

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AYLO FREESITES LTD,

Petitioner

v.

DISH TECHNOLOGIES L.L.C.,

Patent Owner

U.S. Patent 8,868,772

Issue Date: October 21, 2014

Title: APPARATUS, SYSTEM, AND METHOD FOR ADAPTIVE-RATE
SHIFTING OF STREAMING CONTENT

Inter Partes Review No. IPR2024-00519

**DECLARATION OF HENRY HOUH, Ph.D.
IN SUPPORT OF PETITION FOR
INTER PARTES REVIEW OF
U.S. PATENT NO. 8,868,772**

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I, Henry Houh, Ph.D., declare as follows:

I. INTRODUCTION

1. My name is Henry Houh, and I have been retained by counsel for Aylo Freesites, Ltd (“Petitioner”) to analyze U.S. Patent No. 8,868,772 (“’772 Patent”) (EX1001) and to provide my opinions regarding the patentability of claims 1-21 of the ’772 Patent.

2. I am being compensated at my normal consulting rate of \$650 per hour for my time. My compensation is not contingent on the outcome of this proceeding, or of any proceedings relating to the ’772 Patent.

II. BACKGROUND AND QUALIFICATIONS

3. I am currently employed by Houh Consulting Inc. as an independent technical consultant. Until October 2022, I also worked as the co-founder of Einstein’s Workshop, a company that provides supplemental science, technology, engineering, and mathematics (“STEM”) education to children of all ages. I also co-founded and serve on the board of BlocksCAD, Inc., which provides educational computer-aided design software used around the world.

4. My professional career has spanned more than 25 years. As set forth in my curriculum vitae (attached as Exhibit A to this declaration), during these years I

have gained extensive experience in web sites, communications systems, networking, distributed systems, protocols and streaming audio/video communications.

5. I have multiple undergraduate and graduate degrees from the Massachusetts Institute of Technology (MIT). I have a Bachelor of Science Degree in Electrical Engineering and Computer Science from MIT which I received in June 1989. I also have a Bachelor of Science Degree in Physics from MIT which I received in February 1990. I have a Master of Science Degree in Electrical Engineering and Computer Science from MIT which I received in February 1991. I have a PhD in Electrical Engineering and Computer Science from MIT which I received in February 1998. My thesis was directed to “Designing Networks for Tomorrow’s Traffic,” and was supervised by Professor David Tennenhouse and Professor John Guttag.

6. I first worked in the area of communications in 1987 when I worked at AT&T Bell Laboratories as part of a five-year dual degree program at MIT. At Bell Labs, I first worked in a group supporting core telephony switching functions, then later I joined the Optical Computing group. In graduate school, I joined the Advanced Network Architecture (ANA) group at the Laboratory for Computer Science (LCS) at MIT, then headed by Prof. Tennenhouse and senior research

scientist David Clark. Dr. Clark is generally considered to be one of the fathers of the Internet Protocol, having acted as chief protocol architect for the development of the Internet. My research and work experience in distributed systems, networking, and network architecture dates back to around 1991 when I joined ANA.

7. Later, when Prof. Tennenhouse formed his own research group, the Telemedia Network Systems (TNS) group, I joined TNS. The TNS group built a high-speed gigabit network and applications which ran over the network, such as remote video capture, processing, and display on computer terminals. I designed the core networking hardware and software, including the high-speed data links and the device drivers for the network interface cards.

8. TNS's research activities focused on high-speed networking and the types of applications that require increased network bandwidth and computing power. One of the applications I investigated was live streaming video, and real-time processing of such video. My work was focused on the transport, switching, and routing of data (including video and audio streams), and the integration of TNS's network into the computing environment, including the protocols, IP/ATM integration, operating system software and device drivers. TNS created a computing environment where it was possible to stream audio/video live, and also created software processing modules to further process video to perform advanced functions

such as green screening, scene change detection, motion detection, compression, video blending and video overlay, among many other features – all in real-time while displaying the processed video live. Our system also had the capability to identify a frame within video files, so that the video could be started at a particular point within the video. While the Internet at the time did not have the capability for such applications to be widely deployed, my group at TNS researched what would be possible when the required network and computing power became available. As discussed above, my Ph.D. thesis work focused on studying the routing resources required to route streams of video through the network, proposing several alternative labeling strategies to speed up network routing, especially for popular applications such as web traffic.

9. During the early part of my graduate studies, a time when there were perhaps a hundred or so web servers in existence, I set up a web server on one of our lab computers, and created content rich web pages for my research group and my research activities. Eventually, I, together with others I was working with, added live video demonstrations to TNS's web site. TNS's web site was one of the first several hundred web servers to exist, and the first to offer live video demonstrations initiated from the web site to a user's remote computer. I helped to build the web pages that initiated these video sessions via a web interface. I started and maintained the

“Commercial Sites Index,” the first listing of all the companies on the web. I later sold this list to OpenMarket, then a leader in web servers and eCommerce servers. I also started a company to build web sites and sell targeted online advertisements. During this time, I followed the evolution of the web very closely.

10. Vice-President Al Gore visited our group in 1996 and received a demonstration of – and remotely drove – a radio controlled toy car with a wireless video camera mounted on it; the video was encoded by TNS-designed hardware, streamed over the TNS-designed network and displayed using TNS-designed software.

11. I authored or co-authored at least twelve papers and conference presentations on my group’s research at TNS. I also co-edited TNS’s final report on its gigabit networking research effort. Some of my papers about web site development were presented at the first World-Wide Web conference held in 1994 at CERN in Geneva, Switzerland. CERN is the birthplace of the Web, and the conference was chaired by Tim Berners-Lee, the inventor of the World-Wide Web. When Tim Berners-Lee formed the World Wide Web Consortium at the MIT LCS in order to manage the progression of web protocols and standards, I assisted him in obtaining the consortium’s domain names and setting up the consortium’s web server.

12. I have extensive experience in creating web pages and commercially setting up websites during the 1993-1997 time frame, and have continued this development since then. As part of this experience, I regularly programmed using HTML and Perl programming languages. I also have experience with CGI scripts and Perl scripts as used for dynamic web pages.

13. From 1997 to 1999, I was a Senior Scientist and Engineer at NBX Corporation, a start-up that made business telephone systems for streaming packetized audio over data networks instead of using traditional telephone lines. NBX was later acquired by 3Com Corporation, and the phone system I worked on at NBX was widely used by numerous businesses. As part of my work at NBX, I designed the core audio reconstruction algorithms for the telephones, as well as the packet transmission algorithms. I also designed and validated the core packet transport protocol used by the phone system.

14. Two of the company founders and I obtained U.S. Patent No. 6,967,963, entitled "Telecommunication method for ensuring on-time delivery of packets containing time-sensitive data," as a result of part of the work I did at NBX.

15. From 2003-2004, I also was the architect for a next-generation web testing platform developed by Empirix, known as e-Test Suite. E-Test Suite is now owned by Oracle Corporation. E-Test provided functional and load testing for web

sites. E-Test emulated a user's interaction with a web site and provided web developers with a method of creating various scripts and providing both functional testing (i.e., did the web site provide the correct response) and load testing (i.e., could the web site handle 5000 users simultaneously). As part of this project, I co-wrote a javascript interpreter for e-Test so that it could understand the javascript code present on advanced web sites.

16. I worked at BBN Technologies from 2004 to 2009. BBN Technologies, formerly known as Bolt, Beranek and Newman, was a pioneer of the Internet and a long-established leader in speech recognition and natural language processing. BBN received the first contract to build components of a packet switched network as part of the ARPANET, a U.S. Department of Defense effort funded through the Advanced Projects Research Agency (ARPA). While this effort preceded my time at BBN by many years, BBN continued to maintain a strong presence in network research and development, including in wireless networking, device discovery, and protocols for a "body area network."

17. In 2006, as part of my role at BBN Technologies, I helped found PodZinger Inc., now known as RAMP Inc. PodZinger utilized BBN's speech recognition algorithms to search through the spoken words inside audio and video. After managing the creation of the initial prototype system, PodZinger built out a

full web-based streaming audio and video search solution when I was the Vice President of Operations and Technology there. The web site had a full load- balanced back end that provided search and indexing solutions for our hosted multimedia (audio and video) content. Our PodZinger system processed videos in order to perform automatic speech recognition on the spoken contents of the video, after which we produced a word transcript we used in a search index for all our processed videos. All of the words in the transcript were individually tagged to frame locations within the video, so that selecting a word in the transcript caused the video to jump to the location within the video at which the word was spoken. For this work and more, we received a patent, on which I was an inventor – U.S. Patent No. 7,801,910, titled “Method and apparatus for timed tagging of media content.” In addition, we received several more patents on which I was an inventor, including U.S. Patent No. 9,697,231, titled “Methods and apparatus for providing virtual media channels based on media search,” and U.S. Patent No. 9,697,230, titled “Methods and apparatus for dynamic presentation of advertising, factual, and informational content using enhanced metadata in search-driven media applications.” These patents described computerized method and apparatus for merging video content segments from discrete media content for playback, and using metadata extracted from multimedia content segments to display additional information, such as advertisements, adjacent

to the media player, while tracking the progression of the playback and changing the information as playback progressed through various segments to correspond to the content of the segments.

18. I also worked on commercializing a service offered by BBN to monitor call centers and provide analytical data on each call. The business became known as AVOKE Analytics and provided call center analytics for large organizations such as Dell and the Centers for Medicare and Medicaid Services (CMMS). For a time, during the rollout of the Affordable Care Act (though I was no longer working at BBN), AVOKE Analytics gathered data and provided call-by-call analytics for every call made to the CMMS main call center.

19. I have web advertising experience as well, including starting a company in 1994 that was funded, in part, through web advertisements. Later in 2008-2009, as the CTO of a venture-funded social network start-up company, I also evaluated different advertising network tools which were used in the roll-out of an advertising network.

20. I am familiar with patents and have numerous provisional and non-provisional patent applications on which I am an inventor, including 4 provisional patent applications, and around 20 non-provisional applications. These patent applications deal with various areas of technology including, but not limited to:

utilizing network processors, network and packet delivery systems, tagging media content, dynamic presentation of advertising and other content using enhanced metadata, methods for web site testing, and organizing and managing files that are transmitted over a network.

III. MATERIALS CONSIDERED

21. In preparing this declaration, I reviewed the '772 patent, including the claims of the patent in view of the specification, and I have reviewed the prosecution history of the '772 patent and numerous prior art and technical references from the time of the alleged invention. Of the materials cited as an exhibit to the '772 patent IPR petition, I reviewed the following:

Exhibit Number	Description
1001	U.S. Pat. 8,868,772 (“the ’772 Patent”)
1002	File History of U.S. Pat. 8,868,772
1004	International P.C.T. Publication WO 2002049343 to Leaning et al. (“Leaning”)
1007	U.S. Patent No. 6,848,004 to Chang (“Chang”)
1008	WO1997044942 to Kliger (“Kliger”)
1009	337-TA-1265 ITC Investigation Initial Determination

1010	337-TA-1265 ITC September 11, 2023 Enforcement Complaint
1013	U.S. Patent No. 6,637,031 to Chou (“Chou”)
1020	U.S. Patent Publication No. US 2004/0093420 to Gamble (“Gamble”)

22. Petitioner’s counsel has asked me to consider whether certain references disclose or suggest, alone or in combination, the features recited in certain claims of the ’772 Patent. I have also been asked to consider the state of the art and the prior art available before the time of the alleged invention of the ’772 Patent. My opinions are provided in this declaration.

23. My opinions in this declaration are based on my review of the documents above, my understanding as an expert in the relevant field, and my education, training, research, knowledge, and personal and professional experience.

24. To my knowledge, I have no financial interest in Petitioner. Counsel for Petitioner has informed me that DISH Technologies, L.L.C. purports to own the ’772 patent and that Sling TV L.L.C. purports to be an exclusive licensee of the ’772 Patent. To the best of my knowledge, I have no financial interest in DISH Technologies L.L.C. or Sling TV L.L.C and, to my recollection, have had no contact

with DISH Technologies L.L.C. or Sling TV L.L.C or the named inventors of the '772 Patent. To the best of my knowledge, I do not have any financial interest in the '772 Patent.

25. To the extent any mutual funds or other investments that I own have a financial interest in the Petitioner, the Patent Owner, or the '772 Patent, I am not aware of, and do not control, any financial interest that would affect or bias my judgment.

IV. LEGAL STANDARDS

26. Petitioner's counsel has informed me that, in an *inter partes* review proceeding, a patent claim may be deemed unpatentable if it is shown by a preponderance of the evidence that the claim was either anticipated by a prior art patent or publication or rendered obvious by one or more prior art patents or publications.

27. Petitioner's counsel has informed me that a claim is unpatentable if the differences between the subject matter of the patent and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the art, or a "POSITA", at the time of the invention.

28. Petitioner's counsel has informed me that a determination of whether a claim would have been obvious should be based upon several factors, including the following:

- The level of ordinary skill in the art at the time the application was filed;
- The scope and content of the prior art; and
- What differences, if any, existed between the claimed invention and the prior art.

29. Petitioner's counsel has informed me that a single reference can render a patent claim obvious if any differences between that reference and the claims would have been obvious to a person of ordinary skill in the art. Alternatively, the teachings of two or more references may be combined in the same way as disclosed in the claims, if such a combination would have been obvious to one having ordinary skill in the art. In determining whether a combination based on either a single reference or multiple references would have been obvious, I understand from Petitioner's counsel that it is appropriate to consider the following factors:

- Whether the teachings of the prior art references disclose known concepts combined in familiar ways, and when combined, would yield predictable results;

- Whether a POSITA could implement a predictable variation, and would see the benefit of doing so;
- Whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by those skilled in the art;
- Whether a person of ordinary skill would have recognized a reason to combine known elements in the manner described in the claim;
- Whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and
- Whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way.

30. Petitioner's counsel has informed me that a POSITA has ordinary creativity and is not an automaton.

31. Petitioner's counsel has informed me that all prior art references are to be looked at from the viewpoint of a POSITA.

32. Petitioner's counsel has informed me that, in considering obviousness, it is important not to determine obviousness using the benefit of hindsight derived from the patent being considered, and that obviousness is analyzed from the perspective of a POSITA at the time of the invention.

V. OVERVIEW OF THE '772 PATENT

33. The '772 Patent (application no. 11/116,783) was filed on April 28, 2005 and issued on October 21, 2014. EX1001, Cover. The '772 Patent purports to relate to adaptive rate shifting of streaming contents such as video, over the Internet. EX1001, Abstract, 1:18-21. The '772 Patent describes an “agent controller module” to “simultaneously request” a plurality of streamlets, “continuously monitor” streamlet requests and subsequent responses and “accordingly request” higher or lower quality streamlets. *Id.*, Abstract. The '772 Patent also describes a “staging module” that stages the streamlets and arranges the streamlets for playback on a content player. *Id.*

34. One embodiment of the system of the '772 Patent includes “a content server 102” and “end user 104” coupled by a data communications network (*e.g.*, the Internet 106) wherein the “end user station 104” may be a personal computer, entertainment system, or a portable electronic device configured to present content. *Id.*, FIG. 1, 6:3-17. The '772 Patent describes encoding the same content file 200 into three different “quality” streams:

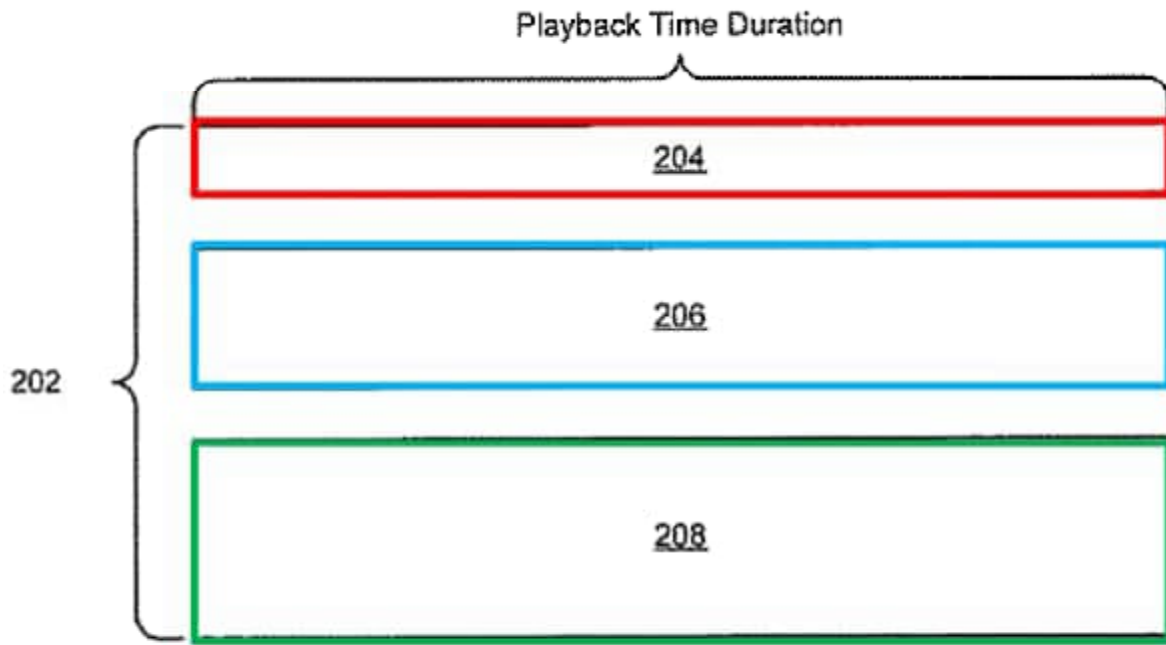


FIG. 2b

Id., FIG. 2b (annotated, low quality (red, 204), medium quality (blue, 206), and high quality (green, 208)), 6:46-57.

35. For example, “low quality stream 204 may be encoded and compressed to a bit rate of 100 kilobits per second (kbps), the medium quality stream 206 may be encoded and compressed to a bit rate of 200 kbps, and the high quality stream 208 may be encoded and compressed to 600 kbps.” *Id.*, 6:53-57. Each stream (204, 206, and 208) is also “divided into a plurality of streamlets” where “streamlet refers to any sized portion of the content file” and may be “an independent media object” where “streamlet 0 may have a time index of 00:00 representing the beginning of

content playback, and streamlet 1 may have a time index of 00:02, and so on.” *Id.*, 6:58-7:3. This is shown in Figure 2c below.

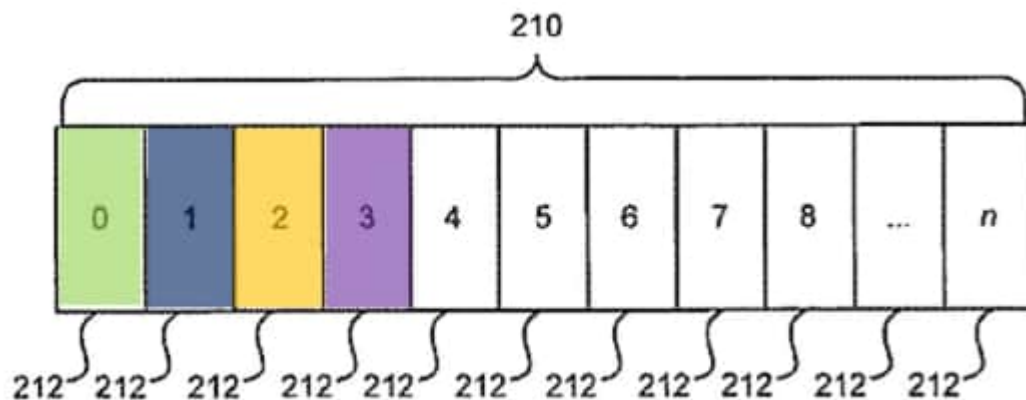


FIG. 2c

Id., FIG. 2c (annotated).

36. As the client receives a streamlet, it “calculates 708 a performance ratio” and “obtain[s] a performance factor.” *Id.*, 12:15-40, FIGs. 6 and 7. Thereafter, the client determines whether to upshift or downshift the stream quality based upon comparing the performance factor versus trigger thresholds and makes a “determination of whether use of the higher quality stream is sustainable.” *Id.*, 12:41-65.

A. Prosecution History

37. The '772 Patent was filed as Application No. 11/116,783 on April 28, 2005. On May 14, 2008, the Examiner issued a non-final office action finding, *inter*

alia, the pending claims anticipated by or obvious over U.S. Publication No. 2002/0144276 (“Radford”). EX1002, 62-80.

38. On September 11, 2008, Applicant conducted an interview and revised the claims, arguing Radford no longer anticipates or renders obvious the claims as amended because Radford does not disclose automatically and progressively requesting video portions, achieving continuous playback, or multiple TCP connections. *Id.*, 110-122.

39. On February 20, 2009, the Examiner issued a final office action rejecting all pending claims. *Id.*, 394-409. The Examiner found most claims indefinite for reciting “performance factors,” “requesting sub-parts,” and “requesting . . . from the server over a plurality of [TCP] connections.” *Id.*, 396-397. The Examiner found that pending claim 39 failed the written description requirement for reciting new matter. The Examiner found all pending claims obvious in view of U.S. Publication No. 2002/0188745 (“Hughes”), U.S. Publication No. 2003/0135631 (“Li”), U.S. Publication No. 2004/0093420 (“Gamble”), and (for some claims) Official Notice. *Id.*, 397-409.

40. On March 11, 2009, Applicant conducted another interview, and on March 14, 2009, Applicant submitted an amendment after final. *Id.*, 441-463. Applicant argued that claim 39, amended to recite that the “current read ahead

margin” is an amount of contiguously available, sequentially arranged portions, is supported by the specification. *Id.*, 445-446. Applicant also amended the claims to recite “one or more factors [that] relate to the performance of the network,” which it asserted encompassed “any factor which relates to the performance of the network in general,” and argued that “requesting sub-parts” “requires that the ‘sub-parts’ encompass **any part of the requested portions of the video**, not just any part of the copies of the video files.” *Id.*, 446-449 (emphasis in original). Applicant further amended claim 20 to recite “requesting by the media player [. . .] from the server.” *Id.*, 449-450. Applicant argued that the combination of asserted references no longer rendered the claims obvious. *Id.*, 450-463. For example, Applicant argued that Gamble’s disclosure of selecting a file to be sent, segmenting the file into segments in the TCP layer, and sending the segments over parallel TCP connections does not teach “**requesting** by the media player a plurality of **sequential portions of one of the copies . . . from the server over a plurality of [TCP] connections**” and “automatically and progressively **requesting** by the media player from the server **over the plurality of TCP connections subsequent portions of the video from different ones of the copies**” (emphasis in original). *Id.*, 450-460.

41. On April 2, 2009, the Examiner declined to enter this amendment. *Id.*, 469-471. On April 10, 2009, Applicant submitted another amendment after final,

making identical claim changes and remarks, except to account for cancellation of claims 22 and 39. *Id.*, 498. On May 12, 2009, the Examiner declined to enter this amendment. *Id.*, 504-506.

42. On June 22, 2009, Applicant further revised its claims in a Request for Continued Examination. *Id.*, 510-536. Applicant again argued that the claims are not indefinite and that the combination of asserted prior art no longer rendered obvious the claims as amended. *Id.*, 527-532.

43. On August 20, 2009, the Examiner issued a non-final office action rejecting all claims. *Id.*, 547-560. The Examiner found that the claims recited new matter and were obvious in view of “Intelligent Streaming” (“Birney”) and U.S. Publication No. 2003/0152036 (“Quigg-Brown”). *Id.*, 549-560.

44. On October 22, 2009, Applicant further amended the then-pending claims. *Id.*, 566-583. Applicant argued that “requesting . . . over a plurality of [TCP] connections based on the time indexes” was supported by the specification’s description of, *inter alia*, streamlets encapsulated as an independent media object or file having a unique time index, and multiple TCP connections. *Id.*, 573-574. Applicant also argued that a claim amendment reciting “**repeatedly** generating a set of one or more factors” means that “the set of factors are generated more than once, not just ‘at any time set.’” *Id.*, 574-575 (underline in original). Applicant further

argued that the asserted combination of Birney and Quigg-Brown no longer rendered obvious the claims as amended, including “requesting by the media player” (first and/or second occurrences), “stored as multiple files,” “time indexes,” and the media player “making the successive determinations.” *Id.*, 575-582.

45. On February 22, 2010, the Examiner issued a final office action finding the claims obvious in view of Birney, U.S. Patent No. 6,490,627 (“Kalra”), and Quigg-Brown. *Id.*, 615-630. Among other things, the Examiner asserted that Birney teaches (i) multiple files through its disclosure of discrete streams with different quality bit rates, and (ii) time indexes through its disclosure of seamlessly switching stream qualities. *Id.*, 627-628.

46. On February 25, 2010, Applicant filed a response arguing the claims are not obvious over the asserted prior art, including that Birney teaches streams stored as a single file (not multiple files) and that seamlessly switching stream qualities does not in and of itself teach time indexes. *Id.*, 635-640. On March 23, 2010, the Examiner issued an Advisory Action maintaining the rejection. *Id.*, 641-643. On April 22, 2010, Applicant filed another response. *Id.* 654-660. On May 17, 2010, the Examiner issued another Advisory Action maintaining the rejection. *Id.*, 661-663.

47. On May 24, 2010, Applicant filed a Notice of Appeal, followed by its Appeal Brief on October 25, 2010, in which it asserted arguments that the prior art does not disclose numerous pending claim limitations. *Id.*, 665-667, 672-721. In addition to arguments based on multiple files, Applicant argued, *e.g.*, that the cited art's disclosure of bandwidth fluctuations does not teach factors indicative of (i) latency, (ii) time intervals between successive receive times for each response, or (iii) delays or losses in one or more TCP connections. *Id.*, 700-703; *see also id.*, 706. Applicant also argued that Birney's disclosure that "the [Windows Media] server selects and delivers the stream with the most appropriate bit rate" or "pushes data to a client" does not teach a web server and/or a cache server without specialized server-side intelligence. *Id.*, 703-705.

48. On February 16, 2011, the Examiner filed an Examiner's Answer to the Appeal Brief, maintaining the rejection of all pending claims. *Id.*, 753-778. On April 28, 2005, Applicant submitted its Reply Brief. *Id.*, 787-807.

49. On July 23, 2014, the PTAB issued a decision reversing the Examiner's rejection, finding that neither Birney nor Kalra discloses "that the different copies of the video are *stored as multiple files.*" *Id.*, 820-825 (emphasis in original). On August 12, 2014, the Examiner issued a Notice of Allowance. *Id.*, 1516-1525. On August 20, 2014, Applicant filed another RCE with an Information Disclosure

Statement. *Id.*, 2153-2154. On September 12, 2014, the Examiner issued another Notice of Allowance. *Id.*, 2158-2166.

B. Priority Date

50. I do not offer any opinion as to whether the '772 Patent can claim a priority date of April 30, 2004 (the "Priority Date") based on the claimed priority to the Provisional application No. 60/566,831. For the purposes of this analysis I assume the Priority Date is April 30, 2004.

VI. LEVEL OF ORDINARY SKILL IN THE ART

51. In my opinion, a person having ordinary skill in the art ("POSITA") as of the Priority Date would have had at least a B.S. degree in computer science or electrical engineering (or comparable degree) and two years of experience in networking or streaming media, or a M.S. in computer science or electrical engineering (or comparable degree). A higher level of education or specific skill might make up for less experience, and vice-versa. I was a POSITA at the time of the Priority Date.

VII. CLAIM CONSTRUCTION

52. Petitioner's counsel has informed me that claims subject to *inter partes* review are construed according to the ordinary and customary meaning of the claim

as understood by a POSITA and the prosecution history of the patent being construed.

53. For purposes of this declaration, I have applied the ordinary and customary meaning of the claims when read in light of the '772 Patent and the prosecution history of the '772 Patent, as understood by a POSITA at the time of the invention.

54. Family members of the '772 Patent were asserted in the International Trade Commission ("ITC") in Investigation No. 337-TA-1265 ("the ITC Investigation"). I also understand that Petitioner was not involved in the ITC Investigation. I understand that that in the ITC Investigation between Patent Owner and iFIT, Inc., the Chief Administrative Law Judge ("ALJ") construed "a factor indicative of the current ability to sustain the streaming [of the video ... wherein the set of one or more factors relate to the performance of the network]" according to its plain and ordinary meaning, "e.g., one or more factors relating to the performance of the network that is indicative of an ability to sustain the streaming of the video." EX1009, 53-61. The ALJ also construed "repeatedly generating a factor" as "generating a factor more than once" and construed "successive determinations" according to its plain and ordinary meaning. *Id.*, 61-64.

VIII. SUMMARY OF OPINIONS

55. In my opinion, at least claims 1-21 (the “Challenged Claims”) of the ’772 Patent are invalid as obvious to a POSITA as of the Priority Date. Although it is my opinion that at least some of the Challenged Claims would have been anticipated by Leaning, here I offer my opinion that the Challenged Claims at least would all (1) have been obvious in view of Leaning and (2) would have been obvious in view of Leaning and Gamble.

56. This declaration reflects my opinions that I have formed to date, based on my review of the materials identified in Section III. I reserve the right to revise, supplement, or amend my opinions based on new information that becomes available to me, and by further continuing analysis of the materials identified in Section III.

A. State of the Art

57. The ’772 Patent admits in the “Description of Related Art” section that “streaming media” was known, including streaming of “audio/video” where “quality that can be received for real time presentation is constrained by the available bandwidth of the user’s network connection.” EX1001, 1:31-41. The ’772 Patent further admits that TCP connections were known and that “[m]ost streaming solutions use a TCP connection.” *Id.*, 2:6-38. Further, Patent Owner admits that the “standard HTTP/TCP protocol” is “the web standard upon which the Internet is

built.” See *DISH Technologies LLC et al v. Aylo Premium Limited et al* Case No. 2:23-cv-00552-BSJ, D.I. 1 at ¶ 30. Other admissions in the ’772 Patent are that “[u]se of cache servers is well known to those skilled in the art.” EX1001, 8:6-10.

58. Before the Priority Date, “client-pull” streaming systems were known in the art wherein a client requested from a server sequential portions of a file at different encoded quality levels based on network bandwidth. For example, Chang (filed in 1999) describes “real time measurement and prediction of bandwidth for adaptive content delivery of rich media according to available user bandwidth.” EX1007, Abstract. Chang discloses a client (via java applets) that performs real time bandwidth measurement according to user’s available bandwidth and fetches the corresponding bandwidth sensitive track content from the server via HTTP requests. *Id.*, 7:43-53, 8:59-9:5, 9:45-51, 10:15-14, 10:35-58. In another example, Kliger (filed in 1997) teaches a media player device that requests from a server the appropriate bandwidth object depending on network bandwidth. EX1008, 3:25-32, 5:25-28, 9:32-10:4, 12:33:13:8, claim 3.

B. Leaning

59. Leaning (EX1004) was filed on December 14, 2001 and published on June 20, 2002. Leaning is prior art under at least (pre-AIA) 35 U.S.C. § 102(b).

Leaning is not cited on the face of the '772 Patent¹ nor was it considered by the ALJ in the ITC action.

60. Leaning discloses delivery of video over the internet from a server to a client terminal by dividing the video into a sequence of “sub-files each of which is independently requested by the terminal, which thereby has control of the rate of delivery” and “switching between alternative sub-file sets representing alternative delivery modes of data rates.” EX1004, Abstract. Leaning further explains that a “server stores two or more versions of the recording, recorded at different compression rates” and client terminal’s “player program is able to switch automatically between them” by using an “index file” that provides a list of the data rates available and each set of sub-files for each different rate. EX1004, 6:5-7:5. The client in Leaning makes repeated assessments relating to network characteristics and

¹ It is my understanding that a different United States Pre-Grant Publication (US 2004/0030547) to Leaning titled “Encoding Audio Signals” with claims drawn to encoding of audio signals was cited on the face of the '772 Patent (EX1001, 3). However, it is also my understanding that this publication is not related to the Leaning reference presented here and was not considered during examination other than being included in a lengthy IDS.

determines to request a next sub-file of a higher (or lower) rate based on these assessments. EX1004, 8:1-9:8.

C. Gamble

61. Gamble (EX1020) was filed on November 13, 2002 and published on May 13, 2004. Gamble is prior art under at least (pre-AIA) 35 U.S.C. § 102(e). Gamble is cited on the face of the '772 Patent but was not used as a reference to reject the claims during prosecution, and was not considered other than being included in an IDS. Gamble was not considered in the ITC investigation.

62. Gamble discloses transferring files over a plurality of parallel TCP connections between client and server. EX1020, Abstract, ¶ 34, 50. Gamble further discloses a client application for receiving multiple subparts of stream files over a plurality of parallel TCP connections to a server. *Id.*, ¶¶ 34-40, 50-52. Gamble further discloses implementing TCP congestion protocols for the client. *Id.*, ¶ 52.

D. Analogous Art

63. Each prior art reference is analogous art to the claimed invention in the '772 Patent. Each is in the same field of endeavor of streaming based on network conditions, with Leaning teaching adaptive-rate streaming based on network conditions. *Compare* EX1001, title, Abstract, 1:18-21, 2:44-48, 2:60-3:67, FIGs. 2c,

4, and 7, *with* EX1004, Abstract, 6:5-7:5, 8:1-9:8, FIGs. 1-5; EX1020, ¶¶ 4-5, 50-52.

64. Additionally, the prior art references are reasonably pertinent to any purported problem addressed in the '772 Patent, such as “alleviat[ing] the problems of reliability, efficiency, and latency” and “offer[ing] instantaneous viewing” using “multiple connections between a source and a destination” and/or “requesting varying bitrate streams depending upon network conditions” *Id.*; EX1001, 2:39-2:48.

E. Claims 1-21 Would Have Been Obvious in view of Leaning

Claim 1:

1[Pre]: “A method for presenting rate-adaptive streams, the method comprising:”

65. In my opinion, whether or not the preamble is limiting, Leaning teaches 1[Pre]. Leaning discloses a method for presenting a rate-adaptive digital stream from a video server (server 1) over a network (Internet 2). EX1004, Abstract (“Delivery of recorded audio or video material over a telecommunications link (2) from a server (1) to a terminal (3) . . . Provision may be made for **switching**² between alternative

² All emphases in citations to prior art references are added unless otherwise indicated.

sub-file sets representing alternative delivery modes of data rates.”), 1:3-29 (“The present invention is concerned with the delivery, over a telecommunications link, of digitally coded material for presentation to a user. . . . there is provided a terminal for playing audio or video material which is stored on a remote server as a set of files representing successive temporal portions of the said material, the terminal comprising: a telecommunications interface for communication with the server; a buffer for receiving the files from the telecommunications interface; means for playing the contents of the buffer; and control means responsive to the state of the buffer to generate request messages for further files for replenishment of the buffer. In another aspect, the invention provides a method of transmitting digitally coded audio or **video** material comprising: partitioning the material into a plurality of discrete files each representing successive temporal portions of the said material; storing the files at a first station; and at a second station - a) transmitting to the first station requests for successive respective ones of the files; b) receiving the files; and c) decoding the files for replay of the material.”), 6:13-15 (“the server stores two or more versions of the recording, recorded at different compression rates (for example at compressions corresponding to (continuous) data rates of 8, 16, 24 and 32 kbit/s respectively) and **the player program is able to switch automatically between them.**”), 16:6-10, claim 1, FIG. 1.

1[A][1]: “streaming by a media player operating on an end user station a video from a set of one or more servers,”

66. In my opinion, Leaning teaches 1[A][1]. Leaning discloses streaming by a media player (player program) operating on the end user station (terminal 3) from a set of one or more servers (server 1). EX1004, 4:4-15 (“Turning now to the terminal . . . Figure 2 shows such a terminal with a central processor 30, memory 31, a disk store 32, a keyboard 33, video display 34, communications interface 35, and audio interface (‘sound card’) 36. For video delivery, a video card would be fitted in place of, or in addition to, the card 36. In the disk store are programs which may be retrieved into the memory 31 for execution by the processor 30, in the usual manner. These programs include a communications program 37 for call-up and display of html pages - that is, a ‘web browser’ program such as Netscape Navigator or Microsoft Explorer, and a further program 38 which will be referred to here as ‘**the player program**’ which provides the functionality necessary for the playing of audio files in accordance with this embodiment of the invention.”), 5:1-14, 1:3-29 (“The present invention is concerned with the delivery, over a telecommunications link, of digitally coded material for presentation to a user. . . . there is provided a terminal for playing audio or video material which is stored on a remote **server** as a set of files representing successive temporal portions of the said material, the

terminal comprising: a telecommunications interface for communication with the **server . . .**”), 6:13-15 (“the **server** stores two or more versions of the recording, recorded at different compression rates . . . and the player program is able to switch automatically between them.”).

1[A][2]: “wherein each of a plurality of different copies of the video encoded at different bit rates is stored as multiple files on the set of servers,”

67. In my opinion, Leaning teaches 1[A][2]. Leaning discloses that each of a plurality of different copies (two or more versions of the recording) of the video encoded at different bit rates (compression rates) is stored on the video server (server 1). EX1004, 6:13-26 (“the server stores **two or more versions** of the recording, recorded at **different compression rates** (for example at compressions corresponding to (continuous) data rates of **8, 16, 24 and 32 kbit/s respectively**) . . . loaded onto the server in separate directories corresponding to the different rate, as in the following example structure, where ‘008k’, ‘024k’ in the directory name indicates a rate of 8 kbit/s or 24 kbit/s and so on.”), 9:3-7, 16:6-12 (“The **same principle** may be applied to the delivery of **video recordings**. . . the file is a video file (e.g. in H.261 or MPEG format) and the player program incorporates a video decoder. The manner of partitioning the file into sub-files is unchanged. As in the

audio case, there may be **two or more recordings corresponding to different data rates, selected by the control mechanism already described.**”).

68. Leaning further discloses that these multiple copies are stored as multiple files (sets of subfiles at each compression rate in appropriate directories). EX1004, Abstract (“dividing the material into a **sequence of sub-files** each of which is independently requested by the terminal . . . switching between **alternative sub-file sets** representing **alternative delivery modes of data rates.**”), 3:1-22 (“the file **is divided into smaller files** before being stored on the server 1. We prefer that each of these smaller files is of a size corresponding to a fixed playing time, perhaps four seconds. . . . divided into **135 smaller files** each representing four seconds’ playing time. In this example these are given file names which include a serial number indicative of their sequence in the original file, for example: 000000.bin 000001.bin 000002.bin 000003.bin. . . 000134.bin. . . ‘sub-files’ is used here to distinguish them from the original file containing the whole recording: it should however be emphasised that, as far as the server is concerned, each sub-file’ is just a file like any other file.”), 5:4-6:8, 6:21-7:7 (describing the same set of 135 sub-files (000000.bin, 000001.bin, 000002.bin. . . 000134.bin) each encoded at a different bitrate (8k, 16k, 18k, 24k, and 32k) and listed in an index file and saved in the directory appropriate for their bitrates); *see also id.*, 12:8-34, 13:23-14:19.

Directory	Subdirectory	Filename
mp3_bvv565	none	link.htm index.htm
mp3_bvv565	008k_11_m	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bvv565	016k_11_m	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bvv565	018k_11_s	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bvv565	024k_11_s	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bvv565	032k_11_s	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin

EX1004, 7 (annotated, showing each of the directories containing the different versions of the same recording (encoded at 8, 16, 24, and 32 kbit/s) and each containing the same set of subfiles (000000.bin-000134.bin) in the same order).

1[A][3]: “wherein each of the multiple files yields a different portion of the video on playback,”

69. In my opinion, Leaning discloses 1[A][3]. *See* 1[A][2]. Leaning discloses that each of the multiple files (subfiles) yields a different portion (temporal portion) of the video on playback. EX1004, 1:3-29 (“The present invention is concerned with the delivery, over a telecommunications link, of digitally coded

material for presentation to a user. . . . there is provided a terminal for playing audio or video material which is stored on a remote server as a **set of files representing successive temporal portions** of the said material . . . the invention provides a method of transmitting digitally coded audio or video material comprising: **partitioning the material into a plurality of discrete files each representing successive temporal portions of the said material**; storing the files at a first station; and at a second station - a) transmitting to the first station requests for successive respective ones of the files; b) receiving the files; and c) decoding the files for replay of the material.”), FIG. 4.

1[A][4]: “wherein the multiple files across the different copies yield the same portions of the video on playback,”

70. In my opinion, Leaning teaches 1[A][4]. *See* 1[A][3]. Leaning discloses that the multiple files (subfiles) across the different copies contains the same portions of the video on playback (*e.g.*, 000000.bin is the same portion of the video in each bitrate directory; 000001.bin is the same portion of the video in each bitrate directory; etc.) because each version has the same number of segments in the same order and having the same duration as each other. EX1004, Abstract, 1:3-29, 3:5-18 (“the file is divided into smaller files before being stored on the server 1. **We prefer that each of these smaller files is of a size corresponding to a fixed playing time,**

perhaps four seconds. With a compressed format such as MP3 this may mean that the files will be of different sizes in terms of the number of bits they actually contain. Thus the Bach file of 9 minutes duration would be **divided into 135 smaller files each representing four seconds' playing time**”), 5:4-6:8, 6:21-7:1 (describing the same set of 135 sub-files (000000.bin, 000001.bin, 000002.bin. . . 000134.bin) each encoded at a different bitrate (8k, 16k, 18k, 24k, and 32k) and listed in an index file and saved in the directory appropriate for their bitrates), 7:1-2 (“Note that because the length of a sub-file corresponds, as explained earlier, to a **fixed length of time**, the **number of sub-files is the same for each directory**.”), 12:8-20 (“It is of interest to discuss further the process of partitioning the original file into sub-files. . . . there is **no expectation that a sub-file will be followed by a sub-file other than that which immediately follows it in the original sequence** . . . the sub-file size can be a fixed number of bits, or a fixed playing time length (or neither of these) . . . In the case of rate switching, it is, if not actually essential, **highly desirable that the sub-file boundaries are the same for each rate**, so that the **first sub-file received for a new rate continues from the same point in the recording that the last sub-file at the old rate ended**. To arrange that every sub-file should represent the same fixed time period (e.g. the 4 seconds mentioned above) is not the only way of achieving this, but it is certainly the most convenient.”).

1[A][5]: “each of said files having a time index such that the files whose playback is the same portion of the video for each of the different copies have the same time index in relation to the beginning of the video, and wherein the streaming comprises:”

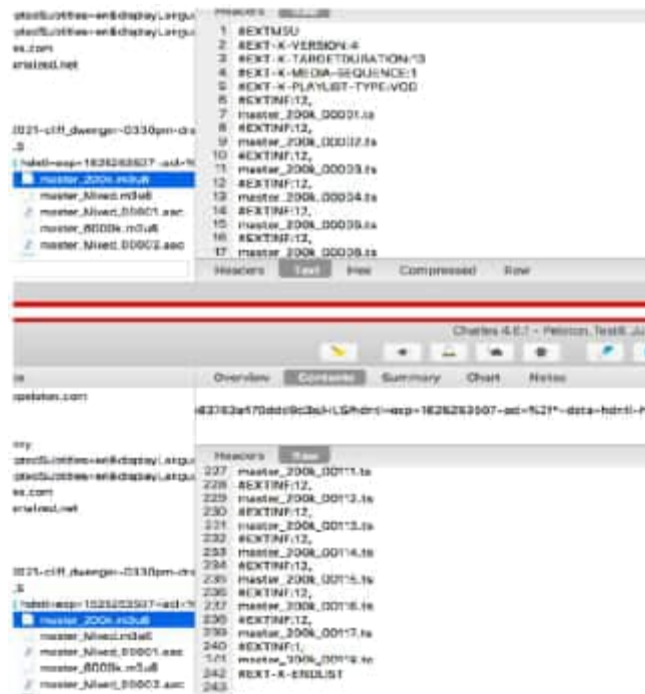
71. In my opinion, Leaning teaches 1[A][5]. Leaning discloses that each of the files (subfiles) in the different copies have a time index because the subfiles are aligned in time such that each begin at the same playback time in relation to the beginning of the video because each directory containing different bitrate copies of the video has the same number of subfiles in the same order with the same time durations encoding the same portion of the video. *See* 1[A][4]. EX1004, 12:6-20 (“In the case of rate switching, it is, if not actually essential, **highly desirable that the sub-file boundaries are the same for each rate**, so that the first sub-file received for a new rate **continues from the same point in the recording** that the last sub-file at the old rate ended.”).

Directory	Subdirectory	Filename
mp3_bwv565	none	link.htm index.htm
mp3_bwv565	008k_11_m	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bwv565	016k_11_m	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bwv565	018k_11_s	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bwv565	024k_11_s	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin
mp3_bwv565	032k_11_s	000000.bin 000001.bin 000002.bin 000003.bin . . 000134.bin

EX1004, 7 (showing each of the directories containing the different versions (8, 16, 24, and 32 kbit/s) containing the same set of subfiles (000000.bin-000134.bin) in the same order).

72. I understand that in the ITC Investigation, the ALJ interpreted “time index” according to its plain and ordinary meaning and found this limitation was met by requesting sequential media segments according to an increasing “sequential Media Sequence number that starts at an initial value (00001) for the first Media Segment and increases sequentially to end at a larger number for the last Media

Segment (00118 ... below)” noting that the “URI contains information that is an index for the relative position in time of the Media Segment within the larger Media Sequence.”



EX1010, 90-92.

73. Here, as explained above, Leaning teaches that each subfile for each quality level is sequentially ordered in the same order starting from the beginning of the video, which corresponds to the playback times and are requested in order. EX1004, 7 (sequentially numbered files 000000 to 000134 in each of the different copies), 12:6-20. Thus, to the extent “time index” is interpreted as the ALJ interpreted this limitation, Leaning meets this limitation.

74. To the extent “time index” requires files to be indexed or named with some indication of playback time, this limitation would have been obvious to a POSITA in view of Leaning. Though Leaning’s exemplary naming convention provided is to name each subfile with a number in ascending order (EX1004, 3:10-11 (“In this example these are given file names which include a serial number indicative of their sequence in the original file.”)); Leaning also teaches that “any naming convention can be used” for the subfiles (*id.*, 6:5-8).

75. Thus, a POSITA would have understood that each subfile could be named according to a time index instead of as an integer (*e.g.*, 000000.bin would be named “00:00.bin” to indicate playback time of 0 seconds; 000001.bin would be named “00:04.bin” to indicate playback time of 4 seconds; 000002.bin would be named “00:08.bin” to indicate playback time of 8 seconds; and so on). *See* EX1004, 15:19-28 (describing including “Odbits” in the index file to provide the player program with indications of playback time relative to the beginning of the recording in the form of “hours:minutes:seconds”). And a POSITA would have been motivated to name segments (subfiles) according to their playback times in this way because it still would allow for ordering the subfiles in proper playback order such that when a POSITA viewed the directory of files saved on the servers the subfiles would be listed in order of how they will be played and it would provide the benefit of

ascertaining an estimate of the overall length of the recording by simply viewing the name of the final segment in the directory. *Id.* A POSITA would have had a reasonable expectation of success with such a modification because it would simply involve changing the naming convention for the file names of subfiles stored on the server—which was contemplated by Leaning. *Id.*

76. As discussed above, the files (subfiles), starting with the first segment, play back the same portion of video for the different copies. *See* 1[A][4]. And the media player (player program) streams the video. *See* 1[A][1].

1[B]: “requesting by the media player a plurality of sequential ones of the files of one of the copies from the set of servers over a plurality of Transmission Control Protocol (TCP) connections based on the time indexes;”

77. In my opinion, Leaning teaches 1[B].

78. First, it is my opinion that Leaning teaches the “requesting a plurality of sequential files” portion of this limitation.

79. In my opinion, Leaning teaches requesting a plurality of sequential files (subfiles) of one of the copies from the set of servers (server 1). As already described above, Leaning discloses that the subfiles of each of the copies are in the same sequential order. *See* 1[A][2], 1[A][4]-[A][5]. Leaning further discloses that end user device (terminal 3) independently requests, via the player program, each of the

sequential files (subfiles) of one of the copies from the video server in order. *See* 1[A][5]; EX1004, Abstract (“Delivery of recorded audio or video material over a telecommunications link (2) from a server (1) to a terminal (3) is accomplished by dividing the material into a **sequence of sub-files each of which is independently requested by the terminal**, which thereby has control of the rate of delivery. Provision may be made for switching between alternative sub-file sets representing alternative delivery modes of data rates.”), 1:12-19 (“According to one aspect of the invention there is provided a terminal for playing audio or **video** material which is stored on a remote server as a set of files representing successive temporal portions of the said material, the terminal comprising: a telecommunications interface for communication with the server; a buffer for receiving the files from the telecommunications interface; means for playing the contents of the buffer; and **control means responsive to the state of the buffer to generate request messages for further files for replenishment of the buffer.**”), 2:15-18 (“The function of the server 1 is to store data files, to **receive from a user terminal a request for delivery of a desired data file and, in response to such a request, to transmit the file to the user terminal via the network.**”), 5:4-6:2 (“The **player program**, having received the URL, adds to this the filename of the first sub-file, to produce a complete address for the sub-file - i.e. `www.server1.com/mp3_bwv565/000000.bin`.”)

. . . The **program constructs a request message for the file having this URL** and transmits it to the server 1 via the communications interface 35 and the internet 2. . . We envisage that the **player program would send the requests** directly to the communications interface, rather than via the browser. The server responds by transmitting the required sub-file. . . . The **player program increments the filename to 000001.bin and requests**, receives, decodes and stores this second sub-file as described in (4) and (5) above. . . . This process is repeated until a ‘file not found error’ is returned.”), 6:27-7:2, 8:6-16, claims 1(“A terminal for playing audio or video material which is stored on a remote server as a set of files representing successive temporal portions of the said material . . . characterised by control means operable to determine the addresses of further files to be requested and operable in response to the state of the buffer to generate request messages, containing such addresses, for further files for replenishment of the buffer”), 11 and 16. Leaning additionally discloses that end user device (terminal 3) requests, via the player program, a plurality of the sequential files (subfiles). EX1004, 5:6-32 (“The player program has a parameter called the playout time T_p . In this example it is set at 10 seconds (it could be made user-selectable, if desired). It determines **the degree of buffering that the terminal performs**. The player program increments the filename to 000001.bin and requests, receives, decodes and stores this second sub-file as

described in (4) and (5) above. **It repeats this process until the contents of the buffer reach or exceed the playout time T_p .**”).

80. Second, it is my opinion that Leaning teaches the “plurality of TCP connections” portion of this limitation.

81. In my opinion, Leaning also teaches that the media player (player program) is configured to stream the video from the video server (server 1) over a plurality of TCP connections. *See* EX1004, 2:5-32 (“The system shown in Figure 1 has as its object the delivery, to a user, of digitally coded audio signals . . . the system may be used to convey video signals instead of, or in addition to, audio signals. In this example, the **network is the internet** or other packet network operating in accordance with the **Hypertext Transfer Protocol (see RFCs 1945/2068 for details)** . . . In Figure 1, a **server 1 is connected via the internet 2 to user terminals 3**, only one of which is shown. The function of the server 1 is to store data files, to **receive from a user terminal a request** for delivery of a desired data **file** and, in response to such a request, to transmit the file to the user terminal via the network. Usually such a **request takes the form of a first part indicating the network delivery mechanism (e.g. http:// or file:// for the hypertext transfer protocol or file transfer protocol respectively)** followed by the network address of the server (e.g. **www.server 1.com)** **suffixed with the name of the file that is being requested.**

. . . In these examples, the **use of the hypertext transfer protocol is assumed** . . . [server 1] is merely **an ordinary ‘web server’.**”), 4:4-21.

82. A POSITA would have understood Leaning’s teachings of a terminal connecting to an ordinary web server via the Internet to request subfiles from the server using HTTP (*i.e.*, HTTP 1.0 (RCF 1945) or HTTP 1.1 (RCF 2068)) to include teaching a plurality of TCP connections for such requests because a POSITA would have known that ordinary web servers supported both HTTP and TCP and that HTTP operates over TCP connections.³ *see also* EX1004, 5:8-14 (“The program constructs **a request message for the file having this URL and transmits it to the server 1 via the communications interface 35 and the internet 2.** (Processes for translating the URL into an **IP** address . . . [is] **conventional** and will not therefore be described). We envisage that the **player program would send the requests** directly to the communications interface, rather than via the browser. **The server responds by transmitting the required sub-file.**”). For example, a POSITA would have known that a terminal requesting sequential subfiles from an ordinary web server

³ Indeed, the ’772 Patent admits that TCP connections were known and used by most streaming solutions, and Patent Owner also admits that the “standard HTTP/TCP protocol” is “the web standard upon which the Internet is built. *See* Section VIII.A

using the HTTP 1.0 protocol (RFC1945) (EX1004, 2:10) as disclosed by Leaning would require using multiple TCP connections because each HTTP request in HTTP 1.0 must establish a new TCP connection to request and receive each sequential subfile. Thus, a POSITA would have understood Leaning to teach that HTTP operates over a plurality of TCP connections.

83. Finally, it is my opinion that Leaning also teaches the “requesting based on the time indexes” portion of this limitation.

84. Leaning also teaches that the client requests the files “based on the time indexes” because, as explained above with respect to limitation 1[A][5], each subfile is sequentially ordered starting from the beginning of the video, which corresponds to the playback times, and the elements are requested in such order. In the ITC Investigation, the ALJ did not explicitly construe “requesting a plurality of sequential files of one of the copies from the video server based on the time indexes.” However, DISH argued, and the ALJ found, that requesting sequential media segments “based on their filenames” that included a unique sequential number corresponding to their position in playback sequence satisfied this limitation of requesting streamlets “based on the time indexes.” EX1009, 93.

85. Here, as explained above, Leaning discloses precisely what DISH argued, and the ALJ determined, met requesting “based on the time indexes” (*i.e.*,

player independently requesting each of the subfiles 000000.bin to 000134.bin in order at the appropriate quality level). *See* 1[Pre]-1[B]. Therefore, according to DISH and the ITC's interpretation, Leaning discloses requesting files (subfiles) according to their playback times.

86. In my opinion, DISH and the ITC are incorrect in their interpretation that simply requesting files in order is requesting “based on the time indexes” because each subfile may be a different time duration and the player may not know which specific playback time it is requesting. For example, if 000000.bin is 5 seconds, 000001.bin is 3.5 seconds, and 000002.bin is 4 seconds then the player would request 000000.bin then 000001.bin then 000002.bin—but the player would not be requesting these subfiles *based on time indexes* but rather requesting them *according to their order*.

87. However, under DISH and the ALJ's interpretation, Leaning explicitly discloses that each sequential subfile is preferably the same time duration (*e.g.*, 4 seconds) such that a request for 000000.bin is a request for playback time 0-4 seconds; a request for 000001.bin is a request for playback time 4-8 seconds; and a request for 000003.bin is a request for playback time 8-12 seconds; and so on. EX1004, 3:5-18 (“We prefer that each of these smaller files is of a size corresponding to a fixed playing time, perhaps **four seconds**. . . . would be **divided**

into 135 smaller files each representing four seconds' playing time”), 5:4-6:8, 6:21-7:1; *see also id.*, FIG. 4. Therefore, it is my opinion that under DISH and the ALJ’s interpretation, Leaning discloses requesting based on the time indexes because all the segments are 4 seconds in duration so the time index of each segment is readily and accurately ascertainable. Further, if the claims are read to require the request having an indication of the time index as described above, a POSITA would have been motivated to name subfiles according to their time indexes (*see* 1[A][5]) and, as such, when subfiles are requested based on subfile name, each subfile would thus be requested “based on the time indexes.”

1[C]: “automatically requesting by the media player from the set of servers over the plurality of TCP connections subsequent portions of the video by requesting for each such portion one of the files from one of the copies dependent upon successive determinations by the media player to shift the playback quality to a higher or lower quality one of the different copies, said automatically requesting including,”

88. In my opinion, Leaning teaches 1[C]. Leaning discloses automatically requesting from the set of servers subsequent portions of the video over the TCP connections by requesting for each such portion one of the files from one of the copies. *See* 1[A][2]-[A][5]. Leaning also teaches that selection of a higher or lower quality for each subfile may be dependent upon successive determinations. More particularly, the player program makes multiple

determinations one after the other before shifting up in quality and before shifting down in quality.

89. For example, when determining to shift down, the Player determines (1) if the buffer is empty, (2) if the measured rate is less than the current rate, and (3) if the measured Buffer Low Percentage more than a Step Down Threshold before shifting down; when determining to shift up, the Player determines (1) if the measured rate exceeds the current rate, and (2) if the measured rate exceeds the next higher rate for a given period of time before shifting up. EX1004, 8:17-26. Once the successive determinations conclude that the player should shift up or shift down, “rate change is effected simply by the player program changing the relevant part of the sub-file address for example, changing ‘008k’ to ‘024k’ to increase the data rate from 8 to 24 kbit/s and changing the current rate parameter to match” and “the next request to the server becomes a request for the higher (or lower) rate, and the sub-file from the new directory is received, decoded and entered into the buffer.” EX1004, 9:3-7, 9-11 (flowchart showing successive determinations to shift up or shift down), claims 4 (“server storing a plurality of sets of files, which sets correspond to respective different delivery modes, the terminal including: means operable to effect mode **switching by providing that subsequent request messages shall request files from a set different from the set to which the**

immediately preceding request related”), 5 (“said sets of files correspond to respective different data rates, in which: the terminal includes means for **monitoring the received data rate**; the mode switching means is operable, in the event that the **measured rate is below** that needed for the set to which the currently requested file belongs, to provide that subsequent said request messages shall request files from a set corresponding to a **lower data rate**”), 6 (“in the event that the **measured rate is sufficient** to support delivery of files of a **higher data rate** than that of the set to which the currently requested file belongs, to provide that subsequent said request messages shall request files from a set corresponding to a **higher data rate**”), 11 and 12

1[D]: “repeatedly generating a set of one or more factors indicative of the current ability to sustain the streaming of the video using the files from different ones of the copies, wherein the set of one or more factors relate to the performance of the network;”

90. In my opinion, Leaning teaches 1[D]. Patent Owner contended during prosecution of the ’772 Patent that there is allegedly sufficient disclosure for such a factor being “indicative of latency, delays or losses of the requested portions, and available bandwidth of the TCP connections.” EX1002, 447-448 (footnotes omitted).

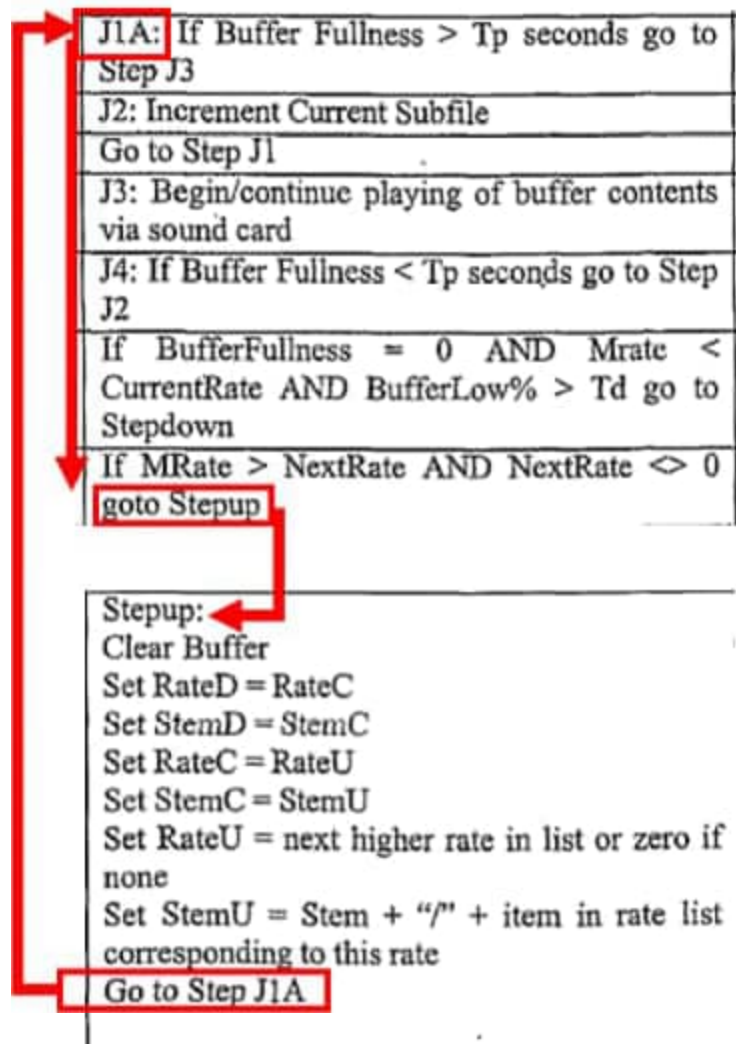
91. Leaning discloses “repeatedly generating a set of one or more factors indicative of the current ability to sustain the streaming of the video using the files from different ones of the copies, wherein the set of one or more factors relate to the performance of the network” because it teaches repeatedly generating a “measured rate” (*i.e.*, the measured actual data rate being received from the server, averaged over a period of time) and comparing it to a “current rate” (*i.e.*, the bitrate of the current stream) to determine if the current stream is sustainable. EX1004, 8:7-26, claims 5 and 6. Additionally, Leaning repeatedly generates another factor (“Buffer Low Percentage”) which is “the percentage of time that the buffer contents represent less than 25% of the playout time (*i.e.* the buffer is getting close to being empty).” EX1004, 8:27-28. Leaning also explains “that interruption” of the video stream “can be avoided and therefore it is preferable to employ a criterion which anticipates underflow and avoids it in the majority of cases” by omitting the first determination (*i.e.*, whether the buffer is completely empty) and generating measured rate and Buffer Low Percentage factors as indicators of whether the current streaming rate is sustainable. EX1004, 15:3-8, 8:11-16 (repeatedly generates the factor because “process **from then on** is that the player program **measures the actual data rate being received from the server, averaged over a period of time (for example 30 seconds)**). It does this by timing every URL request; the transfer rate achieved

(number of bits per second) between the client and server is determined. The **accuracy of this figure improves as the number of requests goes up**. The player maintains two stored parameters which indicate, respectively, the current rate, and the **measured rate.**”), 8:17-11:1; 1[C].

1[E]: “making the successive determinations to shift the playback quality based on at least one of the set of factors to achieve continuous playback of the video using the files of the highest quality one of the copies determined sustainable at that time; and”

92. In my opinion, Leaning teaches 1[E]. As explained above, Leaning discloses making the successive determinations to shift the playback quality based on the factor to achieve continuous playback of the video using the files (subfiles) of the highest quality copy of the video that is determined to be sustainable at that time. *See* 1[C]-1[D]. Leaning teaches choosing the highest quality copy that is sustainable (*i.e.*, if measured rate > current rate AND measured rate > next highest rate for period of time, then shift up until no longer true—meaning shift up to highest sustainable version). EX1004, 8:24-26 (“if the measured rate exceeds not only the current rate **but also the next higher rate** for a given period of time (e.g. 120 seconds: this could if desired be made adjustable by the user) **increase the current rate.**”), 9:3-7, 9-11 (flowchart showing successive determinations to shift up to highest rate deemed sustainable). For example, the excerpted and annotated portion

of Leaning's process flow chart below shows that the player on the terminal beginning with step J1A moves through the process and if "MRate [measured rate] is greater than NextRate [next highest rate] AND NextRate $\leq$ 0 [there exists a next higher rate] then goto Stepup; and the Stepup process shifts up by changing the RateC [current rate] to the RateU [next highest rate] and changes RateU to the next higher rate, or to "0" if the current rate is the highest rate then loops back to step J1A and continues the process. Thus, Leaning discloses looping "Stepup" until the highest sustainable rate is achieved up to the highest available rate (by setting RateU to zero). EX1004, 9-11.



EX1004, 10 (flowchart excerpted and annotated)

1[F]: “presenting the video by playing back with the media player on the end user station the requested files in order of ascending playback time.”

93. In my opinion, Leaning discloses 1[F]. Leaning teaches presenting the video by decoding and playing back the subfiles of the video with the player program

on the terminal in order of ascending start time. EX1004, 1:13-28, 4:4-21, 5:23-6:2, 12:16-18, 14:6-11, claim 1 (“means for playing the contents of the buffer”).

Claim 2: “The method of claim 1, wherein said requesting the plurality of sequential ones of the files includes requesting sub-parts of the files over different ones of the plurality of TCP connections, and wherein said presenting includes reassembling the files from the received sub-parts.”

94. In my opinion, Leaning teaches claim 2. *See* 1[B] (establishing plurality of TCP connections). A POSITA would have been motivated to configure Leaning’s apparatus to request sub-parts of the files (subfiles) over different TCP connections and reassemble the files from the received subparts. A POSITA would have understood that this improves reliability in situations where one connection fails by retrieving other subparts over other connections and retrieving more of file more quickly. A POSITA also would have understood that it takes advantage of available bandwidth by parallelizing retrieval of a segment to increase throughput where an individual TCP connection’s maximum throughput is the bottleneck. A POSITA would have had a reasonable expectation of success with such a modification because the TCP protocol allows for multiple connections, and utilizing multiple connections to request and retrieve different parts of a single file was well known.

Claim 3: “The method of claim 1, wherein said making the successive determinations to shift comprises: upshifting to a higher quality one of the different copies when the at least one factor is greater than a first threshold; and determining if the higher quality playback can be sustained.”

95. In my opinion, Leaning teaches claim 3. Leaning discloses that the media player (player program) upshifts to a higher quality one of the different copies when the factor (the “measured rate” factor) is greater than a first threshold (the “next higher rate” for a given period of time) and determines that the higher quality playback can be sustained. *See* 1[C]-1[E]; EX1004, 8:17-26, claims 4 (“server storing a plurality of sets of files, which sets correspond to respective different delivery modes, the terminal including: means operable to effect mode switching by providing that subsequent request messages shall request files from a set different from the set to which the immediately preceding request related”), 6 (“in the event that the measured rate is sufficient to support delivery of files of a higher data rate than that of the set to which the currently requested file belongs, to provide that subsequent said request messages shall request files from a set corresponding to a higher data rate”).

Claim 4: “The method of claim 3, wherein said making the successive determinations to shift comprises downshifting to a lower quality one of the different copies when the at least one factor is less than a second threshold.”

96. In my opinion, Leaning teaches claim 4. Leaning discloses that that the media player (player program) downshifts to a lower quality one of the different copies when the at least one factor (the “measured rate” factor) is less than a second threshold (“current rate” (and when the Buffer Low Percentage more than a Step Down Threshold)). *See* 1[C]-1[E]; EX1004, 8:17-26, claims 4, 5 (“said sets of files correspond to respective different data rates, in which: the terminal includes means for monitoring the received data rate; the mode switching means is operable, in the event that the measured rate is below that needed for the set to which the currently requested file belongs, to provide that subsequent said request messages shall request files from a set corresponding to a lower data rate”).

Claim 5:

5[A]: “The method of claim 1, further comprising: receiving user input to enable one of fast-forward, skip randomly, and rewind functionality; and”

97. In my opinion, Leaning teaches 5[A]. Leaning discloses functionality for fast forward and fast reverse modes, as well as skipping randomly, including receiving user input. *See* EX1004, 16:11-18:17 (describing fast forward and fast reverse functionality, including “**a fast forward command**” and “fast rewind being

similar [to fast forward] but in reverse”), 11:12-12:17 (jumping to an arbitrary point of the video, “implemented by the **user indicating which part of the recording he wishes to jump to** - for example by **moving a cursor to a desired point on a displayed bar** representing the total duration of the recording” or alternatively whereby “the user may be presented with a **list of text labels or indices which may be selected (e.g. by means of a mouse)** to initiate a jump”). To the extent Leaning does not expressly disclose receiving user input for rewind functionality, a POSITA would have understood it to be taught by Leaning’s disclosure of a fast forward command and rewind being similar but in reverse.

Claim 5[B]: requesting files of the video at a specified time index that is not the next sequential time in the current playback.”

98. In my opinion, Leaning teaches 5[B]. As explained with respect to limitation 5[A], Leaning discloses requesting a specified time index that is not the next sequential time in the current playback, such as via jump functionality, where the user can move a cursor on a bar representing the total duration of the recording or selecting text labels or indices. *See* EX1004, 11:12-12:17 (describing the index as containing lines in the form of “hours:minutes:seconds” timecodes).

99. Additionally, Leaning discloses pre-requesting files (sub-files) before playback. *See* EX1004, 5:6-6:2 (repeating the process of requesting, receiving,

decoding, and storing sub-files until the contents of the buffer reach or exceed a threshold T_p and requesting a further sub-file from the server (“pre-request files”) when the buffer is below the T_p threshold). The ’772 Patent explains, without elaboration, that “the agent controller module 402 may be configured to anticipate streamlet 212 requests and pre-request streamlets 212. By pre-requesting streamlets 212, the user may fast-forward, skip randomly, or rewind through the content and experience no buffering delay.” EX1001, 8:46-50. A POSITA would have understood from Leaning’s commensurate disclosure of pre-loading subfiles that fast-forward, skip randomly, and rewind functionality was enabled. Moreover, a POSITA would have understood that when fast forwarding or randomly skipping to a part of the video past the length of one subfile, or rewinding to a previous part of the video, whether or not those subfiles already have been retrieved and are stored or remain in the cache, then those subfiles are at a specified time index that is not the next sequential time in the current playback.

100. To the extent Patent Owner argues that Leaning does not teach anticipating file requests and pre-requesting files to enable fast-forward, skip randomly, and rewind functionality, a POSITA would have been motivated to configure Leaning’s apparatus to anticipate file requests and pre-request files in order to utilize available bandwidth and ensure a sufficient buffer of data for such

standard playback and control functionality. These functions were well known in the art and expected by consumers of multimedia content. *See* EX1013, 2:64-3:4 (discussing seeking to a particular point of time in on-demand multimedia content and its inherent delay). A POSITA would have had a reasonable expectation of success with such a modification because Leaning teaches preloading sub-files as well as functionality for fast-forwarding, skipping randomly, and rewinding, and these functions were well known and commonly implemented in media players in the art.

Claim 6: “The method of claim 1, wherein said requesting the plurality of sequential one of the files includes requesting the files from a low quality one of the different copies to enable instant playback of the video, and wherein said automatically requesting includes-upshifting to a higher quality one of the different copies.”

101. In my opinion, Leaning teaches claim 6. Leaning teaches that the media player (player program) initially requests low quality files (*e.g.*, requesting first subfile at 024k) to enable instant playback of the content file, and subsequent upshifts according to the performance factor (*e.g.*, upshifting to 032k when “measured rate” exceeds 32 kbit/s for a set period of time). *See* 1[C]-1[E]; EX1004, (“It then **begins to request** the audio sub-files as described earlier, **from the first-mentioned ‘rate’** directory in the index file - **viz. 024k_11_s** (or the terminal could

override this by modifying this to a default rate set locally for that terminal). The process from then on is that the player program **measures the actual data rate** being received from the server, averaged over a period of time (for example 30 seconds). It does this by timing every URL request; the transfer rate achieved (number of bits per second) between the client and server is determined. The accuracy of this figure improves as the number of requests goes up. The player maintains two stored parameters which indicate, respectively, the current rate, and the **measured rate.**”).

Fig.3.

```
<html>
<head>

<!-- Odbits: Mode = "recorded" -->
<!-- Audio = "mp3-024k_11_s mp3-032k_11_s mp3-018k_11_s mp3-016k_11_m
mp3-008k_11_m" -->
<!-- LFI = "44" -->
<!-- SL = "178" -->
<!-- Title = "Toccat and Fugue in D minor" -->
<!-- Author = "J.S. Bach" -->
<!-- Created = "6 Nov 2000" -->
<!-- Copyright = "© 1999" -->
<!-- Comments = "One of Bach's many organ works." -->
</head>
<body>
An announcement to appear on the display
</body>
</html>
```

EX1004, FIG. 3 (annotated, showing initially requested 24 kbit/s which is lower than higher potential quality level 32 kbit/s)

Claim 7: “The method of claim 1, wherein said requesting the plurality of sequential ones of the files includes requesting the plurality of sequential ones of the files over different ones of the plurality of TCP connections.”

102. In my opinion, Leaning teaches claim 7. *See* 1[B] (establishing multiple TCP connections), claim 2 (obvious to establish multiple TCP connections for sub-parts). A POSITA would have been motivated to configure Leaning’s apparatus to request sequential files (subfiles) over different TCP connections. As a POSITA would have understood, this improves reliability in situations where one connection fails by retrieving sequential files over other connections and retrieving file data more quickly. It also takes advantage of available bandwidth by parallelizing retrieval of files to increase throughput where an individual TCP connection’s maximum throughput is the bottleneck. A POSITA would have had a reasonable expectation of success with such a modification because the TCP protocol enables multiple connections through the use of different port number combinations, and utilizing multiple connections to request and retrieve different files was well known. *Id.* Whether to utilize multiple TCP connections to retrieve multiple sequential files was a known design choice to improve performance of media playback when the bandwidth of a single TCP connection is the bottleneck.

Claim 8: “The method of claim 1, wherein said presenting comprises sequentially arranging the requested files from the different copies in the order of ascending playback time for playback with the media player on the end user station.”

103. In my opinion, Leaning teaches claim 8. *See* 1[F] (requesting, receiving, and displaying ordered series of presentation segments, including collections of segments at different quality levels), 1[A][2] (different copies encoded at different bit rates), 1[C][2] (retrieving collections of segments at different quality levels).

Claim 9: “The method of claim 1, wherein said automatically requesting includes requesting sub-parts of the files over different ones of the plurality of TCP connections, and wherein said presenting includes reassembling the files from the received sub-parts.”

104. In my opinion, Leaning teaches claim 9. *See* claim 2. A POSITA would have understood requesting subparts over different TCP connections and reassembling them into files in connection with both (initial) requests (as in claim 2) and automatic requests of subsequent portions (as in claim 9), as requesting and reassembling subparts of a subfile is agnostic as to the subfile’s time index in relation to the beginning of the video.

Claim 10: “The method of claim 1, wherein the at least one of the set of factors is indicative of the available bandwidth of the plurality of TCP connections.”

105. In my opinion, Leaning teaches claim 10. *See* 1[B] (establishing plurality of TCP connections), 1[D] (factor indicative of available bandwidth); One of the set of factors Leaning teaches is the “measured rate.” This factor is measured “by timing every URL request” and determining “the transfer rate achieved (number of bits per second) between the client and server,” “averaged over a period of time (for example 30 seconds).” EX1004, 8:11-14. Because the measured rate accounts for the timing of both the request and the response, a POSITA would have understood that this factor is a measure of latency (timing of the request) and network bandwidth (rate of the response), and as such is “indicative of the available bandwidth of the plurality of TCP connections.”

106. To the extent that Patent Owner argues that Leaning does not teach that the factor is indicative of the available bandwidth of the plurality of TCP connections, a POSITA would have been motivated to configure the performance factor to be indicative of such bandwidth. For example, a POSITA would have understood that the available bandwidth over the TCP connections impacts streaming performance because it measures how much data can be retrieved within a given time, thereby being an important factor in considering when the requested

sub-file will be fully available for playback. As such, a POSITA would have been motivated to repeatedly monitor and factor such available bandwidth over the plurality of TCP connections in the determination whether to shift quality. A POSITA would have had a reasonable expectation of success with such a modification because Leaning teaches measuring the transfer rate in response to each request, and monitoring streaming performance and network conditions such as available bandwidth was well known. EX1004, 8:13-14, 10.

Claim 11: “The method of claim 1, wherein the at least one of the set of factors is indicative of latency of the requested files, wherein the latency is a time measure between when one of the requests is issued and a time that response data of the request begins to arrive at the end user station.”

107. In my opinion, Leaning teaches claim 11 As explained in connection with element 1[D], one of the set of factors Leaning teaches is the “measured rate.” This factor is measured “by timing every URL request” and determining “the transfer rate achieved (number of bits per second) between the client and server,” “averaged over a period of time (for example 30 seconds).” EX1004, 8:11-14. Because the measured rate accounts for the timing of both the request and the response, a POSITA would have understood that this factor is a measure of latency (timing of the request) and network bandwidth (rate of the response), and as such is “indicative of latency of the requested files [subfiles], wherein the latency is a time

measure between when one of the requests is issued and a time that response data of the request begins to arrive at the end user station [terminal].”

108. To the extent that Patent Owner argues that Leaning does not teach that the factor is indicative of latency measured as a time measure between when one of the requests is issued and a time that response data of the request begins to arrive at the end user station, a POSITA would have been motivated to configure the performance factor to be indicative of such a latency measure. For example, a POSITA would have understood that the time difference between a request and the beginning of arrival of response data impacts streaming performance and could reflect network conditions such as congestion, whereby a larger time difference increases the risk of interrupted playback because there is less time to retrieve a requested file before it is needed to be played back. Furthermore, it would have been obvious to a POSITA that the initial latency represents when the start of the reply to the sub-file request would be received, and this latency is an important factor in considering when the requested sub-file will be initially available for playback. As such, a POSITA would have been motivated to repeatedly monitor and factor such latency in the determination whether to shift quality. A POSITA would have had a reasonable expectation of success with such a modification because Leaning teaches

timing the URL requests, and monitoring streaming performance and network conditions such as latency was well known. EX1004, 8:13, 10.

Claim 12: “The method of claim 1, wherein the at least one of the set of factors is indicative of time intervals between successive receive times for each response to the requested files.”

109. In my opinion, Leaning teaches claim 12. As explained in connection with claim 11, one of the set of factors Leaning teaches is the “measured rate,” which is measured “by timing every URL request” and determining “the transfer rate achieved (number of bits per second) between the client and server,” “averaged over a period of time (for example 30 seconds).” EX1004, 8:11-14. Because the measured rate reflects multiple measurements of request and response, a POSITA would have understood that this factor is indicative of time intervals between successive receive times for each response to the requested files (subfiles).

110. To the extent that Patent Owner argues that Leaning does not teach that the factor is indicative of time intervals between successive receive times for each response to the requested files, a POSITA would have been motivated to configure the performance factor to be indicative of such time intervals. For example, a POSITA would have understood that the interval between successive receive times data impacts streaming performance and could reflect network conditions such as

congestion, whereby a larger interval increases the risk of interrupted playback because there is less time to retrieve a given file and the next file before they are played back. As such, a POSITA would have been motivated to repeatedly monitor and factor such intervals between receive times in the determination whether to shift quality. A POSITA would have had a reasonable expectation of success with such a modification because Leaning teaches timing the URL requests and measuring response rates, which for known bit rates are indicative of response times, and monitoring streaming performance and network conditions was known. EX1004, 8:11-14, 10.

111. As an additional example, a POSITA was aware of network jitter—“variability in the rate at which data is transmitted through a network” (EX1013, 2:46-47)—as a factor indicative of time intervals between successive receive times. A POSITA knew to utilize it as a performance factor because large jitter could result in a buffer underflow and necessitate a lower quality level, *i.e.*, an inability to sustain the current level. A POSITA would have had a reasonable expectation of success because adapting to network conditions such as jitter was well known and consistent with Leaning’s teaching of utilizing adaptive bitrate streaming to remedy problems caused by network conditions such as congestion. *See* EX1004, 8:9-12.

Claim 13: “The method of claim 1, wherein the at least one of the set of factors is indicative of delays or losses in one or more of the plurality of TCP connections.”

112. In my opinion, Leaning teaches claim 13. As explained in connection with element 1[D], one of the set of factors Leaning teaches is “Buffer Low Percentage,” which reflects how often the buffer contents are close to empty. Leaning teaches that buffer underflow can be caused by network congestion, which its disclosure of adaptive bitrate streaming is designed to remedy. *See* EX1004, 6:10-12. Accordingly, a POSITA would have understood that this factor is indicative of congestion and thus delays or losses in the one or more TCP connections.

Claim 14: “The method of claim 1, wherein at least one of the set of servers is a web server.”

113. In my opinion, Leaning teaches claim 14. *See* 1[Pre]; EX1004, 2:31-32 (“Thus it is merely an ordinary ‘web server’.”).

Claim 15: “The method of claim 14, wherein the files are requested from the web server using Hyper Text Transfer Protocol (HTTP), and wherein the web server is without specialized server-side intelligence to respond to said requesting.”

114. In my opinion, Leaning teaches claim 15. *See* EX1004, 2:5-32 (“In this example, the network is the internet or other packet network operating in accordance with the **Hypertext Transfer Protocol** (see RFCs 1945/2068 for details)”; “Usually such a request takes the form of a first part indicating the network delivery

mechanism (e.g. **http:// . . . for the hypertext transfer protocol . . .**); “In these examples, the use of the **hypertext transfer protocol** is assumed”; “Conventionally, a server for delivery of MP3 files takes the form of a so-called streamer which includes processing arrangements for the dynamic control of the rate at which data are transmitted . . . , for the masking of errors due to packet loss and . . . the control of the flow of data between server and client; **here however the server 1 need contain no such provision.** Thus it is **merely an ordinary ‘web server’.**”); 1[A][2] (TCP connection).

Claim 16: “The method of claim 1, wherein at least one of the set of servers is a cache server of a network infrastructure operator.”

115. In my opinion, Leaning teaches claim 16. Patent Owner admits that “[u]se of cache servers is well known to those skilled in the art, and will not be discussed further herein.” EX1001, 8:6-10; *see* Section VIII.A; A POSITA would have been motivated to configure Leaning’s apparatus to connect to a cache server in order to improve and increase reliability of response time and performance as compared to connecting to a webserver. A POSITA would have had a reasonable expectation of success with such a modification because the cache servers were well known, as admitted by Patent Owner, and implemented by ISPs and other network infrastructure operators in common networking protocols as alternatives to

webservers, and Leaning teaches that “other . . . networks can be used” besides the Internet. EX1004, 2:9-11

Claim 17:

17[A]: “The method of claim 1, wherein: said generating the set of factors comprises: monitoring time intervals between successive receive times for each of the requested files;”

116. In my opinion, Leaning teaches 17[A]. *See* claim 12.

17[B]: “calculating a current performance ratio across a current window of the time intervals; and”

117. In my opinion, Leaning teaches 17[B]. Leaning discloses that the player program “measures the data rate being received from the server . . . by timing every URL request; the transfer rate (number of bits per second) between the client and server is determined.” EX1004, 8:11-14. A POSITA would have understood that the data rate is a ratio (number of bits per second) indicative of performance (where a larger ratio indicates better performance) across a current window of the time intervals (the window covering each request).

17[C]: “calculating a current average of the performance ratio to obtain a current performance factor of the set of factors;”

118. In my opinion, Leaning teaches 17[C]. Leaning discloses that the performance ratio (number of bits per second) is “averaged over a period of time (for example 30 seconds)”; Leaning refers to this average as “the measured rate.”

EX1004, 8:11-16. A POSITA would have understood that the measured rate is indicative of current performance (where a larger ratio indicates better performance).

17[D]: “said making further comprises: comparing the current performance factor with a set of one or more trigger thresholds; and”

119. In my opinion, Leaning teaches 17[D]. *See* 1[E], claim 3 (comparing performance factor to threshold).

17[E]: “determining whether to upshift or downshift to a higher or lower quality one of the different copies based on said comparing.”

120. In my opinion, Leaning teaches 17[E]. *See* 1[E], claims 3, 4 (upshifting or downshifting).

Claim 18:

18[A]: “The method of claim 1, wherein said making comprises: comparing a current performance factor of the set of factors with a set of one or more trigger thresholds, wherein the set of one or more trigger thresholds is determined by a combination of two of the set of factors relating to a current read ahead margin and a minimum safety margin, wherein the current read ahead margin is an amount of contiguously available, sequentially arranged requested files of video received by the media player for playback at a current playback time index; and”

121. In my opinion, Leaning teaches 18[A]. Leaning discloses that the media player (player program) compares a current performance factor with a set of one or more trigger thresholds. The set of one or more trigger thresholds is determined by

a combination of factors relating to a current read ahead margin—an amount of contiguously available, sequentially arranged requested files received by the media player for playback at a current playback time index—and a minimum safety margin.

122. Leaning teaches that buffer fullness is a current performance factor that is compared to a trigger threshold T_p , playout time. EX1004, 5:6-32, 8:17-9:2, 10. A POSITA would have understood that buffer fullness is indicative of current performance insofar as having more subfiles in the buffer means there is more time for the video to play out while the next subfiles are retrieved, reducing the risk of interruption. A POSITA also would have understood that because Leaning's subfiles are all the same length (*i.e.*, four seconds), it would be an obvious design choice whether the buffer fullness was measured based on playback time or the number of contiguously available, sequentially arranged files that were requested and received by the media player for playback at a current playback time index—a current read ahead margin. Using counters to measure the number of files in a buffer or queue was well-known in the art. A POSITA further would have understood that the trigger threshold is determined in part by a factor relating to a minimum safety margin, as the playout time T_p reflects how far the video can be read ahead and played back with the amount of subfiles that already have been retrieved.

123. To the extent that Patent Owner argues that Leaning does not teach that the set of one or more trigger thresholds is determined by a combination of factors relating to a current read ahead margin and a minimum safety margin, wherein the current read ahead margin is an amount of contiguously available, sequentially arranged requested files received by the media player for playback at a current playback time index, a POSITA would have been motivated to configure Leaning's media player (player program) to use such a threshold. For example, a POSITA would have understood that based on the amount of sequential stream segments present in the media player's buffer—including whether that amount is lower than a minimum safety margin, the available network bandwidth may be (i) sufficient to retrieve the segments at the given quality level (bit rate) and play them back without interruption, (ii) high enough to retrieve higher quality segments, or (iii) too low to sustain uninterrupted playback such that lower quality segments should be requested. Accordingly, a POSITA would have been motivated to factor in the presence of such stored files and their quantity compared to a minimum amount in the factor's comparison that determines whether to sustain or shift the quality level. Indeed, Leaning recognizes that automatically switching between bitrates offers a “remedy for the possibility of buffer underflow (due for example to network congestion).” EX1004, 6:9-15. A POSITA would have had a reasonable expectation

of success with such a modification because Leaning teaches that assessment and management of the buffer contents are part of the determination whether to shift or sustain quality level. EX1004, 8:17-9:2, 10.

18[B]: “determining whether to upshift or downshift to a higher or lower quality one of the different copies based on said comparing.”

124. In my opinion, Leaning teaches 18[B]. Leaning discloses that the media player upshifts or downshifts to a higher quality copy or lower quality copy based on comparison of a performance factor to a threshold. *See* 18[A], 1[C] (successive determinations to shift quality higher), 1[D] (performance factor), 1[E], claims 3, 4 (upshifting or downshifting). Leaning discloses that the media player allows for shifting up and/or continuing playing by comparing the buffer fullness factor to the playout time trigger threshold, upshifting only if “Buffer Fullness > T_p seconds.” *See* EX1004, 8:17-9:2, 10.

Claim 19: “The method of claim 1, wherein: said requesting comprises issuing for each of the plurality of sequential ones of the files a request with the filename of that file, and said automatically requesting comprises issuing for each of the files a request with the filename of that file.”

125. In my opinion, Leaning teaches claim 19. Leaning discloses requesting subfiles by filename, both for the initial request and subsequent automatic requests. *See* EX1004, 7 (chart showing “Filename[s]” “000000.bin”, “000001.bin”, *et seq.*

for subfiles stored in subdirectories that correspond to different quality levels); 10 (flowchart that “Set[s] **Current Subfile** = 000000.bin”; then at step J1 “Set[s] **URL** = StemC + **Current Subfile**” and “**Request[s] this URL**”; and at step J2 iteratively “**Increment[s] Current Subfile**” and “Go[es] to Step J1”).

Claim 20: “The method of claim 1, wherein the set of servers includes a content server storing the multiple files of the different copies, and wherein the set of servers includes one or more cache servers caching at least some of the files.”

126. In my opinion, Leaning teaches claim 20. *See* 1[A][1] (server 1 that stores the content); claim 16 (obvious to utilize cache server caching at least some of the files).

Claim 21: “The method of claim 1, wherein the multiple files are independently cacheable by a cache server without specialized server-side intelligence.”

127. In my opinion, Leaning teaches claim 21. *See* claim 16 (obvious to utilize cache server caching at least some of the files), claim 15 (no specialized server-side intelligence). A POSITA would have understood that the Leaning’s disclosure of a web server without specialized server-side intelligence is equally applicable to a cache server.

F. Claims 2 and 9 Would Have Been Obvious in view of Leaning and Gamble

128. The sections of Ground 1 (Section VIII.F) are incorporated into this section by reference. As explained above, it is my opinion that Leaning teaches claims 1-21. To the extent that Patent Owner argues that Leaning fails to teach certain limitations, Leaning in view of Gamble teaches these limitations.

Claim 2: “The method of claim 1, wherein said requesting the plurality of sequential ones of the files includes requesting sub-parts of the files over different ones of the plurality of TCP connections, and wherein said presenting includes reassembling the files from the received sub-parts.”

129. In my opinion, Leaning and Gamble teach claim 2. Leaning teaches a plurality of TCP connections. *See* 1[B]. Gamble teaches sub-parts of a plurality of files that are requested over a plurality of TCP connections and reassembled. Gamble discloses a network application 112 operating on a client 106 that creates a receive buffer 706 to store a plurality of N segments (here, N=4) from stream files 706₁ through 706₄ received over N parallel connections from server 108. EX1020, ¶¶ 50-51. The receive buffer 706 includes multiple sub-buffers B1 through B4 to store N(=4) segments of a data file 702A that are respectively streamed out of stream files 706₁ through 706₄. *Id.* ¶ 51. The segments in the receive buffer 706 are ordered into a data file 702B to match the order in data file 702A, and the process continues until

all segments have been received and ordered. *Id.*, ¶ 52; *see also* ¶ 40. Gamble explains that the TCP layer 312 of the network connection operating on the client 106 acknowledges and reorders packets and can send packets on multiple or parallel connections. *Id.*, ¶ 37.

130. A POSITA would have been motivated to configure Leaning's apparatus to request sub-parts of the files (subfiles) over different TCP connections and reassemble the files from the received subparts, such as taught by Gamble. A POSITA would have understood that this improves reliability in situations where one connection fails by retrieving other subparts over other connections and retrieving more of file more quickly. A POSITA also would have understood that it takes advantage of available bandwidth by parallelizing retrieval of a segment to increase throughput where an individual TCP connection's maximum throughput is the bottleneck. A POSITA would have had a reasonable expectation of success with such a modification because the TCP protocol allows for multiple connections, and utilizing multiple connections to request and retrieve different parts of a single file was well known, as exemplified by Gamble.

Claim 9: “The method of claim 1, wherein said automatically requesting includes requesting sub-parts of the files over different ones of the plurality of TCP connections, and wherein said presenting includes reassembling the files from the received sub-parts.”

131. In my opinion, Leaning and Gamble teach claim 9. *See* 1[A][2] (establishing TCP connection), 1[C][2] (factor indicative of available bandwidth), 1[B], Ground 2 claim 2 (establishing multiple TCP connections, requesting sub-parts over different connections, and reassembling files from sub-parts); Ground 1 claim 9 (requesting and automatically requesting sub-parts).

IX. CONCLUSION

132. In my opinion, and for the reasons provided above, the Challenged Claims are at least obvious over Leaning and at least obvious over Leaning in view of Gamble.

133. I declare that all statements made in this declaration regarding my personal knowledge are true and accurate, and that all statements made on information and belief are believed to be true. Further, I understand that these statements were made with the knowledge that willful false statements and the like are punishable by fine, imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Henry H. Houh.

Henry Houh

Executed on January 29, 2024.

Exhibit A

Henry H. Houh

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Lexington, MA 02420
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Education

Massachusetts Institute of Technology, Cambridge, MA

- PhD in Electrical Engineering and Computer Science, February 1998. “Designing Networks for Tomorrow's Traffic,” thesis supervised by Professor David Tennenhouse and Professor John Guttag. GPA 4.7/5.0
- Master of Science in Electrical Engineering and Computer Science, February 1991. “Demonstration of a laser repetition rate multiplier,” thesis. GPA 4.5/5.0
- Bachelor of Science in Electrical Engineering and Computer Science, June 1989. “Boundary element analysis of arbitrarily shaped dielectric structures,” thesis. GPA 4.7/5.0
- Bachelor of Science in Physics, February 1990. GPA 4.7/5.0

MITx, Cambridge, MA

- September 2020 – present: Enrolled in Statistics and Data Science MicroMasters program, a sequence of five MIT-offered graduate-level courses in statistics and machine learning, culminating in a MicroMasters certificate. Have completed four of five required courses.

Experience

Houh Consulting Inc. / Independent Consultant

- 2009 - present: Technical consultant specializing in Social Networking, Web 2.0, Web Site Development, Data Networking, Optical Networking, Telecommunications, Media Streaming and Voice Over IP. Clients include: Akin Gump Strauss Hauer & Feld LLP, Arnold & Porter Kaye Scholer LLP, BBN, Baker Botts LLP, Barnes & Thornburg LLP, BBN Technologies, Beus Gilbert McGroder PLLC, Bracewell LLP, Christensen O'Connor Johnson Kindness PLLC, Cooley LLP, Covington & Burling LLP, Cozen O'Connor P.C., DLA Piper, Davis Polk & Wardwell LLP, Desmarais LLP, Duane Morris LLP, Erise IP, P.A., Faegre Baker Daniels LLP, Finnegan, Henderson, Farabow, Garrett & Dunner, LLP, Fish & Richardson P.C., Goldman Ismail Tomaselli Brennan & Baum LLP, Haynes and Boone, LLP, Kaye Scholer, Kellogg Huber Hanson Todd Evans & Figel PLLC, Kirkland & Ellis LLP, Klarquist Sparkman, LLP, McCarthy Tetrault LLP, McGuireWoods LLP, Morgan, Lewis & Bockius LLP, Munger Tolles & Olson LLP, Orrick, Herrington & Sutcliffe LLP, O'Melveny & Myers LLP, Orrick, Herrington & Sutcliffe LLP, Paul Hastings LLP, Paul, Weiss, Rifkind, Wharton & Garrison LLP, Perkins Coie LLP, Quinn Emanuel Urquhart & Sullivan, LLP, Sidley Austin LLP, Smith Baluch LLP, Sterne, Kessler, Goldstein & Fox PLLC, Troutman Sanders LLP, Venable LLP, Weil, Gotshal &

Manges LLP, Wiley Rein LLP, Wilmer Cutler Pickering Hale and Dorr LLP, and Winston & Strawn LLP.

BlocksCAD Inc. (H3XL spin-out)

- 2014 - present: Founder and member of Board of Directors. BlocksCAD is a visual Computer-Aided Design (CAD) program, designed to teach children mathematics and geometric visualization. BlocksCAD is being used in U.S. schools and worldwide in maker spaces, with 350,000+ users. BlocksCAD was selected to be part of the LearnLaunch 2017 Boost Accelerator, the MIT Play Labs 2018 Summer Accelerator, and the MassChallenge 2018 Boston Cohort. Recipient of DARPA DSO grant in 2014, and SBIR grant from the USDA in 2019.

H3XL Inc. d/b/a Einstein's Workshop (formerly Lexington Robotics)

- 2009 - 2022: Founder and President. Started a science, technology, engineering and math enrichment program and creative/maker space, in 7,000 square feet of space. Serve 2,000+ kids and families annually. As of end of 2022, have delivered an estimated 250,000 student-instruction-hours of STEM courses. Principle Investigator for 2-year DARPA grant to improve 3D Computer Aided Design tool developed in-house for the purposes of teaching 8 year olds and up 3D CAD.

Eons

- 2008 - 2009: Chief Technology Officer. Created product that Eons acquired from BBN Technologies. Integrated BBN product with Eons social networking platform and significantly increased the Eons group creation rate. Helped evaluate advertisement platform offerings and rolled out the "Boom Network" advertising network. Eons raised \$32 million from General Catalyst Partners, Charles River Ventures, Sequoia Capital, and Intel Capital.

BBN Technologies

- 2007 - 2008: Delta Division, Vice President of Technology. Grew "Boomerang" counter-sniper project engineering team and significantly de-risked \$10 million worth of product deliveries. Identified sales team leading to \$10 million dollars of new sales within 6 months and \$100+ million in additional orders in the following two years. Boomerang was a significant asset leading to the acquisition of BBN by Raytheon in 2009. Created new business plan and grew team; launched new fully-featured social networking web site in 5 months. Served as lead expert witness in patent infringement lawsuit, resulting in \$58 million jury award to client; verdict for patents I testified on were upheld on appeal which resulted in a \$120 million settlement.
- 2004 - 2007: Delta Division, Director of Technology, responsible for commercializing IP and creating new businesses. Hired and grew division's initial engineering team. Wrote three business plans, two of which were funded. For call center business plan, acted as general manager, hiring and managing engineering team, inside sales team, and identifying and recruiting a new general manager. Identified and recruited other key employees to Delta Division, including senior members of team leading to successful internal sales growth and spin-outs of projects. Contracted by BBN to BBN spin-out PodZinger as VP of Operations and Technology. Additional areas studied include mesh networking, network security, satellite communications, and semantic web.

PodZinger Inc. (BBN spin-out, also known as EveryZing and now RAMP)

- 2006: Vice President of Operations and Technology. Significantly upgraded capability of consumer-facing search site and redeployed web site from company to co-location facility. Identified key portions of infrastructure for upgrading and cost reduction. Helped write business plan, evaluating advertisement models of revenue. Hired in operations replacement and phased back to BBN.

Commonwealth Capital

- 2004: Entrepreneur-in-residence (informally), performed technical due diligence on business plans, brainstormed ideas for new businesses with venture partner. With venture partner, left for portfolio company BBN to form core of commercialization team.

Empirix, Inc./Teradyne, Inc.

- 2001 - 2004: Chief Technologist, Engineering Manager, Web Application Test Group. Researched potential new product areas; developed product plan and prototype. Responsible for three new and existing products. Managed off-shore development team. Chief architect for all web testing products. Re-architected core testing product, helped write javascript interpreter. Provided technical vision for core product.
- 2000 - 2001: Chief Technologist, Communication Infrastructure Test Group. Responsible for incorporating new technology internally, tracking new technologies, technical evaluation of partnerships and potential acquisitions. Helped develop division strategy. Developed plans which formed core capabilities for successful new products introduced in 2004-5.
- 2000 - 2001: Engineering Manager, Communications Infrastructure Test Group. Execution of new product plan developed in prior role. Grew team from four existing engineers to team of over 30 on immediate team and over 40 on project. Delivered new platform in one year. Platform and derivatives accounted for large portion of booked products for the division within 2 years and is currently (2008) a key portion of new product offerings.
- 2000: Empirix was formed as a spin-out of Teradyne in January 2000. Reported to CEO in carve-out of Empirix from Teradyne.
- 1999: (Teradyne) Director of Business Development, Software Test Units. Reported directly to Chairman of the Board/Founder and then to general manager of software test unit (6 divisions of Teradyne). Evaluated and researched acquisition and partnership candidates. Internally assessed technology position in market and gaps in product lines. Worked with senior division staff to develop new product strategies. Attended internal Teradyne divisional board meetings. Chairman served as my mentor.

3Com Corporation/NBX Corporation

- 1999: Software Engineer 5. Continued work after 3Com acquisition of NBX. Built cross-division relationships for new products and research directions. NBX was acquired by 3Com in March 1999.
- 1997 - 1999: (NBX) Senior Scientist and Engineer. Work in IP Telephony. Architected next-generation product. Protocol design and validation for core protocol now used tens of millions of times daily. Led team in integration of IP protocols into current product. Designed audio reconstruction algorithms. Developed applications for bug analysis and diagnosis of system

problems. Implementation of network simulator. Work on collaborative projects with external partners. Worked to identify gaps in product. Representative at numerous trade shows. Innovated novel methods of using product.

MIT Department of Electrical Engineering and Computer Science, Cambridge, MA

- 1991 - 1998: Research assistant, Telemedia Network Systems Group. Design, development, and implementation of Gigabit ATM network for distributed multimedia system. Studied host interface design issues. ATM network simulation.
- Spring 1989, Fall 1990, Spring 1995: Teaching assistant, Computation Structures digital systems course. (Spring 1995 Head TA)
- 1988 - 1989: Head laboratory teaching assistant for Computation Structures. Responsibilities included writing and revising lab assignments, and maintaining the lab.
- 1987: Laboratory teaching assistant for Computation Structures.
- 1987: Design, construction, and programming of 16-bit computer.

Agora Technology Group, Incorporated

- 1994 - 1996: Founder and CEO. Conceived and oversaw development of targeted advertising-supported Web sites. Responsible for company's vision and direction. Attended the first two WWW Conferences, presenting a workshop and paper at the first, and appearing on the "Commercialization and Economics of the Web" panel and chairing the "Where Commercial Services and the Web Are Headed" panel at the second. Sold company intact; is currently an operating stand-alone company.

AT&T Bell Laboratories, Holmdel, NJ

- 1989 - 1990: Implementation of cascadable all-optical fiber logic gate. Modelocking of all-fiber erbium laser. Construction of modelocked laser repetition rate booster. Strong optics laboratory and fiber optic experience.
- Summer 1988, 1987: Research in integrated optics. Analysis of rectangular waveguides using microwave modeling. Fabrication of integrated optical components.

Honors

- MIT Alumni Association Great Dome Award, 2010, Baker 60th Anniversary Reunion Co-Chair (highest group award given by MIT Alumni Association)
- MIT Alumni Association Presidential Citation Award (now known as Great Dome), 2008, Member of MIT Chairman's Salon committee
- MIT Alumni Association Bronze Beaver Award, 2007 (highest individual award given by MIT Alumni Association)
- MIT Alumni Association Volunteer Honor Roll, February 2004
- MIT Alumni Association Lobdell Award, 1999
- Boston Museum of Science Gold Pin for 1000 hours of Volunteer Service, April 1999
- MIT Alumni Association Presidential Citation Award (now known as Great Dome), 1997, Member of Alumni Online Communications Committee

Patents and Patent Publications

- U.S. Patent #9,697,231, H. Houh, J. Stern, R. Spina, M. Meteer, “Methods and apparatus for providing virtual media channels based on media search,” July 4, 2017.
- U.S. Patent #9,697,230, H. Houh, J. Stern, “Methods and apparatus for dynamic presentation of advertising, factual, and informational content using enhanced metadata in search-driven media applications,” July 4, 2017. See also WO2007056485.
- U.S. Patent #7,975,296, L. Apfelbaum, H. Houh, T. Mayberry and G. Friedman, “Automated security threat testing of web pages,” July 5, 2011. See also US20030159063, WO2003067405.
- U.S. Patent #7,877,736, H. Houh and J. N. Stern, “Computer language interpretation and optimization for server testing,” January 25, 2011. See also US20050138104, WO2005043300.
- U.S. Patent #7,801,910, H. Houh and J. N. Stern, “Method and apparatus for timed tagging of media content,” September 21, 2010. See also US20070112837, US20090222442, WO2007056535.
- U.S. Patent #7,590,542, D. C. Williams, W. C. Hand, H. Houh, A. R. Seeley, “Method of Generating Test Scripts Using a Voice-Capable Markup Language,” September 15, 2009. See also EP1530869, US20030212561, WO2003096663.
- U.S. Patent #6,967,963, H. H. Houh, P. Anderson, C. Gadda, “Telecommunication method for ensuring on-time delivery of packets containing time-sensitive data,” November 22, 2005. See also EP1060400, WO2000033092, CA2318774.
- U.S. Patent #5,144,375, M. C. Gabriel, H. H. Houh, N. A. Whitaker, “Sagnac Optical Logic Gate,” September 1, 1992. Also issued as European Patent # EP0456422, July 23, 1997, German Patent #DE69126913, August 28, 1997
- U.S. Patent Application Publication No. 20020015387, “Voice Traffic Packet Capture and Analysis Tool for a Data Network” (Abandoned in 2007)
- U.S. Patent Application Publication No. 20020016708, “Method and Apparatus for Utilizing a Network Processor as Part of a Test System” (Abandoned in 2007)
- U.S. Patent Application Publication No. 20020016937, “Method and Apparatus for Utilizing a Network Processor as Part of a Test System.” (Abandoned in 2007) See also WO2002011413.
- U.S. Patent Application Publication No. 20070106646, “User-directed navigation of multimedia search results” (Abandoned in 2009)
- U.S. Patent Application Publication No. 20070106660, “Method and apparatus for using confidence scores of enhanced metadata in search-driven media applications” (Abandoned in 2009)
- U.S. Patent Application Publication No. 20070106685, “Method and apparatus for updating speech recognition databases and reindexing audio and video content using the same” (Abandoned in 2015)
- U.S. Patent Application Publication No. 20070118873, “Methods and apparatus for merging media content” (Abandoned in 2015)
- U.S. Patent Application Publication No. 20090222442, “User-directed navigation of multimedia search results” (Abandoned in 2016)
- U.S. Patent Application 11/395,732, “Search snippet creation for audio and video data” (Abandoned in 2009)
- U.S. Patent Application 11/774,931, “Methods and apparatus for managing a social networking web site”
- U.S. Patent Application 11/774,947, “Methods and apparatus for organizing media files”
- U.S. Patent Application 11/774,956, “Methods and apparatus for managing an online event”

- U.S. Provisional Patent Application 61/086,909, “Measuring and ranking relationship activity”
- U.S. Provisional Patent Application 61/086,914, “Detecting media object commonality”
- U.S. Provisional Patent Application 61/086,904, “Message categorization based on message characteristics”
- U.S. Provisional Patent Application 61/086,905, “Photo tagging to request action”

Trials, Testimony and Depositions

- Case No. 1:06CV682 (CMH/BRP), Verizon vs. Vonage, U.S. District Court for the Eastern District of Virginia, filed expert report, was deposed and testified at trial.
- Case No. 1:08CV157 (CMH/TRJ), Verizon vs. Cox, U.S. District Court for the Eastern District of Virginia, was deposed and testified at trial.
- Case No. 5:09-cv-476, Two-Way Media vs. AT&T, U.S. District Court for the Western District of Texas, filed expert report, testified at trial.
- Case No. 2:10-cv-248 (RAJ/FBS), ActiveVideo Networks vs. Verizon, U.S. District Court for the Eastern District of Virginia, filed expert report and was deposed as an expert witness.
- Case No. 1:11-cv-00880-TSE-JFA, Bear Creek Technologies, Inc. vs. Verizon Services Corp., et al, U.S. District Court for the Easter District of Virginia, was deposed as an expert witness.
- Case No. 3:10-CV-298-BBC, AlmondNet, Inc. vs. Microsoft Corp., U.S. District Court for the Western District of Wisconsin, filed expert report.
- Case No. 6:10-cv-00597, Guardian Media Technologies, Ltd. Vs. AT&T Operations, Inc. et al., U.S. District Court for the Eastern District of Texas, Tyler Division, filed expert report.
- Case No. ESCV2010-02282C, The Octopus Solution LLC v. Gary Brown et al., Essex, MA Superior Court, testified at trial.
- Investigation No. 337-TA-882, In the matter of Certain digital media devices, including televisions, Blu-ray disc players, home theater systems, tablets and mobile phones, components thereof and associated software, U.S. International Trade Commission, filed expert reports, was deposed and testified at hearing.
- Investigation No. 337-TA-995, In the matter of Certain communications or computing devices, and components thereof, U.S. International Trade Commission, filed expert reports, and was deposed.
- Case No. 8:12-cv-122-LES-TDT, Prism Technologies LLC v. AT&T Mobility LLC, U.S. District Court for the District of Nebraska, filed expert report, was deposed and testified at trial.
- Case No. 11-2684 (JWL), Sprint Communications Co., L.P., v. Comcast Cable Communications, LLC, et al., U.S. District Court for the District of Kansas, filed expert report and was deposed.
- Case No. 11-2686 (JWL), Sprint Communications Co., L.P., v. Time Warner Cable, Inc., et. al., LLC, et al., U.S. District Court for the District of Kansas, filed expert report, was deposed, and testified at trial.
- Case No. 12-487 (SLR), Cox Communications, Inc., et al., v. Sprint Communications Company L.P., et al., U.S. District Court for the District of Delaware, filed expert report and was deposed.
- Case IPR 2014-00039, Microsoft Corporation v. B.E. Technology LLC, U.S. Patent No. 6,628,314. Submitted declaration and cross-examined in deposition.
- Case IPR 2014-00086, Apple, Inc. v. Evolutionary Intelligence, LLC, U.S. Patent No. 7,010,536. Submitted declaration and cross-examined in deposition.
- Case No. 6:11-CV-421, Stragent, LLC v. Intel Corporation, U.S. District Court for the Eastern District of Texas, Tyler Division, deposed and testified at trial as a fact witness.

- IPR2014-01366, IPR2014-01367, IPR2014-01368, Samsung et al. v. Straight Path, submitted IPR declarations and was deposed.
- IPR2015-1006, IPR2015-1007, Cisco v. Straight Path, submitted IPR declarations.
- IPR2014-01457, IPR2014-01459, Microsoft v. Biscotti, submitted IPR declaration and was deposed.
- IPR2016-00302, Apple v. Nonend, submitted IPR declaration.
- IPR2014-00812, Yelp and Twitter v. Evolutionary Intelligence, submitted IPR declaration.
- IPR2015-00307, Cisco v. AIP, submitted IPR declaration.
- Microsoft v. Acacia, submitted IPR declaration.
- IPR2015-00342, AT&T Mobility LLC and Cellco Partnership d/b/a Verizon Wireless v. Solocron, submitted IPR declaration.
- Mediatube v. Bell Canada, Canadian Federal Court, submitted expert report and testified at trial.
- CBM2016-00036, Google v. At Home Bondholder's Liquidating Trust, submitted CBM declaration.
- IPR2016-01198, IPR2016-01201, Apple, Inc. v. VoIP-Pal.com, Inc., submitted IPR declaration and was deposed.
- Case No. 3:14-cv-2824-VC, Trend Micro Incorporated v. Rpost Holdings, Inc., et al, submitted expert report and was deposed
- Akamai v. Limelight Networks, IPR2016-01631, IPR2016-01711, IPR2017-00249, IPR2017-00349, submitted IPR declarations and was deposed
- Hyperlync Technologies v. Verizon Sourcing, No. 650151/2015 New York Supreme Court, submitted declaration and was deposed
- Cascades Streaming Technologies v. Big Ten Networks, submitted expert reports and was deposed
- Klaustech, Inc. v. Google LLC., Case No. 4:10-CV-05899-JSW (N.D. Cal.), submitted expert report and was deposed
- Cisco v. Uniloc, IPR2017-00198, IPR2017-00058, submitted IPR declarations and was deposed.
- Cisco v. Uniloc, IPR2017-00597, submitted IPR declaration and was deposed
- Twitter v. Youtoo Technologies, LLC, IPR2017-01133, IPR2017-01131, submitted IPR declarations and was deposed
- Taser International Inc. (now Axon Enterprise, Inc.) v. Digital Ally Inc., IPR2017-00375, submitted IPR declaration and was deposed
- Taser International Inc. (now Axon Enterprise, Inc.) v. Digital Ally Inc., IPR2017-00376, IPR2017-00515, IPR2017-00775, submitted IPR declarations
- HTC Corporation v. IPA Technologies, IPR2018-00306, IPR2018-00307, submitted IPR declaration
- Hulu v. Soundview, IPR2018-00864, IPR2018-01023, submitted IPR declarations and was deposed
- XpertUniverse v. Cisco, 3:17-cv-3848, U.S. District Court for Northern District of California, submitted declaration in support of claim construction and was deposed
- Improved Search v. Microsoft, C.A. No. 16-cv-650-JFB-SRF (Del.), submitted declaration in support of claim construction
- Apple v. Uniloc, IPR2018-00361, IPR2018-00394, IPR2018-00395, IPR2019-00700, IPR2019-00701, IPR2019-01667, submitted IPR declarations
- LG Electronics v. Uniloc, submitted IPR declaration
- SRC Labs and Saint Regis Mohawk Tribe v. Microsoft, 2:18-cv-00321-JLR, U.S. District Court for Western District of Washington at Seattle, submitted declaration in support of claim construction and was deposed

- Verizon Wireless v. Barkan Wireless IP Holdings LP, submitted IPR declarations
- Verizon Wireless and Samsung Electronics America Inc. v. Barkan Wireless IP Holdings LP, IPR2019-199, IPR2019-200, IPR2019-234, IPR2019-631, IPR2019-632, submitted IPR declarations
- Samsung Electronics America Inc. v. Barkan Wireless IP Holdings LP, IPR2019-100, submitted IPR declaration
- Cisco Systems Inc. v. Meetrix IP LLC, IPR2019-539, IPR2019-540, IPR2019-541, IPR2019-542, IPR2019-543, IPR2019-544, submitted IPR declarations
- GMG Products LLC v. Traeger Pellet Grills LLC, PGR2019-24, PGR2019-34, PGR2019-35, PGR2019-36, submitted PGR declaration and was deposed
- Uniloc 2017 LLC v. Google LLC, 2:18-cv-00502-JRG-RSP, U.S. District Court for the Eastern District of Texas, Marshall Division, submitted declaration in support of claim construction
- Microsoft Corporation v. Uniloc 2017 LLC, IPR2020-00102, IPR2020-00103, submitted IPR declarations
- Microsoft Corporation and HP Inc. v. Syncloud Technologies, LLC, IPR2020-00316, IPR2020-01031, IPR2020-01032, IPR2020-01269, IPR2020-01270, IPR2020-01271, submitted IPR declarations
- Seven Networks, LLC v. Apple Inc, 2:19-cv-115-JRG, U.S. District Court for the Eastern District of Texas, Marshall Division, submitted declaration in support of claim construction
- Unified Patents Inc. v. Ortiz & Associates Consulting, LLC, IPR2019-00743, submitted IPR declaration
- Uniloc 2017 LLC v. Apple Inc., 3:19-cv-01905-JD, U.S. District Court for the Northern District of California, San Francisco Division, submitted declaration in support of claim construction and was deposed
- ClearPlay Inc. v. Dish Network LLC et al.; 2:14-cv-00191, U.S. District Court for the District of Utah, Central Division, submitted expert report and re-examination declarations, was deposed, and testified at trial
- AMC Networks, Inc. et al v. Sound View Innovations, LLC, IPR2020-00482, submitted IPR declaration
- Case No. 1:17-cv-01734-RGA, Sprint Communications Co., L.P., v. Charter Communications, Inc., et al., U.S. District Court for the District of Delaware, filed expert report and was deposed.
- CommScope Technologies LLC et al. v. Barkan Wireless IP Holdings LP et al., IPR2020-00827, IPR2020-00829, IPR2020-00831, IPR2020-00833, IPR2020-00835, IPR2020-00838, submitted IPR declarations
- Cisco Systems Inc. v. Monarch Networking Solutions LLC, IPR2020-01226, submitted IPR declaration
- CoolTV Network.com v. Blackboard, Inc., Facebook, Inc., International Business Machines Corporation, Kaltura, Inc., Limelight Networks, Inc., Microsoft Corporation, Ooyala, Inc., Snap, Inc., and Trapelo Corp., submitted declaration in support of claim construction and was deposed
- Facebook, Inc. v. Onstream Media Corporation, IPR2020-01507, IPR2020-01508, IPR2020-01525, IPR2020-01527, IPR2020-01528, submitted IPR declarations
- Hisense Co LTD. v. Maxell, LTD, IPR2020-01598, IPR2020-01600, submitted IPR declarations
- Microsoft Corp. v. O'Brien, IPR2021-00015, submitted IPR declaration and was deposed
- Sable Networks Inc. v. Cisco Systems, Inc., WA:20-CV-00288-ADA, U.S. District Court for the Western District of Texas, Waco Division, submitted declaration in support of claim construction
- Peloton Interactive, Inc. v. Icon Health and Fitness Inc et al., IPR2021-00342, submitted IPR declaration

- Hulu, LLC v. SITO Mobile R&D IP, LLC et al., CBM2020-00028, IPR2020-00158, IPR2020-00206 , IPR2020-00219 , IPR2020-00265 , IPR2020-00298 , IPR2020-00304 , IPR2020-00308 , submitted CMB and IPR declarations and was deposed
- Twitter, Inc. and Google LLC v. B.E. Technology, LLC, IPR2021-00482, IPR2021-00483, IPR2021-00484, IPR2021-00485, submitted IPR declarations
- MG Freesites LTD v. ScorpCast, LLC, IPR2021-00511, submitted IPR declaration
- Avionte, LLC v. Sandeep Acharya, Samar Basnet, and Aqore LLC, Arbitration, Hon. Jeffrey Keyes (Ret.)
- Microsoft Corporation v. WSOU Investments, LLC d/b/a Brazos Licensing and Development, IPR2021-00751, submitted IPR declaration
- SAP America, Inc. v. Express Mobile, Inc., IPR2021-01144, IPR2021-01145, IPR2021-01146, submitted IPR declarations
- StratosAudio Inc. v. Hyundai Motor America, 6:20-cv-01125-ADA, U.S. District Court for the Western District of Texas, Waco Division, submitted claim construction declaration and was deposed
- Peloton Interactive, Inc. v. Ifit Health and Fitness Inc, IPR2022-00029, IPR2022-00030, submitted IPR declarations and was deposed
- Investigation No. 337-TA-1263, In the matter of Certain televisions, remote controls, and components thereof, U.S. International Trade Commission, filed expert reports, was deposed, and testified at hearing
- Alexander Stross v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-00861-AB(JC), filed expert reports, and was deposed
- Ralph Ledergerber v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-00862-AB(JC), filed expert reports and was deposed
- John Walmsley v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-00863-AB(JC), filed expert reports and was deposed
- Bernhard Kuhmstedt v. Netease, Inc., et al., U.S. District Court (Central District of California), Case 2:20-cv-02044-AB(JC), filed expert reports and was deposed
- Netflix, Inc. v. CA, Inc., IPR2021-01319, submitted IPR declaration and was deposed
- F45 Training Pty Ltd. v. Body Fit Training USA Inc., C.A. No. 20-1194 (LPS) (D. Del.), filed expert report
- Apple v. Fintiv, IPR2022-00976, IPR2022-01149, IPR2022-01150, IPR2023-00399, submitted IPR declarations and was deposed
- Estech Systems, Inc. v. Howard Midstream Energy Partners d/b/a Howard Energy Partners, C.A. No. 6:20-cv-777-ADA (Western District of Texas, Waco Division), filed expert reports and was deposed
- Echelon Fitness Multimedia, LLC. v. Peloton Interactive, Inc., IPR2020-01187, submitted IPR declaration and was deposed
- VIZIO. V. Maxell Ltd., IPR2022-01458, submitted IPR declaration
- Maxell, Ltd. et. el. v. VIZIO, Inc., Case No. 2-21-cv-06758 (C.D. Cal.). filed declaration and was deposed
- Microsoft Corporation v. SurfCast, Inc., submitted IPR declarations
- The Walt Disney Company et. al. v. WAG Acquisition LLC, IPR2022-01227, IPR2022-01228, IPR2022-01346, submitted IPR declarations and was deposed
- Rakuten Rewards et. al. v. IBM, submitted IPR declarations and was deposed
- Fubotv Media Inc. v. SITO Mobile R&D IP, LLC et. al., submitted IPR declarations
- Unified Patents, LLC v. Noblewood IP LLC, IPR2022-01111, submitted IPR declaration
- Unified Patents, LLC. v. Pedersen, Peter Henrik, IPR2023-00029, submitted IPR declaration
- Ericsson Inc v. Dali Wireless Inc., submitted IPR declarations

- Universal Electronics, Inc. et. al. v. Roku, Inc., IPR2022-00818, submitted declarations and was deposed
- Google LLC v. Wildseed Mobile LLC et. al., IPR2023-00244, IPR2023-00245, IPR2023-00246, IPR2023-00247, IPR2023-00248, submitted declarations
- Lululemon Athletica Canada Inc. et. al. v. Nike, Inc., IPR2023-00180, IPR2023-00424, submitted declarations
- Zoho Corporation, et. al. v. Meetrix IP, LLC, IPR2023-00371, IPR2023-00377, IPR2023-00379, IPR2023-00380, IPR2023-00382, submitted declarations
- WSOU Investments, LLC d/b/a/ Brazos Licensing and Development v. Google LLC, 6:20-cv-572, U.S. District Court for the Western District of Texas, Waco Division, submitted reports and was deposed
- Google LLC v. Safecast Limited LLC, IPR2023-00652, submitted declaration
- Investigation No. 337-TA-1338, In the matter of Certain smart televisions, U.S. International Trade Commission, filed reports and was deposed
- Cisco Systems, Inc. v. Orckit IP LLC, IPR2023-00714, submitted declaration
- SupplyPro, Inc. v. Sandvik Machining Solutions AB, et. al., AAA Case No. 01-22-000-7897. submitted declaration
- TrackThings LLC v. NETGEAR, Inc., Case No. 22-00981-RGA-JLH, U.S. District Court for the District of Delaware, submitted declaration
- Walt Disney Parks & Resorts US Inc. v. Agile Journeys LLC; IPR2024-00029, submitted declaration
- Aylo Freesites Ltd v. Dish Technologies LLC; IPR2024-00043, IPR2024-00044, IPR2024-00045, IPR2024-00046, IPR2024-00047, IPR2024-00048, IPR2024-00146, IPR2024-00147; submitted declarations

Publications

- “IP switching: server driven flow classification,” H. H. Houh, *Proceedings of the Washington University Workshop on Integration of IP and ATM*, November 1996.
- “Aurora at MIT,” D. D. Clark, H. H. Houh, and D. L. Tennenhouse, Editors, *MIT Laboratory for Computer Science Technical Report 673*, December 1995.
- “ViewStation Applications: Implications for Network Traffic,” C. J. Lindblad, D. Wetherall, W. Stasior, J. F. Adam, H. H. Houh, M. Ismert, D. Bacher, B. Phillips, and D. L. Tennenhouse, *IEEE Journal of Selected Areas in Communications*, 1995.
- “The VuNet Desk Area Network: Architecture, Implementation, and Experience,” H. H. Houh, J. F. Adam, M. Ismert, C. J. Lindblad, and D. L. Tennenhouse, *IEEE Journal of Selected Areas in Communications*, 13 (4), May, 1995.
- “Reducing the Complexity of ATM Host Interfaces,” H. H. Houh and D. L. Tennenhouse, Hot Interconnects II Symposium Proceedings, Stanford, August 11-12, 1994.
- “Media-intensive data communications in a ‘desk-area’ network,” J. F. Adam, H. H. Houh, M. Ismert, and D. L. Tennenhouse, *IEEE Communications*, August 1994.
- “ViewStation Applications: Intelligent Video Processing Over A Broadband Local Area Network,” C. J. Lindblad, D. J. Wetherall, W. Stasior, B. Phillips, D. Bacher, J. Adam, H. Houh, M. Ismert, and D. L. Tennenhouse, Proceedings of the 1994 USENIX Symposium on High-Speed Networking, Oakland, CA, August 1994.

- “The Media Gateway: Live Video on the World Wide Web,” H. H. Houh, C. J. Lindblad, J. Soo, D. L. Tennenhouse, and D. J. Wetherall, Workshop at the 1994 World Wide Web Conference, Geneva, Switzerland, May 1994.
- “Active Pages: Intelligent Nodes on the World Wide Web,” H. H. Houh, C. J. Lindblad, and D. J. Wetherall, Proceedings of the 1994 World Wide Web Conference, Geneva, Switzerland, May 1994.
- “Wavelength Division vs. Code Division Access Methods for Optical Networks,” H. H. Houh, Area Exam Paper, May 1993.
- “Experience with the VuNet: A Network Architecture for a Distributed Multimedia System,” J. F. Adam, H. H. Houh, D. L. Tennenhouse, Proceedings of the 18th Conference on Local Computer Networks, pp. 70-76, September 1993
- “The VudBoard: A Simple DMA Interface,” H. H. Houh, Proceedings of the 4th Gigabit Minijam, January 1994.
- “A Software-Oriented Approach to the Design of Media Processing Environments,” D. L. Tennenhouse, J. Adam, D. Carver, H. Houh, M. Ismert, C. Lindblad, W. Stasior, D. Weatherall, D. Bacher, and T. Chang., submitted to the International Conference on Multimedia Computing and Systems, May 1994.
- “A Network Architecture for Distributed Multimedia Systems,” J. F. Adam, H. H. Houh, M. Ismert, and D. L. Tennenhouse, submitted to the International Conference on Multimedia Computing and Systems, May 1994.
- “The Viewstation Collected Papers,” D. L. Tennenhouse, J. Adam, C. Compton, A. Duda, D. Gifford, H. Houh, M. Ismert, C. Lindblad, W. Stasior, R. Weiss, D. Wetherall, D. Bacher, D. Carver, and T. Chang, MIT Laboratory for Computer Science Technical Report, MIT/LCS/TR-590, November 1993.
- “The Viewstation Collected Papers II,” W. F. Stasior, D. L. Tennenhouse, J. F. Adam, D. R. Bacher, H. H. Houh, M. Ismert, C. J. Lindblad, B. M. Phillips, D. J. Wetherall, MIT Laboratory for Computer Science Technical Report, MIT/LCS/TR-696, April 1996.
- “A System's Perspective of the Sagnac Fiber Logic Gates and Their Possible Applications,” A. Huang, N. Whitaker, C. Gabriel, H. Avramopoulos, P. M. W. French, H. H. Houh, and I. Chuang, Applied Optics, September 10, 1994
- “Complete Switching in a Three-Terminal Sagnac Switch,” H. Avramopoulos, P. M. W. French, M. C. Gabriel, H. H. Houh, N. A. Whitaker, T. Morse, IEEE Phot. Tech. Lett. **3** (3), 235
- “Complete Switching in a Three-Terminal Sagnac Switch,” H. Avramopoulos, P. M. W. French, M. C. Gabriel, H. H. Houh, N. A. Whitaker, IEEE/LEOS Annual Meeting, Paper PDP-13, November 1990
- “All-optical phase-locked oscillator,” N. A. Whitaker, Jr., H. H. Houh, H. Avramopoulos, T. F. Morse, IEEE/LEOS Annual Meeting, Paper ELT2.4/MOO3, November 1990
- “Passive modelocking of an all-fiber erbium laser,” H. Avramopoulos, H. H. Houh, N. A. Whitaker, M. C. Gabriel, T. F. Morse, IEEE/LEOS Conference on Optical Amplifiers and their Applications, Paper PDP-8, August 1990
- “Transverse modes, waveguide dispersion, and 30ps recovery in submicron GaAs/AlAs microresonators,” J. L. Jewell, S. L. McCall, A. Scherer, H. H. Houh, N. A. Whitaker, A. C. Gossard, and J. H. English, Appl. Phys. Lett. **55** (1), July 3, 1989

Leadership, Activities and Interests

- Leadership
 - Reading Symphony Orchestra
 - Board of Directors (Treasurer), 2022 - present
 - Discovery Museums (Acton, MA)
 - Board of Directors, 2023 – present
 - Board of Directors, Development Committee, 2023 – present
 - Science and Technology Advisory Council, 2012 - present
 - Tau Beta Pi National Engineering Honor Society
 - Executive Councilor Elect, to serve 2024-2026
 - Advisor, MA B Chapter at MIT, 2003 - present
 - District Director (National Officer), Tau Beta Pi, New England Area, 1991 - 2003
 - President, MA B Chapter at MIT, Fall 1988 - Spring 1989
 - Laureate award, 1989
 - MIT Alumni Association Board of Directors
 - National Selection Committee, 3 year term, 2020 – 2023
 - K-12 STEM Initiatives Co-chair, 2013 – 2017
 - Awards Committee Chair, 2012 – 2014
 - Awards Committee, 3 year term, 2011 – 2014
 - Vice President, 2 year term, 2004 – 2006
 - Alumni Ad-Hoc Committee, Chair, 2005-2006
 - Board Member, 2 year term, 1997 – 1999
 - MIT Club of Boston
 - Board of Directors, 2006 - 2011
 - K-12 Initiatives Chair, 2009 - 2012
 - VP of Communications, MIT Club of Boston, 2003 - 2006
 - Past-President, MIT Club of Boston, 2002 - 2003
 - President, MIT Club of Boston, 2001 - 2002
 - President-Elect, MIT Club of Boston, 2000 - 2001
 - VP of Programs, MIT Club of Boston, 1999 - 2000
 - Activities Super-Chair, MIT Club of Boston, 1998 - 1999
 - MIT Enterprise Forum of Cambridge, Inc.
 - Past Chair, 2009 – 2011
 - In-NOW-vation Co-chair, 2010
 - Chair, 2007 - 2009
 - Vice Chair, 2005 - 2007
 - Executive Board Member, 2002 - 2011
 - Winter Workshop Co-Chair, February 2007 - conceived idea for conference, which sold-out and produced largest attendance numbers in recent memory
 - Spring Workshop Co-Chair, Spring 2004
 - Membership Committee Chair, Fall 2003 - 2006
 - 25th Anniversary Dinner Chair, Fall 2003
 - As Membership Chair and Board Member, started Special Interest Groups in 2004; a SIG won the MIT Presidential Citation award, the MIT Alumni Association's highest award for organizations, in 2006
 - Estabrook Elementary School PTA

- Advisory committee to the superintendent on PCB issue, 2010-2011
 - 4th Grade after-school science program co-organizer, 2010-2012
 - 4th and 5th Grade before-school Math Olympiad co-organizer, 2009-2013
 - 5th Grade BBQ and Yearbook Committee, 2011, 2013
 - Family Math Night volunteer, 2008-2012
- MIT Class of 1989
 - Secretary, five consecutive 5 year terms, 1989 - 2014
 - 30-year Reunion Committee, 2019
 - 25-year Reunion Committee, 2014
 - 20-year Reunion Committee and Gift Committee, 2009
 - 15-year Reunion Committee and Gift Committee, 2004
 - 10-year Reunion Committee and Gift Committee, 1999
 - 5-year Reunion Committee, 1994
 - Interim Treasurer, 1993 - 1994
 - Instituted annual senior class career fair, now raising over \$100,000 annually for senior class activities, Fall 1988
- Strong, consistent record of leadership dating to high school
- Acting
 - ‘21’ (Sony Pictures), credited as “Chinatown Dealer,” 2007, Kevin Spacey's movie about the MIT Blackjack Team inspired by “Bringing Down the House” by Ben Mezrich, opened nationwide on March 28, 2008. 21 was the number one movie in US for two weeks and number one globally for one week. 21 also topped the DVD sales, Blu-ray sales and DVD rental charts.
 - Spring Lake Theater Company, first New York-area off-broadway production of “A Chorus Line,” played role of Mark, Summer 1990
- Former member of the MIT Blackjack team
- Producer for 10,000 Maniacs’ 2013 album “Music from the Motion Picture”
- Executive Producer for 10,000 Maniacs’ 2015 album “Twice Told Tales”
- Violist, violist, harpist, guitarist, singer, actor: played in many amateur/semi-professional groups including Firebird Pops Orchestra, Reading Symphony Orchestra, MIT Summer Philharmonic Orchestra, Carlisle Chamber Orchestra, Rivers Symphony Orchestra, Opera51 Orchestra, Freisinger Chamber Orchestra, Merrimack Valley Philharmonic, Longwood Symphony, MIT Symphony, and Somerville Community Chorus
- Violist, “Coming Home” album by Karen Phillips, 2014
- Google Scholar citations: 2079, h-index: 21, i10-index: 26 (since 2017: 662/12/14)
- Erdos-Bacon number of 7
- Erdos-Bacon-Sabbath number of 11