stevens Institute of Technology, Schaefer School of Engineering, Undergraduate Teaching Award, December 2006.

Life Senior Member, Institute of Electrical and Electronic Engineers - Member of Communications, Signal Processing, Computer and Education Societies

Member, American Society for Engineering Education

Secretary, IEEE Communications Society Communications Security Committee

Identified by Rutberg & Co. Investment Bankers (San Francisco) as member of a group of 213 "Top Wireless Influencers: 2002"

Member of the Council of Communications Advisors

Amateur radio operator licensed since 1963, Amateur Extra Class since 1970

**Contact
Information**

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US Patents

- "Liquid Crystal Display using the photovoltaic behavior of LED backlights as a source of electrical energy." US Patent #10,310,326, June 4, 2019.
- "Method and apparatus for locating and distinguishing blood vessel." US Patent #8,764,663, July 1, 2014.
- "Secure IP access protocol framework and supporting network architecture," US Patent #8,046,577, October 25, 2011.
- "Method for Estimating Time and Frequency Offset in OFDM Systems," US Patent #7,990,839, August 2, 2011.
- "Simulcasting OFDM system having mobile station location identification," US Patent 7,962,162, June 14, 2011.
- "RFID Devices for Verification of Correctness, Reliability, Functionality and Security," US Patent 7,712,674, May 11, 2010.
- "Dynamic Channel Assignment," US Patent 7,457,259, November 25, 2008.
- "RFIDs Embedded into Semiconductors," US Patent 7,348,887, March 25, 2008.
- "Method for Estimating Time and Frequency Offset in OFDM Systems," US Patent #7,310,302, December 18, 2007.
- "Mobile Device Having Network Interface Selection," US Patent #7,180,876, February 20, 2007.
- "Dynamic Channel Assignment," US Patent #6,954,465, October 11, 2005.
- "Method for Estimating Time and Frequency Offset in OFDM Systems," US Patent #6,891,792, May 10, 2005.
- "Security System Providing Lockout for Invalid Access Attempts," US Patent #5,559,505, September 24, 1996.
- "Telecommunications Fraud Detection Scheme," US Patent #5,504,810, April 2, 1996.
- "Authenticator Card and System," US Patent #5,450,491, September 12, 1995.
- "Secure Telecommunications," US Patent #5,392,357, February 21, 1995.
- "Data Message Storage and Pickup Service," US Patent #5,392,336, February 21, 1995.
- "System and Method for Granting Access to a Resource," US Patent #5,375,244, December 20, 1994.
- "Secure Teleconferencing," US Patent #5,353,351, October 4, 1994.
- "Method and Apparatus for Processor Based Encryption," US Patent #5,278,905, January 11, 1994.
- "Centralized Security Control System," US Patent # 5,276,444, January 4, 1994.
- "Technique for Voice Based Security System," US Patent #5,265,191, November 23, 1993.

**US Patents
(continued)**

- "Video Scrambling System", US Patent # 5,206,906, April 27, 1993.
- "Cryptographic Transmission System," US Patent #4,642,424, February 10, 1987.
- "Processing of Encrypted Voice Signals," US Patent #4,608,455, August 26, 1986.
- "Control of Coefficient Drift for Fractionally Spaced Equalizers," US Patent #4,376,308, March 8, 1983

Several other published and unpublished US patents pending

**International
Patents**

- "Voltage-controlled apparatus for battery-powered electronic devices," EP Patent #0568237 B1, January 23, 2002.
- "A Dynamic Channel Assignment," EP Patent #1,137,299, September 26, 2001.
- "Data Message Storage and Pickup Service," EP Patent #0626776 B1, April 7, 1999.
- "Data Message Storage and Pickup," Canadian Patent #CA-2119227A1, February 24, 1998.
- "Centralized Security Control System," Canadian Patent #CA-2078077, January 27, 1998.
- "Improved centralized security control system and method," EP Patent #0534679, August 12, 1997.
- "Authenticator Card with Changing Bar Code Pattern," EP Patent #0,715,789, June 12, 1996.
- "Technique for voice-based security systems," Canadian Patent #CA-2072172, April 30, 1996.
- "Method and apparatus for user identification and verification of data packets in a wireless communications network," EP Patent #0,689,316, December 27, 1995.
- "Central Difference Control System," Japanese Patent #1995-131526, May 19, 1995.
- "Authenticator Card with Changing Bar Code Pattern," WO Patent #1995/006371, March 2, 1995.
- "Method for safety system of voice base and device therefore," Japanese Patent #1995-049696, February 21, 1995.
- "Data message storage and pick up service, EP Patent #0,626,776, November 30, 1994.
- "Method for safety system of voice base and device therefore," Japanese Patent #1995-049696, February 21, 1995.
- "Data message storage and pick up service, EP Patent #0,626,776, November 30, 1994.
- "Apparatus for battery type electronic device," Japanese Patent #1994-138983, May 20, 1994.
- "Method and system for making communication via exchange network available, method for providing," Japanese Patent #1994-085811, March 25, 1994.

**International
Patent
(continued)**

- Voltage-controlled apparatus for battery-powered electronic devices," EP Patent #0,568,237, November 3, 1993
- "Security node in switched telecommunication network", EP Patent #0,553,553, August 4, 1993.
- "Improved centralized security control system and method," EP Patent 0,534,679, March 31, 1993.
- "An improved technique for voice-based security systems," EP Patent #0,533,396, March 24, 1993.
- "Cryptographic Transmission System," Canadian Patent #CA-1223932, July 7, 1987.

Several other published and non-published applications pending.

**Journal
Publications**

- Leung, K., Clark, M.V., McNair, B., Kostic, Z., Cimini, L.J., Winters, J.H., "Outdoor IEEE 802.11 Cellular Networks: Radio and MAC Design and Their Performance", *IEEE Transactions on Vehicular Technology*, Vol. 56, No. 5, pp. 2673-2684, September 2007.
- Chuang, J., Cimini, L., Li, G., Lin, L., McNair, B., Sollenberger, N., Suzuki, M., Zhao, H., "High Speed wireless data access based on combining EDGE with wideband OFDM," *IEEE Communication Magazine*, November, 1999.
- D'Angelo, D.M., McNair, B., Wilkes, J.E., "Security in Electronic Messaging Systems," *AT&T Technical Journal*, Volume 73, Number 3, 1994.

**Research
awards**

- "Standalone/Networked Compact, Low Power, Image-fused Multi-Spectrum Sensor System for Target Acquisition, Tracking and Fire Control," ARDEC, \$2365000, co-PI with Victor Lawrence, Hong Man. AY2008-2009
- NSF: "REU Site: Integrated Software Radio and Radio Frequency Test Bed for Wireless Research in Dynamic Spectrum Access"; \$296,754; NSF; Co-PI with Yu-Dong Yao. AY2004-2005
- AT&T Labs-Research Equipment donation of \$900k DSP systems and wireless test equipment. AY2003-2004
- AT&T Labs-Research - \$60k grant for "Investigation of Broadband Powerline technology" AY2003-2004

**Masters
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- Xiongwei Xu, "The synchronization of IEEE 802.11A System", May 2014.
- Abdurazak Fathalla, "Security of Cloud Computing," May 2011.
- Tejas Marathe, "Comprehensive Performance Criteria for Wi-Fi Location Systems," December 2008.

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- Milin Patel, "Network Performance Enhancement using QoS, TCP Optimization, Application Acceleration and Dynamic Resource Allocation Techniques," January 2008.
- Leo Gerard Raj, "Security in 4G Wireless Systems," May 2005.

**PhD
committees**

- Chao Tian, "Realization of Pure AM/FM Modulation via Combined Optical and Electrical Injection of Carriers in DFB Laser," Stevens Institute of Technology, Physics Department, March 2015.
- Tao Yang, "All-optical frequency modulation of quantum cascade laser and its application on infrared spectroscopy," Stevens Institute of Technology, Physics Department, May 2014.
- Fangming He, "Physical Security in Wireless Communications," Stevens Institute of Technology, Electrical and Computer Engineering Department, May, 2012.
- Vinod Challa, "Vibration Energy Harvesting for Low Power and Wireless Applications," Stevens Institute of Technology, Mechanical Engineering Department, May, 2011.
- Brian Borowski, "Application of Channel Estimation to Underwater Acoustic Communication," Stevens Institute of Technology, Computer Science Department, June, 2010.
- Gang Chen, "All-Optical Modulation of Quantum Structure/Devices," Stevens Institute of Technology, Physics Department, May 2010.

**Conference
Papers**

- He, F., Man, H., Kivanc, D., McNair, B., "EPSON: Enhanced Physical Security in OFDM Networks," *Proc. ICC 2009*, Dresden, Germany, June 2009.
- Patel, S.; Cimini Jr, L.J.; McNair, B., "Comparison of frequency offset estimation techniques for burst OFDM," *Proc. IEEE Vehicular Technology Conference VTC2002*, Birmingham, AL, May, 2002.
- Cimini, L., Leung, K., McNair, B., Winters, J. "Outdoor IEEE 802.11b Cellular Networks: MAC Protocol Design and Performance," *Proc. ICC 2002*, New York, NY, April 2002
- Clark, M., Leung, K., McNair, B., Kostic, Z., "Outdoor IEEE 802.11b Cellular Networks: Radio Link Performance", *Proc. ICC 2002*, New York, NY, April 2002.
- McNair, B., "Software Radio – the Commercial Perspective," *Proc. IEEE Sarnoff Symposium*, Princeton, NJ, March 2002.
- Zou, H., Daneshmand, B., McNair, B., "An Integrated OFDM Receiver for High-Speed Mobile Data Communications," *Proc. IEEE Globecom 2001*, San Antonio, TX, Oct. 2001.
- McNair, B., "Future Directions for Wireless Communications," *Supercomm2001*, Atlanta, GA, June, 2001

**Conference
Papers
(continued)**

- Cimini, L., McNair, B, "OFDM for High Data Rate, High-Mobility, Wide-Area Wireless Communications," *Proc. IEEE Sarnoff Symposium*, Princeton, NJ, March, 2001.
- Cimini, L., McNair, B, Sollenberger, N., "Implementation of an Experimental 384 kb/s Radio Link for High-Speed Internet Access," *Proc. IEEE Vehicular Technology Conference VTC2000*, Boston, MA, September, 2000.
- Cimini, L., McNair, B, Sollenberger, N., "Performance of an Experimental 384 kb/s 1900 MHz Radio Link In a Wide-Area High-Mobility Environment," *Proc. IEEE Vehicular Technology Conference VTC2000*, Boston, MA, September, 2000.
- Takamura, K.; Kunihiro, T.; Yamaura, T.; Fujita, E.; Anderson, G.; Chibane, C.; Feinberg, P.; Sollenberger, N.; McNair, B.; Mielcarek, E., "Field trial results of a band hopping OFDM system," *Proc. IEEE Vehicular Technology Conference VTC99-Fall*, 1999. Amsterdam, the Netherlands, September 1999.
- McNair, B., Cimini, L., Sollenberger, N., "A Robust Timing and Frequency Offset Estimation Scheme for Orthogonal Frequency Division Multiplexing (OFDM) Systems," *Proc. IEEE Vehicular Technology Conference, VTC99*, Houston, TX, May 1999.
- McNair, B., Gupta, S., Kostic, Z., Sollenberger, N., "Experimental Results for Extensions to the IS-136 TDM Standard Based on Higher Level Modulation, Coherent Detection, and Equal Gain Antenna Combining," *Proc. IEEE Vehicular Technology Conference, VTC99*, Houston, TX, May 1999.
- Kostic, Z., McNair, B., Sollenberger N., "Experimental Performance Results of an Indoor Wireless Extension of IS-136 Based on $\pi/8$ D8PSK, Coded Modulation, and Antenna Diversity," *Proc. IEEE Vehicular Technology Conference, VTC98*, Ottawa, Canada, May 1998.
- McNair, B., "The Effectiveness of Preselection Diversity for Indoor Wireless Systems," *Proc. Int. Conf. on Universal Personal Communications*, San Diego, CA, Oct. 1997.

Invited talks

- "Adventures in On-Line Education," Tsinghua University Webinar: Showcasing Online Course Designs, Online Teaching Guidance Expert Group, International Center for Engineering Educations (ICEE) – The United Nations Educational, Scientific and Cultural Organization (UNESCO), April 27, 2020.
- "Providing Structure, Motivation and Process in Security Education," Stevens/NIKSUN Workshop on Innovations in Cyber Security Research, Education and Training, Hoboken, NJ, March 2015
- "Wireless Security Panel," IEEE/AFCEA Fort Monmouth Annual Information Technology Forum and Expo, April 2005.

**Invited talks
(continued)**

- “Of What Use is Wireless Multimedia Without Security,” “What’s Next in Multimedia Panel,” 14th Annual Wireless and Optical Communications Conference, April 2005.
- “Is Wireless Security an Oxymoron?” IEEE Princeton/Central NJ Communications and Consumer Electronics and Computer Science Chapters, December, 2003.

**Other
Publications**

- McNair, B., “Automatic Repeater Offsets,” *73 Magazine*, November 1978, pp. 82-86.
- McNair, B, Williman, G., “Digital Keyboard Entry System,” *Ham Radio*, Volume 11, Number 9, September, 1978, pp. 92-97.
- McNair, B., “A Digital Display for Amateur Radio Communications Equipment,” *Ham Radio*, Volume 9, Number 9, September 1976, pp. 16-25.
- MIL-STD-188-114, “Electrical Characteristics of Digital Interface Circuits,” Department of Defense Interface Standard, 24 March 1976
- Graduate:
 - EE/CpE-517 - Digital and Computer Systems Architecture (on-campus)
 - EE/TM/NIS-584 – Wireless System Security (on-campus and on-line)
 - EE-585/PEP-685/MT-685 – Physical Design of Wireless Communications (on-campus and on-line)
 - NiS/CpE-691 – Information Systems Security (on-campus and on-line)
 - EE/CpE-810A - Special Topics in EE/CpE - Digital and Computer Systems Architecture (on-campus)
- Undergraduate (on-campus):
 - E-232 – Design IV
 - BME-322 – Biomedical Design VI
 - EE/CpE-322 – ECE Design VI
 - EE/CpE-345 – Modeling and Simulation
 - CpE-358/CS-381 – Switching Theory and Logical Design
 - EE-359 – Electronic Circuits
 - EE/CpE-423; EE/CpE-424 – Senior Design
 - CpE-450 – Real-time Embedded Systems

Short Courses

- "Electronics and Computers," preparation course for Fundamentals of Engineering/Professional Engineering license
Stevens Institute of Technology
- "Digital Signal Processing - Principles, Architecture, and System Applications"
 - *Organizational Effectiveness Institute (originally Johns Hopkins University's continuing education program),*
- "Wireless Digital Communications Systems: Components, Specifications, Test and Evaluation"
 - *Organizational Effectiveness Institute*
- "Security in Digital Communications Networks"
 - *Bell Labs Architecture Area Adopt a University Program: Grambling State University*
 - *Monmouth University*
- "Digital Telephony"
 - *Monmouth University*
 - *Fort Monmouth Education Center*
 - *Berlin (F.R.G.) Continuing Engineering Education Program*
- "Digital Communications & Applications"
 - *University of Maryland*
 - *Fort Monmouth Education Center*
 - *UCLA Extension University*
- "Digital Communications," presented with Allen Gersho, N.S. Jayant and David Falconer.
 - *George Washington University*
- "Data Communications for the System Designer"
 - *Bell Labs In-Hours Continuing Education Program*

**Expert
witness,
patent
consulting
experience**

- Authentication technology
- Bluetooth, WiFi, ZigBee, and other local/personal area wireless networking
- Cellular systems
- Communications networking
- Digital clock control for power management in SoCs
- Digital Rights Management
- Digital Subscriber Loop (DSL) technology
- Electronic technology
- Embedded systems
- Geolocation technology
- Industrial process control software
- Localization services
- Messaging systems
- Multifactor Authentication
- Peer-to-peer and client-server networks
- Secure voice communications
- Signal processing
- Smart cards and magnetic stripe cards for payment systems
- Software/firmware code analysis (C, VHDL)
- Software trade secrets
- Television and television tuner technology
- Trusted systems
- User and system authentication technology
- Video messaging
- Video scrambling and pay-per-view systems
- Voice processing and voice response systems
- Wireless communications and networking – particularly PHY and MAC layers

**Law firms
supported**

- Avant Law, Overland Park, KS (Hissan Anis)
- Baker & McKenzie, Dallas, TX (William McSpadden)
- Bradley, Birmingham, AL (Paul Sykes, Benn Wilson, Jake Gipson)
- Bragalone-Conroy, Dallas, TX (Nick Kliewer, Daniel Olejko, Stephanie Wood)
- Cantor-Colburn, Hartford, CT (Steve Coyle)
- Carella-Byrne (Donald Ecklund)
- Clark-Hill, Pittsburgh, PA, (J. Alexander Hershey)
- Desmarais, New York, NY (Kerri-Ann Leembeck)
- DLA Piper, Austin, TX, San Francisco, CA and San Diego, CA (Brian Erickson, Gerald Sekimura, Kevin Hamilton)
- Fox Rothschild, Lawrenceville, NJ (Gerard Norton)
- Gibbons-Deldeo, Newark, NJ (Michael Cukor, Sheila McShane, Vin McGeary, Erich Falke, Chris Strate)
- Greenberg-Taurig, McLean, VA (Andrew Sommer)
- Hogan-Lovells, Denver, CO (Matt Rozier, Aaron Oakley, Lucky Vidmar)
- Jones-Day, New York, NY (Tom Gianetti)
- Latimer, LLP, Oakhurst, NJ (Brian Latimer)
- Merchant-Gould, Atlanta, GA (George Jenson)
- Morrison-Foerster, San Diego, CA (Christian Andreau-von Eaw)
- Oblon Spivak, Arlington, VA (Robert Mattson, Scott McKeown)
- Orrick, Herrington and Sutcliffe, Silicon Valley (Jason Angell)
- Quattlebaum, Grooms, Tull & Burrow, Little Rock, AR (Steve Quattlebaum)
- Quinn-Emanuel, New York, NY (Marc Kaplan)
- Ropes & Gray, Washington, DC, (Scott McKeown, Victor Cheung)
- Sabety & Associates (Ted Sabety)
- Sidley Austin, Chicago, IL, Washington, D.C. (Doug Lewis, Rick Cederoth, Mike Franzinger)
- Steptoe & Johnson, Washington, D.C. (Kate Cappaert, Brian Johnson)
- Carr & Waddoups, Salt Lake City, UT (Trent Waddoups)
- Unified Patents, Washington, DC (Michelle Callaghan, Ashraf Fawzy, Jung Hahm, Roshan Mansinghani, Jessica Marks, Jordan Rossen, David Seastrunck)
- Wilson, Sonsini, Goodrich & Rosati, Palo Alto, CA, Seattle, WA (Matthew Argenti, Quincy Lu)
- White Case, Washington, DC, New York, NY (David Tennant, Grace Wang)
- Wisser and Weinstein, West Hartford, CT (Kerry Wisser)
- Woodcock and Washburn, Philadelphia, PA (Michael Bonella)

APPENDIX B

APPENDIX B: MATERIALS CONSIDERED

Besides the materials cited therein, I have also considered:

- '055 Patent
- '055 Patent File History
- '411 Patent
- '411 Patent File History
- '348 Patent
- '348 Patent File History
- '809 Patent
- '809 Patent File History
- TQ Delta's 2nd Supplemental Objections and Responses to Nokia's 2nd Set of Interrogatories (Nos. 4-17), served August 19, 2022
- TQ Delta's 2nd Supplemental Objections and Responses to CommScope's 1st Set of Interrogatories, served August 19, 2022
- TQ Delta's responses and Objections to Nokia's Second Set of RFAs, dated August 15, 2022
- Nokia Defendants' Initial Invalidity Contentions, served January 13, 2022 and all exhibits cited therein.
- CommScope Defendants' Initial Invalidity Contentions, served January 13, 2022 and all exhibits cited therein.
- Nokia Defendants' Amended Invalidity Contentions, served March 23, 2022 and all exhibits cited therein.
- Nokia Defendants' Amended Invalidity Contentions, served July 28, 2022 and all exhibits cited therein.
- TQ Delta's Opening Claim Construction Brief (Dkt. 124), filed April 26, 2022 and all exhibits cited therein.
- Defendants' Responsive Claim Construction Brief (Dkt. 135), filed May 6, 2022 and all exhibits cited therein.
- TQ Delta's Reply Claim Construction Brief (Dkt. 140), filed May 13, 2022 and all exhibits cited therein
- Markman Hearing Transcript (Dkt. 172), hearing held June 1, 2022
- Claim Construction Memorandum and Order (Dkt. 169), filed June 8, 2022
- "Details of 'RTS/TSGR-0225322Uv4' Work Item Schedule" found at https://portal.etsi.org/eWPM/index.html#/schedule?WKI_ID=13564
- "Details of 'RTS/TSGR-0225322Uv4' Work Item" found at https://portal.etsi.org/webapp/workprogram/Report_WorkItem.asp?WKI_ID=13564
- "Specification # 25.322 Versions" found at <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificatonId=1176>
- "G.993.1 Very high speed digital subscriber line transceivers (VDSL)" found at <https://www.itu.int/rec/T-REC-G.993.1-200406-I/en>