

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 10,757,156

Issue Date: August 25, 2020

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

Inter Partes Review No. IPR2024-00147

**DECLARATION OF HENRY HOUH, Ph.D.
IN SUPPORT OF PETITION FOR
INTER PARTES REVIEW OF
U.S. PATENT NO. 10,757,156**

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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. 10,757,156 (“’156 Patent”) (EX1001) and to provide my opinions regarding the patentability of claims 1-17 of the ’156 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 ’156 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, 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 '156 Patent, including the claims of the patent in view of the specification, and I have reviewed the prosecution history of the '156 Patent and numerous prior art and technical references from the time of the alleged invention. Of the materials cited as an exhibit to the '156 Patent IPR petition, I reviewed the following:

Exhibit	Description
1001	U.S. Pat. 10,757,156 (“the '156 Patent”)
1002	File History of U.S. Pat. 10,757,156
1003	Declaration of Dr. Henry Houh including Curriculum Vitae (“Houh”)
1004	U.S. Patent No. 6,161,137 to Ogdon et al. (“Ogdon”)
1005	<RESERVED>
1006	Synchronized Multimedia Integration Language (SMIL 2.0) (“SMIL 2.0”)
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
1011	Internet Archive Affidavit for URLs including EX1006 and EX1019
1012	<RESERVED>
1013	U.S. Patent No. 6,637,031 to Chou (“Chou”)
1014	U.S. Provisional Application No. 60/041,770 (“Ogdon Provisional”)
1015	File History of U.S. Pat. 6,161,137 to Ogdon
1016	U.S. Patent No. 7,529,806 to Shteyn (“Shteyn”)
1017	U.S. Patent Publication No. 2003/0055995 to Ala-Honkola (“Ala-Honkola”)
1018	File History of U.S. Patent No. 8,868,772
1019	HTTP 1.1 Protocol - RCF2616 (https://web.archive.org/web/20020802040147/https://www.ietf.org/rfc/rfc2616.txt)

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 ’156 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 ’156 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 '156 Patent and that Sling TV L.L.C. purports to be an exclusive licensee of the '156 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 '156 Patent. To the best of my knowledge, I do not have any financial interest in the '156 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 '156 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 '156 PATENT

33. The '156 Patent (application no. 16/291,343) was filed on March 4, 2019, which is a continuation of U.S. patent application Ser. No. 15/207,172 (now U.S. Pat. No. 10,225,304), which is a continuation of U.S. patent application Ser. No. 14/516,303 (now U.S. Pat. No. 9,407,564), which is a continuation of U.S. patent application Ser. No. 11/116,783 (now U.S. Pat. No. 8,868,772), which claims priority to U.S. Provisional No. 60/566,831 filed on Apr. 30, 2004. The '156 Patent issued on August 25, 2020. EX1001, Cover.

34. The '156 Patent relates to “adaptive-rate shifting of streaming content,” such as video, over the Internet. EX1001, Abstract, 1:25-28. The '156 Patent teaches “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, 6:20-34. As shown in Figure 2b below, the '156 Patent describes encoding the same content file into three different “quality” streams: low, medium, and high.

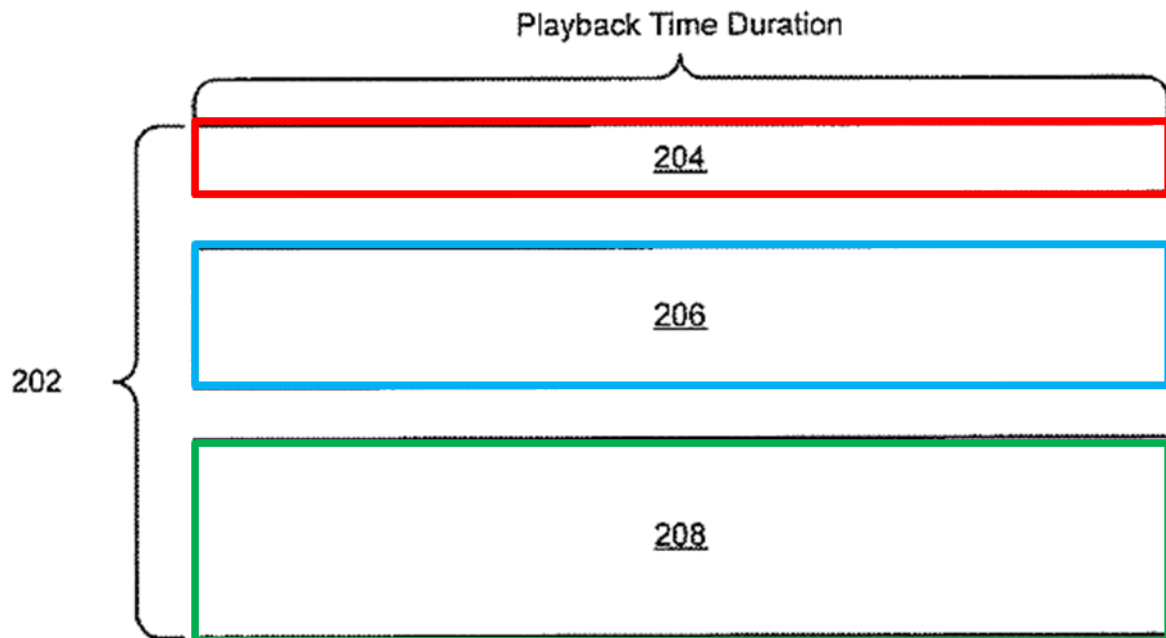


FIG. 2b

Id., FIG. 2b (annotated, low quality (red, 204), medium quality (blue, 206), and high quality (green, 208)), 6:64-7:8.

35. Each stream (204, 206, and 208) is “divided into a plurality of streamlets 212” 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.*, 7:9-21. This is shown in Figure 2c below.

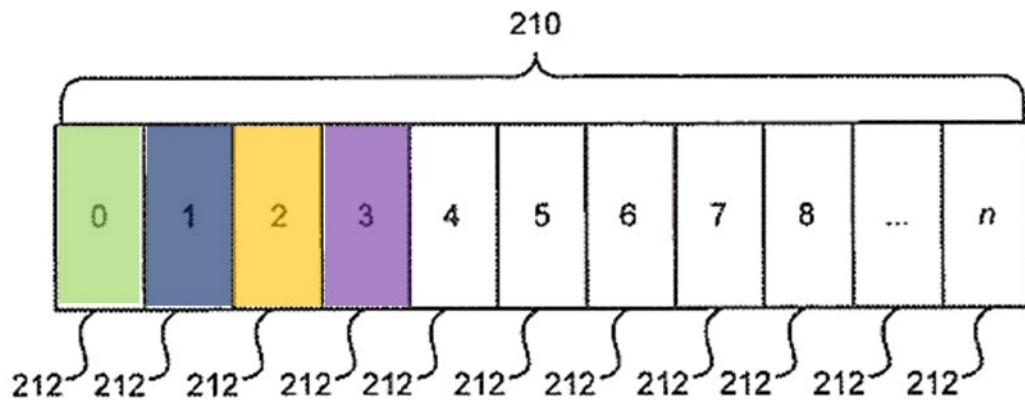


FIG. 2c

Id., FIG. 2c (annotated).

36. As the client receives a streamlet, it “calculates 708 a performance ratio” and “obtain[s] a performance factor.” *Id.*, 12:28-65, 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.*, 13:1-40.

A. Prosecution History

37. The '156 Patent was filed as Application No. 16/291,343 on March 4, 2019. On August 23, 2019, the United States Patent Office (“USPTO”) Examiner issued a non-final rejection of all pending claims. EX1002, 69-83. For instance, claims 1, 3, 5, 7, 9-11, 13-20 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Publication No. 2002/0144276 to Radford; claims 2, 12 were rejected under 35 U.S.C. § 103(a) as being obvious in view of Radford and U.S. Patent No. 6,880,017 to Maree; and claims 4, 6, 8 were rejected under 35 U.S.C. § 103(a) as being obvious in view of Radford and U.S. Publication No. 2003/0055995 to Ala-Honkola. *Id.* The Examiner found that Ala-Honkola taught that “the streamlet comprises a Hyper Text Transfer Protocol file” and “selecting a suitable transmission speed rate for the media stream and correspondingly a suitable data source” such that “the need of special media stream server is avoided.” *Id.*, 81.

38. On February 24, 2020, Applicant did not traverse the above findings of the Examiner with respect to Ala-Honkola in its response, but significantly amended the claims including deleting limitations that were rejected under 35 U.S.C. § 112. *Id.*, 91-102.

39. Based on the newly-amended language, Applicant argued the prior art “lacks any teaching . . . that the video server stores multiple different copies of the video encoded at different bit rates as multiple sets of streamlets, wherein each of the streamlets yields a different portion of the video on playback, wherein the streamlets across the different copies yield the same portions of the video on playback, and wherein the streamlets in the different copies are aligned in time such that the streamlets that play back the same portion of the video for the different copies each begin at the same playback time in relation to the beginning of the video.” *Id.*, 91.

40. Then, after an Examiner-initiated interview where Applicant agreed to make all independent claims parallel to claim 1 (*id.*, 122), the Examiner issued a Notice of Allowance on April 30, 2020 (*id.*, 123-138).

B. Priority Date

41. I do not offer any opinion as to whether the '156 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

42. 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

43. 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.

44. For purposes of this declaration, I have applied the ordinary and customary meaning of the claims when read in light of the ’156 Patent and the prosecution history of the ’156 Patent, as understood by a POSITA at the time of the invention.

45. The ’156 Patent and other family members 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 “streamlet” as “any sized portion of the content file.” EX1009, 38-43. The ALJ also construed “a factor relating to the performance of the network that is indicative of an ability to sustain the streaming of the video” 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.” *Id.*, 53-61. Finally, the ALJ 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

46. In my opinion, at least claims 1-17 (the “Challenged Claims”) of the ’156 Patent are invalid as obvious to a POSITA as of the alleged Priority Date. Although it is my opinion that at least some of the Challenged Claims would have been anticipated by Ogdon and anticipated by Shteyn, here I offer my opinion that at least (1) all Challenged Claims would have been obvious in view of Ogdon; (2) all Challenged Claims would have been obvious in view of Ogdon and Ala-Honkola;

(3) claims 4 and 7 would have been obvious in view of Ogdon and Shteyn or, alternatively, Ogdon in view of Ala-Honkola and Shteyn; (4) claims 10 and 12 would have been obvious in view of Ogdon and Chou or, alternatively, Ogdon in view of Ala-Honkola and Chou; and (5) claims 8 and 14 would have been obvious in view of Ogdon and SMIL 2.0 or, alternatively, Ogdon in view of Ala-Honkola and SMIL 2.0.

47. 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

48. The '156 Patent admits in the "Description of Related Art" section that "streaming media" was known, including streaming of "audio/video," including on demand and live broadcasts. EX1001, 1:41-51. The '156 Patent further admits that TCP connections were known and that "[m]ost streaming solutions use a TCP connection" (*id.*, 2:16-50) and admits later in the Specification that HTTP GET requests were "standard" (*id.*, 9:40-42). 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-HCN, D.I. 1 at ¶ 30.

49. 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 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 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. Ogdon

50. Ogdon (EX1004) was filed on March 31, 1998 and issued on December 12, 2000. Ogdon is prior art under at least (pre-AIA) 35 U.S.C. § 102(b). Ogdon is not cited on the face of the ’156 Patent nor was it considered in the ITC Investigation.

51. Ogdon discloses a system for distributing a video presentation, during the performance of the presentation, over the Internet via web servers to a plurality

of client nodes at a quality level appropriate for each client node based upon the transmission characteristics of the network, such as data transmission rate. EX1004, Abstract, 1:9-15, 2:21-35. Ogdon discloses that each presentation includes presentation “elements” (also referred to as “collections” or “subcollections”) containing “one or more segments” of the presentation and being “an indivisible portion of a presentation performance” wherein each such element has multiple versions of the same content and same duration at a different quality levels such that each version of each element can be substituted for the other as an alternative based upon network performance. *Id.*, 2:36-66, 13:47-49. Ogdon further discloses that each client node selects and requests each element at the appropriate quality level based upon its calculated network characteristics. *Id.*, 4:29-36, 6:40-51, 7:10-15, 21:40-45, 22:10-33, 23:40-24:3, 25:24-30.

C. Ala-Honkola

52. Ala-Honkola (EX1017) was filed on October 10, 2001 and published on March 20, 2003. Ala-Honkola is prior art under at least (pre-AIA) 35 U.S.C. § 102(b). Ala-Honkola is cited on the face of the '156 Patent and was used as a secondary reference to reject the claims during prosecution, but was not considered in the ITC Investigation. The grounds involving Ala-Honkola are new and combine Ala-Honkola with a primary reference that was not considered by the Examiner.

53. Ala-Honkola discloses adaptive streaming of content including video. EX1017, Abstract. Ala-Honkola further teaches storing multiple copies of the content at different bitrates at a server and indexing the different quality copies of the content by time. *Id.*, ¶¶ 10, 22, 24, 25, 30-32, 46, 45, FIG. 1. Ala-Honkola further teaches a client making HTTP GET requests over multiple TCP connections for copies of a file at a server at different quality levels by requesting specific byte ranges (timing marks) and the client repeatedly checking the sustainability of streaming at the current bitrate and making repeated requests for higher or lower qualities at the present timing marks based on changing bandwidth. *Id.*, ¶¶ 4, 7-12, 14, 15, 30-45, FIGs. 1-2.

D. Shteyn

54. Shteyn (EX1016) was filed on November 4, 1999 and issued on May 5, 2009. Shteyn is prior art under at least (pre-AIA) 35 U.S.C. § 102(e). Shteyn is not cited on the face of the '156 Patent, nor was it considered in the ITC Investigation.

55. Shteyn discloses partitioning a content file into segments at a server including storing alternates encoded at different bitrates for each segment. EX1016, Abstract, FIGs. 1-2, claims 1, 9, 11. Shteyn discloses that the client connects to the server and downloads the control XML file that enables the client to request,

download, and play out each segment of the content file sequentially. *Id.*, 2:57-3:36, 3:44-61, 4:8-16. Shteyn further discloses that the client application may detect a change in bandwidth and select a different quality (higher or lower quality) segment when requesting subsequent segments. *Id.*, 4:20-31, FIG. 2, claim 1.

E. Chou

56. Chou (EX1013) was filed on December 4, 1998 and issued on October 21, 2003. Chou is prior art under at least (pre-AIA) 35 U.S.C. § 102(e). Chou is not cited on the face of the '156 Patent, nor was it considered in the ITC Investigation.

57. Chou discloses obtaining real-time responses with interactive multimedia servers providing at least two different audio/visual data streams, with a first data stream having fewer bits per frame and providing a video image much more quickly than a second data stream with a higher number of bits and quality. EX1013, Abstract. Chou discloses that the first data stream is available much faster and may be more quickly displayed on demand. *Id.* Chou further discloses that start-up delay and seek delay occur in order to guard against future buffer underflow due to network jitter. *Id.*, 2:59-3:8.

F. SMIL 2.0

58. Synchronized Multimedia Integration Language 2.0 (“SMIL 2.0”) is an XML markup language for multimedia presentations and was publicly accessible on

the World Wide Web Consortium's ("W3C") website at least as of November 9, 2001. *See* EX1006 (SMIL 2.0); EX1011 (Wayback Affidavit showing SMIL 2.0 available on November 9, 2001).

59. Thus, SMIL 2.0 is prior art under at least (pre-AIA) 35 U.S.C. § 102(b). SMIL 2.0 is not cited on the face of the '156 Patent and was not considered by the ALJ in the ITC Investigation. I understand that during prosecution of later family members of the '156 Patent, Applicants submitted an article titled "Mobile Streaming Media CDN Enabled by Dynamic SMIL" by Yoshimura. Applicants did not submit the actual SMIL standard, and the article submitted by Applicants does not mention important elements of SMIL such as "<seq>," "<switch>," or "systemBitrate" teaching three quality levels (high, medium, and low) and switching to a particular quality level based upon measured system bitrate, which are pertinent to this Petition.

60. SMIL 2.0 discusses these elements. SMIL 2.0 discloses that, using "<seq>," a client can request and play media elements one after the other. EX1006, 123-126. SMIL 2.0 further teaches that a client can select different encoded files based on the client's available bandwidth. EX1006, 61-63. Specifically, the "<switch>" element can be used to list different quality files with a "systemBitrate," and, depending on the client's bandwidth, only one will be selected. *Id.*

G. Analogous Art

61. Each prior art reference is analogous art to the claimed invention in the '156 Patent, and each is in the same field of endeavor of adaptive-rate streaming based on network conditions. *Compare* EX1001, title, Abstract, 1:25-28, 2:57-60, 3:5-4:12, FIGs. 2c, 4, and 7, *with* EX1004, Abstract, 1:9-15, 3:38-63, 7:10-15, 7:40-63, 21:40-22:33, 23:40-24:3, FIG. 2; EX1016, Abstract, 1:6-14, 2:53-63, 3:44-64, 4:20-31, FIGs. 1-2; EX1017, Abstract, ¶¶ 1, 10-11, 14, 25, 31-33, 38, FIGs. 1-2; EX1013, Abstract, 2:7-3:19, 3:29-60, 6:50-7:30, FIG. 2; EX1006, 61-62, 123-126.

62. Additionally, each prior art reference is reasonably pertinent to any purported problem addressed in the '156 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, requesting varying bitrate streams depending upon network conditions” *Id.*; EX1001, 2:51-2:60.

H. Claims 1-17 Would Have Been Obvious in view of Ogdon

Claim 1:

1[Pre]: “An apparatus for rendering a video that is adaptively received as a digital stream from a video server over a network, the apparatus comprising;”

63. In my opinion, whether or not the preamble is limiting, Ogdon teaches 1[Pre]. Ogdon discloses an apparatus (client node 56) for rendering a video (video

presentation) received as a digital stream from a video server (webserver(s)) over a network (Internet). EX1004, Abstract (“distributing a performance of a presentation synchronously to a plurality of client nodes” via “the Internet”), 7:40-48 (“at least one of a client node 56 (e.g., a personal computer) . . . may receive video . . . from a communications network 70 such as the Internet”), 8:27-40 (“content webserver 96a, and alternate content web servers 96b” provide “presentation data to client sites 54 requesting such data via client nodes”), FIGs. 1A-1B.

64. Ogdon further teaches that each client node adaptively receives the video data and switches between versions of the video presentation based on network characteristics. EX1004, 3:38-41 (“**dynamically and adaptively switch**¹ between . . . versions of the presentation according to network transmission characteristics at each client network node”), 22:10-23 (“the client node 56 uses its most recent network 70 data transmission characteristics together with the host 200 transmitted list of current network 70 addresses for content webserver 96 to select an appropriate content webserver and an appropriate version of the next collection of segments to be retrieved.”).

¹ All emphases in prior art citations are added unless otherwise noted.

1[A][1]: “a media player operating on the apparatus,”

65. In my opinion, Ogdon teaches 1[A][1]. Ogdon discloses a media player (client presentation software 88 and/or browser 78) operating on the apparatus (client node). EX1004, 7:52-63 (“if the client node 56 is resident at a client site 54, then a network interface **software package** is required for receiving, e.g., video presentation information from the communications network 70 . . . includ[ing] a network browser 78 such as the Internet browsers offered by Microsoft and Netscape, together with a **client presentation software system 88** that coordinates with the browser 78 for requesting, receiving and displaying presentation segments (from the network 70) as appropriate during the presentation.”).

66. Because Ogdon refers to the client presentation software and the browser as part of a “software package” that “together” perform functions of the invention, a POSITA would have considered the client presentation software and the browser as together forming “a media player.”

67. Alternatively, if “a media player” is interpreted as requiring one single computer program, Ogdon contemplates receiving and displaying presentation data via just “an internet browser” or a plug-in within the browser (EX1004, 5:28-36), and a POSITA would have been motivated to modify the system such that each of the functions performed in Ogdon collectively by the client presentation software

and browser be performed by a single program alone to simplify the system, reduce the number of programs that are required to run on the client node, and make it easier to debug. Further, this would have been a straightforward modification because it would have been a simple matter of programming one computer program to perform all functionality that the client presentation software and the browser are disclosed to perform collectively.

1[A][2]: “wherein the media player is configured to stream the video from the video server via at least one transmission control protocol (TCP) connection over the network,”

68. In my opinion, Ogdon teaches 1[A][2]. Ogdon discloses that the media player (client presentation software and/or browser) is configured to stream the video from the video server (webserver(s)) via at least one TCP connection over the network (Internet). EX1004, 7:59-63 (“client presentation software system 88 that coordinates with the browser 78 for requesting, receiving and displaying presentation segments **(from the network 70)** as appropriate during the presentation”), 2:1-10 (“the present invention may communicate the video portion of a presentation to a user site via the Internet (more generally, via any **TCP/IP network)** . . . both the video and audio portions of the presentation may be provided solely by a **TCP/IP network** such as the Internet”), 19:34-44 (“when the time for the presentation arrives, the client’s client presentation software 88 via the network

70 establishes a network 70 connection between the client's client node 56 and the host 200 controlling the presentation performance. . . . After the host 200 is contacted, it instructs the client presentation software 88 to establish a connection with one of the internal web servers 248 for dynamic content."), claim 7 ("a network using **TCP/IP** for communicating between at least one of: (a) one of said content supplying nodes and said first client node; (b) said presentation controlling node and said first client node; (c) one of the content supplying nodes and said presentation controlling node.").

1[A][3]: "wherein the video server stores multiple different copies of the video encoded at different bit rates as multiple sets of streamlets,"

69. In my opinion, Ogdon teaches 1[A][3]. Ogdon discloses that each copy of the video presentation is made up of set(s) of "streamlets" ("segments") and each segment has alternative bitrate versions for the client nodes to choose from. Ogdon uses the term "segment" to mean a portion of the video presentation and explains that "one or more" segments may be grouped into an "element," "collection," or "subcollection." *E.g.*, EX1004, 2:36-49, 4:29-36, 18:40-45, 22:10-29. Ogdon explains that this is "an indivisible portion" of the video presentation. EX1004, 2:36-42. The entire presentation is therefore a set of streamlets (segments).

70. Ogdon further discloses that the video presentation has multiple different copies (*e.g.*, high quality (*e.g.*, full-animation video) and lower quality (*e.g.*, limited-animation video) versions) encoded at different bitrates because these streamlets (segments) can each be for “[d]ifferent versions of the same presentation” with “different network requirements,” for example, “a first version of a presentation may require a network transmission rate sufficient for real time or **animated video**” and “another version of the presentation may only require a transmission rate sufficient for **graphic slides**.” EX1004, 2:30-66. Further, “if a low transmission data rate is detected . . . presentation elements of a reduced size can be retrieved” or “if a higher transmission rate is detected . . . presentation elements of a greater size (and **corresponding enhanced quality of presentation**) can be retrieved.” *Id.*, Abstract; *see also id.*, 22:44-47 (“better presentation quality presentation elements may be retrieved (*e.g.*, the presentation quality may be enhanced from **limited** or no animation **to full animation**)”), 13:47-49 (“**several variations** of presentation content can be provided to clients based on the available bandwidth”), 24:55 (“alternative segment collections that are smaller”), claim 9 (“said first subcollection includes a first video portion, and said second subcollection includes a different second video portion that corresponds in content with said first video portion, and wherein said first and second video portions have substantially different expected

data transmission rates for being transmitted to said first client node”). A POSITA would have understood the smaller size and lower transmission rate for “limited or no animation” video to be encoded at a lower bitrate than the larger size, higher quality, and higher transmission rate requirement “full animation” video, which would be encoded at a higher bitrate.

71. Ogdon further discloses that the video server (webserver(s)) stores the streamlets (segments) of the video presentation as “[d]ifferent versions of the same presentation, accessible from the one or more of the content webserver(s).” EX1004, 2:30-31, 9:30-31, 22:60-64; *see also id.*, 9:44-46 (“content manager 104 distributes presentation content (e.g., presentation segments) to the content webserver(s) 96”); claim 21 (“storing a plurality of segments of a presentation for network access via one or more content supply nodes”), FIG. 2C (step 508 “list of network 70 addresses (URLs) of the content webserver(s) 96 from which this next collection of segments can be retrieved”).

1[A][4]: “wherein each of the streamlets yields a different portion of the video on playback,”

72. In my opinion, Ogdon teaches 1[A][4]. *See* 1[A][2]. Ogdon discloses that each of the streamlets (segments) yields a different portion of the video on playback because, the “subcollection of segments (i.e. presentation elements) [are]

ordered according to their presentation sequence.” EX1004, 2:44-45, 3:46-47 (“presentation as an **ordered series of presentation segments**”), claim 21 (“there are subcollections of one or more segments, each subcollection having a predetermined presentation order”), FIG. 2C (step 508 “next collection of one or more (video) segments”).

1[A][5]: “wherein the streamlets across the different copies yield the same portions of the video on playback,”

73. In my opinion, Ogdon teaches 1[A][5]. *See* 1[A][3]. Ogdon discloses that the streamlets (segments) across the different copies contains the same portions of the video on playback because each version (*e.g.*, high quality (full animation) and lower quality (limited animation) versions) of the stream encodes the same portion of the presentation at different quality levels. EX1004, 2:43-49 (“each version of a presentation typically has its subcollection of segments (*i.e.* presentation elements) ordered according to their presentation sequence” and “**every segment** (or subcollections thereof) in one version corresponds with a segment (or subcollections thereof) **having the same presentation order in each of the other versions.**”); *see also id.*, 2:49-55 (“**corresponding segments** (or subcollections thereof) in different versions” are the same such that “any of the corresponding alternative segments (or subcollections thereof) from different versions can be **presented as a replacement**

for another such corresponding segment (or subcollection) during the presentation.”), claim 21 (“said first subcollection is replaceable with said second subcollection”).

1[A][6]: “and wherein the streamlets in the different copies are aligned in time such that the streamlets that play back the same portion of the video for the different copies each begin at the same playback time in relation to the beginning of the video, and wherein the media player streams the video by:”

74. In my opinion, Ogdon teaches 1[A][6]. Ogdon discloses that the streamlets (elements) in the different copies (versions) are aligned in time such that each begin at the same playback time in relation to the beginning of the video because they have the same video presentation order (just different quality levels). EX1004, 2:44-49 (“substantially every segment (or subcollections thereof) in one version corresponds with a segment (or subcollections thereof) having **the same presentation order**, in each of the other versions.”); 3:11-15 (“ordering of predefined segments (or subcollections thereof) is capable of being presented and archived . . . such ordering can take into account alternative segments for the presentation.”). Additionally, the provisional application of Ogdon (U.S. 60/041,770) also discloses that “corresponding presentations segments in the collection can have identical audio portions” (EX1014, 35 (claim 25)), meaning that

corresponding alternate video presentation segments versions with identical audio portions also have identical (*i.e.*, same or equal) playback time durations. Further, during prosecution of the Ogdon patent, the Applicant characterized the Ogdon invention as having different versions “with identical (and/or content corresponding) portions of the presentation” (EX1015, 239), meaning the corresponding video segments (portions) are in the same order and each of the corresponding segments have identical (*i.e.*, same or equal) playback time durations in each version.

75. Here, as explained above, Ogdon teaches that each segment for each quality level is sequentially ordered in the same order starting from the beginning of the video presentation, which corresponds to the playback times and are requested in order. EX1004, FIG. 2 (step 508: “The host 200 sends one or more commands to the client presentation software 88 at each client node 56 indicating; (A) **the next** collection of one or more (video) segments”, then at step 560, when there are no more segments to present, the process loops back to step 476 for identifying **the next** collection of presentation segments).

76. Additionally, Ogdon teaches presenting the video presentation “synchronously to a plurality of client nodes” such that each corresponding segment begins at the same playback time. EX1004, Abstract, *see also id.*, 3:38-63 (“it is an aspect of the present invention to dynamically and adaptively switch between . . .

versions of the presentation according to network transmission characteristics at each client network node so that the clients at the client nodes have **presented to them simultaneously, synchronously and in real time, corresponding (in content) segments of the presentation**. For example, a first client (at a **first client node**) may experience the presentation as an ordered series of presentation segments, wherein the **first and second ordered segments are presented in full animation . . . synchronously with the presentation to the first client**, a second client (at a **second client node**) may experience **the presentation in a slide show format . . .** wherein the initial two segments presented are corresponding alternative segments to the first and second segments presented to the first client. . . . a **third client** may synchronously experience the **first segment** of the presentation . . . but subsequently experience the corresponding **slide show alternative to the second segment . . .** due to, for example, network transmission slowdowns.”).

77. As discussed above, the streamlets (segments), starting with the first segment, play back the same portion of video for the different copies. *See* 1[A][5]. And the media player (client presentation software and/or browser) streams the video. *See* 1[A][1]-1[A][2].

1[B][1]: “requesting sequential streamlets of one of the copies from the video server according to the playback times of the streamlets by transmitting hypertext transport protocol

(HTTP) GET requests that identify the selected streamlets stored by the video server,”

78. In my opinion, Ogdon teaches 1[B][1]. Ogdon discloses requesting sequential streamlets of one of the copies from the video server. Ogdon discloses that the streamlets of each of the copies are in the same sequential order. *See* 1[A][3], 1[A][5]-[A][6]. Ogdon further teaches that end user device client nodes request (via client presentation software and/or browser) each of the sequential streamlets (segments) of one of the copies from the video server because Ogdon is a “client-request” system that requires the client to request each sequential collection of one or more segments where “each client node” must “request presentation content from a given set of communications network servers rather than having such servers push presentation content to the client node.” EX1004, 6:41-44. More specifically, “the present invention employs a ‘**client-request**’ technology, where each presentation member’s browser **requests** information from a communication network server.” *Id.*, 7:10-13, claim 12 (“a network interface component, residing on said first client node, for receiving said presentation control information and transmitting a request for a subcollection of said collection of data segments to one of said content supplying nodes, wherein said network interface component includes a network browser for communicating with said communications network”), FIG. 2C (step

528: “the browser, in turn, sends a network 70 (Internet) **request** to the selected content webserver 96 for the selected collection of segments”), 6:18-23 (“Thus, when the data required for a segment is not timely cached prior to its intended performance at a client’s node, alternate segment data is automatically **requested** from the communications network by the client node.”).

79. Ogdon discloses that “requesting sequential streamlets” may include a request for a **single** segment per request or **multiple** segments per request because Ogdon discloses that each requested “element” (a/k/a “subcollection” or “collection”) of segments contains “**one or more** segments.” EX1004, 2:39-40, 22:30-33. Thus, each requested element may contain one segment (streamlet) or, alternatively, each requested element may contain two or more segments (streamlets). In the latter case, the request would be for multiple segments (streamlets) at once.

80. Ogdon also teaches that the client requests the segments “according to the playback times of the streamlets.” In the ITC Investigation, the ALJ did not explicitly construe “requesting sequential streamlets of one of the copies from the video server according to the playback times of the streamlets.” However, the ALJ did find that requesting sequential media segments by unique filenames (*i.e.*, where each segment in the sequence has “a unique identifying number” corresponding to

position in playback sequence) satisfied this limitation of requesting streamlets “according to the playback times.” EX1009, 118-120.

81. Here, as explained above, Ogdon teaches that each element / collection / subcollection comprising one or more segments is sequentially ordered starting from the beginning of the presentation, which corresponds to the playback times of each segment in the larger video presentation, and the elements are requested in such sequential order. *See* 1[A][6]. Further, Ogdon teaches that each streamlet (segment) has a unique “resource name” and/or path name at the server(s) indicative of segment ordering and may also include an “item number.” EX1004, 28:14-28 (the “Resource Name” in the script “provide[s] an identification of a presentation resource (e.g. presentation data segment file)” while “Path—Denotes a path name to a file directory relative to the resource location” and “File—Denotes a name of a resource file”), FIG. 3 (616 “item number”). This is in line with the ’156 Patent’s description of “identifying” streamlets “with a unique filename.” EX1001, 8:66-67. Thus, Ogdon teaches that segments are requested according to the playback times under the ITC interpretation because each segment has a unique identifying name indicative of the sequence of the segments (*e.g.*, via resource name and/or item number) and that the segments are requested in order.

82. To the extent requesting “according to the playback time” requires files to be named and requested with some indication of playback time, Ogdon also teaches this limitation. For example, Ogdon contemplates a “virtual time” identification for segments of the video presentation. EX1004, 25:63-26:14 (“A ‘virtual time’ column 620”), FIG. 3 (620: “Virtual Time HR:MN:SEC”). A POSITA would have been motivated to name each segment of a video presentation according to its playback time (*e.g.* in the format of HR:MN:SEC), and thus request said files by this resource name (playback time), because a naming convention in this format would provide each streamlet with a unique and separately-identifiable filename in order to simplify the system such that when a client requests a segment (or collection of segments) the client requests the name of the file in the format HR:MN:SEC (*e.g.* Segment 1 = 00:00:00; Segment 2 = 00:00:05; etc.). Further, a POSITA would have been motivated to make such a combination because naming segments according to their playback times would allow for ordering the segments in proper playback order when arranging by name such that when a POSITA viewed the directory of files saved on the servers the segments would be in order of how they will be played. A POSITA would have had a reasonable expectation of success with such a modification because it would simply involve changing the file names of segments stored on the web servers.

83. Finally, Ogdon teaches that the client requests can be made by transmitting HTTP requests. Ogdon discloses that “the presentation element(s) selected is dependent upon network protocols such as HTTP” noting that “as the size of the presentation data and the time for retrieval decreases, the present invention tends to use HTTP” and, for example, “there is a primary webserver 96a and an alternative webserver 96b, and each has presentation versions for both HTTP and FTP as well as both having animated and non-animated interchangeable presentation elements.” EX1004, 22:48-64.

84. It was known to a POSITA that HTTP requests are made by a client transmitting GET requests. *See* EX1019, 46 (HTTP 1.1 protocol describing “GET” as the means by which to “retrieve whatever information (in the form of an entity) is identified by the Request-URI”). Further, a Request-URI stands for Request-Uniform Resource Identifier and “Uniform Resource Identifiers are simply formatted strings which identify—via name, location, or any other characteristic—a resource” (EX1019, 16) such that an HTTP GET request is “used to identify a resource on an origin server or gateway” (EX1019, 32). In fact, the ’156 Patent also admits that HTTP GET requests were “standard” (EX1001, 9:40-42).

85. Further, to the extent Ogdon does not explicitly teach HTTP GET requests, a POSITA would have been motivated to modify Ogdon to request

elements from servers via standard HTTP GET requests because GET requests are one of a finite number of possible request solutions available in the HTTP protocol, and thus one of a finite number of identified predictable solutions for requesting files from a server with a reasonable expectation of success. EX1019, 45-47. There also would have been a reasonable expectation of success because HTTP is a universally known and used protocol and GET requests are a standard method within that protocol for requesting data. *Id.* Finally, as noted above, the requested elements / collections / subcollections in Ogdon each contain “**one or more** segments” (EX1004, 2:39-40), and thus each requested element may contain one segment (streamlet) or, alternatively, each requested element may contain two or more segments (streamlets).

1[B][2]: “wherein the sequential streamlets are selected by the media player from the based upon successive determinations to shift the playback quality to a higher or lower quality one of the different copies of the video;”

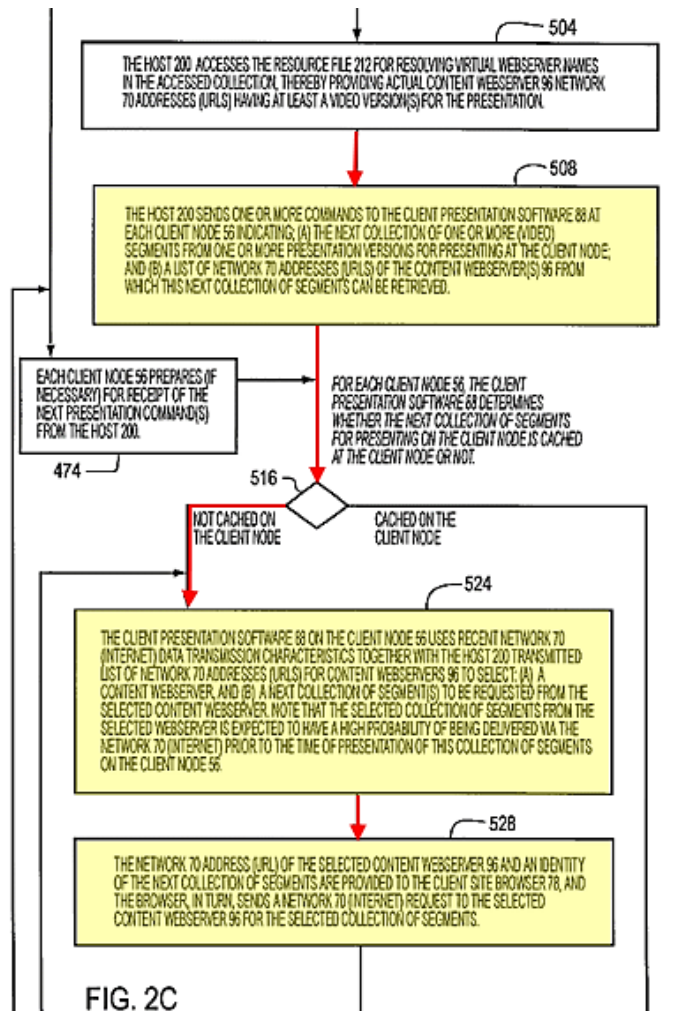
86. In my opinion, Ogdon teaches 1[B][2]. Ogdon discloses sequential streamlets selected by the media player. *See* 1[A][3]-[A][6]; EX1004, FIG. 2C (step 524: “The client presentation software 88 . . . select[s] . . . a next collection of segment(s)”). Ogdon also teaches that this selection is from the based upon [*sic*] successive determinations. EX1004, FIG. 2C-2D ((step 516) client **determines**

whether segments are already cached; (step 532) after requesting, client **determines** whether the requested segments are cached within a desired time; (step 536) if no, client **determines** whether there is time to try again; (step 544) if yes, client **determines** network characteristics at client node), 24:50-57 (“on such **subsequent iterations for determining** an alternative way to present a particular portion of the presentation, the following steps may be performed: the **original calculation is again performed with new times and current bandwidth information . . .** [a]n overall limit of three re-tries of any URL will force smaller alternative segment collections to be selected”).

87. Ogdon discloses making such successive determinations to shift the playback quality to a higher or lower quality of one of the different copies of the video because Ogdon repeatedly determines, based on bandwidth, in a loop to shift the quality of the segments.

[I]f the next collection of segments is not cached on a client node 56, then step 524 is performed wherein the client presentation software 88 on the client node 56 uses its most recent network 70 data transmission characteristics together with the host 200 transmitted list of current network 70 addresses for content webserver 96 **to select** an appropriate content webserver and **an appropriate version of the next collection of segments to be retrieved.**

Id., 22:10-18, 23:5-22 (calculating bandwidth to “[s]elect the highest quality collection of presentation elements available”), 23:40-48, 24:50-57, FIGs. 2B-2D.



EX1004, FIG. 2C (annotated).

1[C]: “repeatedly generating, by the media player, a factor relating to the performance of the network that is indicative of an ability to sustain the streaming of the video;”

88. In my opinion, Ogdon teaches 1[C]. Patent Owner contended in the file history of parent U.S. Patent No. 8,868,772 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.” EX1018, 447-448 (footnotes omitted). Ogdon discloses repeatedly generating “a factor relating to the performance of the network that is indicative of an ability to sustain the streaming of the video” because it teaches repeatedly calculating data transmission characteristics such as the current client node bandwidth to select a quality version for each segment collection. EX1004, 22:10-23 (“the client node 56 uses its **most recent network 70 data transmission characteristics** together with the host 200 transmitted list of current network 70 addresses for content webserver 96 **to select** an appropriate content webserver and **an appropriate version of the next collection of segments to be retrieved.**”), 23:5-22 (calculating “average bandwidth” for “[s]elect[ing] the highest quality collection of presentation elements available”), FIG. 2C (“Client node 56 uses recent network 70 (Internet) data transmission characteristics . . . to select . . . (B) a next collection of segment(s) to be requested from the selected content webserver.”), 5:36-39 (“several variations of presentation

content can be delivered **based on, e.g., the current bandwidth available** and the client's affiliated network server(s).”), 13:47-49, 24:50-57 (“on such subsequent iterations for determining an alternative way to present a particular portion of the presentation, the following steps may be performed: the original calculation is again performed with new times and current bandwidth information . . . [a]n overall limit of three re-tries of any URL will force smaller alternative segment collections to be selected”), claim 2.

89. Ogdon also explains that additional factors may be calculated for selecting the quality segments such as “network 70 error rates, fluctuations in bandwidth, or a predictive statistical expectation of bandwidth.” *Id.*, 23:6-28. Both current bandwidth and these additional factors also “indicative of an ability to sustain the streaming of the video” because bandwidth determines the capacity of the network and clients will select the most appropriate version to ensure the requested segments are delivered in time for presentation to sustain the stream. *Id.*, 23:18-20 (“Select the highest quality collection of presentation elements available”), 23:10-23 (“the goal of assuring that there is a **high probability** of this next collection of segments being delivered to the client node 56 **prior to the time that this collection is to be used in the presentation performance on the client**”), 21:62-63 (“attempt

to assure a **timely caching** of this next collection of segments for timely performance”).

1[D]: “adapting the successive determinations to shift the playback quality based on the factor to achieve continuous playback of the video using the streamlets of the highest quality copy of the video that is determined to be sustainable at that time; and”

90. In my opinion, Ogdon teaches 1[D]. As explained above, Ogdon discloses adapting the successive determinations to shift the playback quality based on the factor to achieve continuous playback of the video using the streamlets (segments) of the highest quality copy of the video that is determined to be sustainable at that time. *See* 1[B][2]-1[C]. In Ogdon, the process for retrieving the next file and determining whether to shift the playback quality of the next file to the highest quality sustainable is carried out in a loop. *See* 1[B][2], 1[C]; EX1004, 23:18-20, 23:10-23, FIG. 2B (step 476 “first (next) collection of corresponding presentation segments”), FIG. 2C (step 508 “next collection of one or more (video) segments from one or more presentation versions” and steps 524, 528), FIG. 2D (step 552 present “the next segment” and loop at 560), 22:10-18, 23:5-22 (calculating bandwidth to “[s]elect the **highest quality** collection of presentation elements **available**”), 23:40-48, 24:50-57.

1[E]: “presenting the video for playback by providing the requested streamlets in order of ascending start time.”

91. In my opinion, Ogdon teaches 1[E]. Ogdon describes that the elements are played back by the client node(s) in order of ascending time. *See* 1[Pre], 1[B][1]-1[B][2], 1[D]; EX1004, 7:59-63 (“a client presentation software system 88 that coordinates with the browser 78 for requesting, receiving and displaying presentation segments (from the network 70) as appropriate during the presentation”), 26:37-39 (“provide a particular presentation content file (e.g., of presentation elements) at a client node 56 in time for display.”), 2:45 (“ordered according to their presentation sequence”), claim 21 (“each subcollection having a predetermined presentation order”).

Claim 2: “The apparatus of claim 1, wherein the apparatus is configured to establish multiple Transmission Control Protocol (TCP) connections with a content server, and request streamlets of varying bitrates.”

92. In my opinion, Ogdon teaches claim 2. *See* 1[A][2], 1[B][2]; EX1004, 2:13-23 (“[t]he present invention distributes a presentation [] among network server nodes of a TCP/IP network . . . a version of the presentation may be accessed **synchronously from different network server nodes**, or different versions of the presentation may be accessed **synchronously from one or more of the network server nodes**.”), claim 7, 22:48-64 (“the presentation element(s) selected is

dependent upon network protocols such as HTTP” noting that “as the size of the presentation data and the time for retrieval decreases, the present invention tends to use HTTP” and, for example, “there is a primary webserver 96a and an alternative webserver 96b, and each has presentation versions for both HTTP and FTP as well as both having animated and non-animated interchangeable presentation elements.”).

93. A POSITA would have understood the above disclosures of Ogdon to teach establishing multiple TCP connections with the content server. It was well-known to a POSITA at the time of the alleged Priority Date that simultaneously connecting to different server nodes requires multiple TCP connections. For example, a POSITA understood that TCP connections are distinguished by their IP addresses and port numbers, and that different servers have different IP addresses. As such, synchronously connecting to more than one content server, as Ogdon discloses, requires multiple TCP connections.

94. To the extent that Patent Owner argues that Ogdon does not teach multiple TCP connections, a POSITA would have been motivated to configure Ogdon’s apparatus to establish multiple TCP connections between a client and content server. For example, a POSITA understood that having multiple TCP connections provides a back-up if one connection fails. It also allows parallel

downloading of multiple segments at the same time, which increases efficiency, *e.g.*, where maximum TCP throughput is the limiting factor of performance. Multiple TCP connections also permits connections to an alternative webserver(s) for the user to request different quality segments, to ensure sufficient buffer of data for continuous playback. A POSITA would understand that multiple TCP connections would be required to access content parts residing on different server computers, since TCP connections are defined by the source/destination IP addresses and source/destination ports, and different server computers would have different IP addresses, and source port numbers for a TCP connection are selected at the time of the connection. A POSITA would have had a reasonable expectation of success with such a modification because the TCP protocol allows for multiple connections and Ogdon teaches using TCP to request different quality versions or the same version from different server nodes.

Claim 3: “The apparatus of claim 1, wherein each streamlet further comprises a portion of a content file provided by the server.”

95. In my opinion, Ogdon teaches claim 3. *See* 1[Pre], 1[A][4] (explaining that each segment (streamlet) is a portion of a larger video presentation stored at the web server(s)).

Claim 4: “The apparatus of claim 1, wherein the requesting the sequential streamlets comprises the apparatus transmitting hypertext transport protocol (HTTP) GET requests for selected streamlets, wherein each of the HTTP GET requests identifies the separate file stored by the video server that corresponds to the requested streamlet.”

96. In my opinion, Ogdon teaches claim 4. Ogdon teaches client nodes using HTTP GET requests for requesting selected sequential streamlets (segments) that identify the specific resource (segment) stored on the server (webserver(s)). *See* 1[B][1] (HTTP GET requests, which include Resource-URI string identifying the requested resource, for sequential streamlets). Additionally, Ogdon further teaches that the streamlets (segments) are separate files that are stored by the video server (webserver(s)); EX1004, 28:17-18 (“presentation data segment file”), FIG. 2C (step 508 “list of network 70 addresses (URLs) of the content webserver(s) 96 from which this next collection of segments can be retrieved”). A POSITA would have understood separate URL addresses for each segment to indicate separate segment files stored by the video server.

Claim 5: “The apparatus of claim 1 wherein each of the streamlets of each of the different copies is independently requestable and playable by the apparatus.”

97. In my opinion, Ogdon teaches claim 5. *See* 1[B][1] (different versions of each element / collection / subcollections (comprising one or more segments) are independently requestable), 1[E] (and playable).

Claim 6: “The apparatus of claim 4, wherein the requesting of the sequential streamlets comprises the end user device transmitting hypertext transport protocol (HTTP) GET requests for selected streamlets.”

98. In my opinion, Ogdon teaches claim 6. Ogdon teaches a client node (end user device) transmitting HTTP GET requests for selected streamlets. *See* 1[B][1].

Claim 7: “The apparatus of claim 1 wherein each of the streamlets in each of the plurality of different copies is a separate file stored by the video server.”

99. In my opinion, Ogdon teaches claim 7. Ogdon discloses that the streamlets (segments), including in each of the plurality of different copies (quality levels), may be stored at the video server (webserver(s)) as separate files. *See* 1[Pre], 1[A][3], claim 4 (segments are separate files stored on server(s)).

Claim 8: “The apparatus of claim 1 wherein the media player upshifts to a higher quality one of the different copies when the factor is greater than a first threshold and downshifts to a lower quality one of the different copies when the factor is less than a second threshold.”

100. In my opinion, Ogdon teaches claim 8. As explained above, Ogdon teaches generating a factor, according to responses from streamlet requests, from various measurements relating to network performance indicative of the ability to sustain the stream. *See* 1[C]. Ogdon also teaches that a client can “dynamically and adaptively **switch** between . . . **versions** of the presentation according to network transmission characteristics at each client network node.” EX1004, 3:38-41. Such switching to higher or lower quality version based on “network characteristics” teaches the existence of some “first” threshold of network characteristics (*e.g.*, client bandwidth) that, once exceeded, indicates that a client can and should request a higher quality version segment. Such switching to higher or lower quality version also teaches the existence of some “second” threshold of network characteristics (*e.g.*, client bandwidth) that, once exceeded, indicates that a client can and should request a lower quality version segment.

101. Ogdon also teaches “**several** variations of presentation content.” EX1004, 5:36-37, 13:47-48. A POSITA would have understood this teaching of “several” (which means more than two) to include at least three different versions at

different quality levels (*e.g.*, a highest quality, a lowest quality, and a medium quality in between). Further, it was well-known to a POSITA at the time of the alleged Priority Date to provide three or more alternatives of media at different bitrates (quality levels). *See, e.g.*, EX1007, 9:14-22 (three alternative files), 10:15-24 (four alternative video files encoded at four different bitrates (20 kbps; 50 kbps; 80 kbps; and 140 kbps) requested by the client based on client-determined bandwidth).

102. Thus, Ogdon further teaches that when the media player (client presentation software and/or browser) is streaming at a medium quality, it upshifts to a highest quality one of the different copies (*e.g.*, highest quality full animation version) when a certain first threshold (*i.e.*, bandwidth sufficient for streaming in highest quality) is exceeded such that the factor is greater than a first threshold (*e.g.*, bandwidth is high enough to timely cache highest quality segment(s)). Similarly, when the media player is streaming at a medium quality it downshifts to a lowest quality one of the different copies (*e.g.*, lowest quality reduced animation version) when the factor is less than a second threshold (*e.g.*, bandwidth sufficient to timely cache the medium quality stream). 1[B][1]-1[D]; EX1004, 6:14-23 (“the present invention monitors: . . . the data transmission rate . . . the amount of data cached on each client’s node” and “when the data required for a segment is not timely cached prior to its intended performance at a client’s node, alternative segment data is

automatically requested”), FIG. 2C (step 524 selecting segments that “have a high probability” of being delivered “prior to the time of presentation”), 2:62-66, 21:61-62; *see also id.*, 3:38-63 (“it is an aspect of the present invention to dynamically and adaptively switch between . . . versions of the presentation according to network transmission characteristics at each client network node . . . a **third client** may synchronously experience the **first segment** of the presentation . . . but subsequently experience the corresponding slide show **alternative to the second segment** . . . due to, for example, network transmission slowdowns.”) 1[C]-1[E].

Claim 9: “The apparatus of claim 1, wherein the requesting the sequential streamlets comprises the apparatus transmitting hypertext transport protocol (HTTP) GET requests for selected streamlets, and wherein each of the HTTP GET requests identifies a separately-identifiable portion of the one or more files that corresponds to the requested streamlet.”

103. In my opinion, Ogdon teaches claim 9. *See* 1[Pre], 1[A][4] (explaining that each segment (streamlet) is a different portion of a larger video presentation stored at the web server(s)), 1[B][1] (HTTP GET requests). As explained above in 1[B][1], Ogdon teaches requesting streamlets using a unique filename (resource name). *See* 1[B][1]. Ogdon thus teaches that each segment is a separately-identifiable portion of the one or more files (segments making up the entire video presentation) because each segment has its own unique file name (resource name)—

just as contemplated by the '156 Patent (EX1001, 8:66-67)—and are thus separately-identifiable. EX1004, FIG. 2C (“content webserver 96 network 70 addresses (URLs)”), 12:40-44 (“identifiers with content webserver 96 URIs and path names on these web servers where presentation content data resides”).

104. Also, as explained above in 1[B][1], HTTP GET requests each include a Request-URI, *i.e.* “Uniform Resource Identifiers” which “are simply formatted strings which identify—via name, location, or any other characteristic—a resource” (EX1019, 16) such that an HTTP GET request is “used to identify a resource on an origin server or gateway” (EX1019, 32). Additionally, Ogdon further explains that presentation scripts sent to client nodes provide “identification of segments to be presented during the presentation” and “sequencing information regarding the order of presentation segments.” EX1004, 18:39-43, FIG. 3 (showing script identifying segment). Thus, Ogdon teaches that each HTTP GET request identifies a separately identifiable portion (separately identifiable segment) of the one or more files (of the multiple segments that make up the entire video presentation) that corresponds to the requested resource (segment).

Claim 10: “The apparatus of claim 1, wherein the apparatus is configured to initially request low quality streamlets to enable instant playback of the content file, and subsequent upshifting according to the performance factor.”

105. In my opinion, Ogdon teaches claim 10. Ogdon teaches that if lower network transmission characteristics exist prior to an initial request, the request for the first element (*i.e.*, subcollection of segments), the client node will initially request a low quality element, which would enable instant playback, and if the network characteristics subsequently improve after requesting the low quality streamlets, the client node will select a higher quality next element. EX1004, Abstract (“if a **low** transmission data rate is **detected** at a first client node, **presentation elements of a reduced size can be retrieved.**”), 3:38-63 (explaining that a second client node initially requests low quality segments); *see* 1[B][1]-1[D]. Thus, Ogdon expressly discloses an initial request for segments of low quality (*i.e.*, reduced size) where a client detects a low transmission data rate and also expressly teaches, when the bandwidth improves, selecting the highest quality copy available and sustainable—which would entail upshifting—and thus Ogdon’s teachings meets these limitations. EX1004, 23:5-22 (calculating bandwidth to “[s]elect the highest quality collection of presentation elements available”).

106. Alternatively, a POSITA would have known that it was desirable to “reduce[] the start-up” for streaming content to beneficially allow the user to view the stream more quickly and thus request a low quality first then switch up to a better quality once there is sufficient buffering at the client. EX1013, 3:29-54. Therefore, a POSITA would have been motivated to modify the apparatus of Ogdon to initially request lower quality streamlets in order to have a quicker start-up time for the stream to minimize the wait for the user wishing to view the stream. A POSITA would have had a reasonable expectation of success with such a combination because it would have been a straightforward modification of Ogdon to specify that a lower quality of collections of segments be retrieved initially to enable faster playback and then upshift to enhance the quality of the video presentation if bandwidth permits.

Claim 11: “The end user device of claim 1 wherein each of the streamlets in each of the plurality of different copies is a separately-identifiable portion of one or more files stored by the video server.”

107. In my opinion, Ogdon teaches claim 11. *See* 1[Pre], 1[A][4] (explaining that each segment (streamlet) is a portion of a larger video presentation stored at the web server(s)), claim 9 (explaining how streamlets are separately identifiable).

Claim 12: “The apparatus of claim 1 wherein the apparatus is a mobile computing device comprising a processor and a non-transitory data storage.”

108. Ogdon teaches claim 12. Ogdon discloses “client node 56 (e.g., a personal computer).” EX1004, 7:45. A POSITA would have understood a “personal computer” to include mobile personal computers as laptops which contain processors and non-transitory data storage.

Claim 13:

13[Pre]: “A method executable by an end user device to stream a video received via a connection with a server over a network, the method comprising:”

109. In my opinion, whether or not the preamble is limiting, Ogdon teaches 13[Pre]. Ogdon teaches a method executable by an end user device (client node(s) 56) to stream a video (presentation) received via a connection with a server (webserver(s)) over a network (network 70, e.g., Internet); *See* 1[Pre].

13[A][1]: “requesting, by the end user device, wherein the end user device streams the video from the video server via at least one transmission control protocol (TCP) connection over the network,”

110. In my opinion, Ogdon teaches 13[A][1]. *See* 1[A][2], 1[B][1]-1[B][2], 1[D].

13[A][2]: “a plurality of sequential streamlets of one of the copies from the server based on playback times of the streamlets wherein multiple different copies of the video

encoded at different bit rates are stored as multiple sets of streamlets on the server,”

111. In my opinion, Ogdon teaches 13[A][2]. *See* 1[A][3], 1[B][1].

13[A][3]: “wherein each of the streamlets yields a different portion of the video on playback,”

112. In my opinion, Ogdon teaches 13[A][3]. *See* 1[A][4].

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

113. In my opinion, Ogdon teaches 13[A][4]. *See* 1[A][5].

13[A][5]: “and wherein each of the streamlets comprises a playback time such that each of the streamlets for each of the different copies that encode the same portion of the video begins at the same playback time in relation to the beginning of the video,”

114. In my opinion, Ogdon teaches 13[A][5]. *See* 1[A][6].

13[A][6]: “wherein the end user device requests the streamlets by transmitting hypertext transport protocol (HTTP) GET requests that each identify one of the requested streamlets stored by the server; and wherein the end user device streams the video by:”

115. In my opinion, Ogdon teaches 13[A][6]. *See* 1[A][6] and 1[B][1].

13[B]: “repeatedly generating, by the end user device, a factor that is indicative of an ability to sustain the streaming of the video;”

116. In my opinion, Ogdon teaches 13[B]. *See* 1[C].

13[C]: “making successive determinations by the end user device to shift the playback quality based on the factor to

achieve continuous playback of the video using the streamlets of the highest quality copy determined sustainable at that time; and”

117. In my opinion, Ogdon teaches 13[C]. *See* 1[B][2], 1[D].

13[D]: “presenting the video by playing back the requested media streamlets on the end user device in order of ascending playback time.”

118. Ogdon teaches 13[D]. *See* 1[E].

Claim 14: “The method of claim 13 wherein the making of 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 downshifting to a lower quality one of the different copies when the at least one factor is less than a second threshold.”

119. In my opinion, Ogdon teaches claim 14. *See* claim 8.

Claim 15: “The method of claim 14 wherein each of the streamlets of each of the different copies is independently requestable and playable by the end user device.”

120. In my opinion, Ogdon teaches claim 15. *See* 1[B][1], 1[E], claim 5.

Claim 16: “The method of claim 13 wherein each of the streamlets in each of the plurality of different copies is a separately-identifiable portion of one or more files stored by the video server.”

121. In my opinion, Ogdon teaches claim 16. *See* 1[Pre], 1[A][4], claims 3,

9, 11.

Claim 17: “The method of claim 16 wherein the requesting of the sequential streamlets comprises the end user device transmitting hypertext transport protocol (HTTP) GET requests for selected streamlets, and wherein each of the HTTP GET requests identifies the separately-identifiable portion of the one or more files that corresponds to the requested streamlet.”

122. In my opinion, Ogdon teaches claim 17. *See* 1[Pre], 1[A][4], 1[B][1], claims 3, 9.

I. Claims 1-17 Would Have Been Obvious in view of Ogdon and Ala-Honkola

123. The sections of Ground 1 (Section VIII.H) are incorporated into this section by reference.

Claims 1-17

124. As explained above in Section VIII.H, Ogdon teaches all limitations of claims 1-17 including all limitations of independent claims 1 and 13. To the extent it is argued that Ogdon lacks certain limitations, Ala-Honkola teaches these limitations.

1[A][1]

125. In my opinion, while Ogdon alone teaches this limitation (*see* Section VIII.H: 1[A][1]), Ala-Honkola teaches a single media player (video player) operating on the apparatus (running in the user terminal) that performs the functions of adaptive streaming including making requests to the server for video at a selected

quality level based upon determined bandwidth and playing back the received requested video. EX1017, ¶ 33 (“**video player client** running in the user terminal sends 34 a **request** message from the terminal 33 to the service provider’s server”), ¶ 35 (“The **player in the client terminal** chooses 21 one of the supported speed rate”).

126. A POSITA would have been motivated to modify the system of Ogdon such that each of the functions performed in Ogdon collectively by the client presentation software and browser are performed by a single program alone, as taught by Ala-Honkola, because both Ogdon and Ala-Honkola are drawn to the same field of adaptive video streaming and in order to simplify the system of Ogdon, reduce the number of programs that are required to run on the client to stream video presentations, and make the program easier to debug. A POSITA would have had a reasonable expectation of success with such a combination because both Ogdon and Ala-Honkola are drawn to similar systems of client-server based streaming, where the client adaptively receives video segments based on client requests based on playout capabilities including network conditions. Implementing a media player as a single computer program as opposed to the combination of presentation software and a browser would have been a straightforward modification for a POSITA—a simple matter of programming one computer program to perform all functionality

that the client presentation software and the browser are disclosed to perform collectively.

1[B][1], 13[A][2], 13[A][6]

127. In my opinion, while Ogdon alone teaches these limitations (*see* Section VIII.H: 1[B][1], 13[A][2], 13[A][6]), Ala-Honkola also teaches client requests to a server being HTTP GET requests including identifying the particular file or separately identifiable portion of file being requested. EX1017, ¶ 14 (“The information of the selection of the new data source may transmitted from the user's terminal to the sending terminal **using a GET method of an HTTP protocol**”), ¶ 22 (“More preferably, the arrangement further comprises a GET method of an HTTP protocol”), ¶¶ 33-34 (“The video player client running in the user terminal sends 34 a request message . . . **using a GET method, which is one of the methods defined in the HTTP 1.1 protocol.** . . . GET http://www.service provider.com/video/music/song1.video”), ¶ 38 (“a GET command with an additional field RANGE is sent 310 from the user's terminal to the server . . . GET http://serviceprovider.com/video/music/song3video RANGE: bytes=805000-”).

128. A POSITA would have been motivated to use HTTP GET requests, as taught by Ala-Honkola, for requesting specific streamlets (segments) in Ogdon because HTTP GET requests were a well-known and reliable means of requesting

and obtaining files from a server and thus ensure Ogdon's client properly receives each quality file for continuous playing. Further, GET requests are one of a finite number of possible request solutions available in the HTTP protocol, and thus one of a finite number of identified predictable solutions for requesting files from a server with a reasonable expectation of success. A POSITA would have had a reasonable expectation of success with such a combination because both Ogdon and Ala-Honkola are directed to similar systems for adaptive streaming and such a modification would simply entail using known HTTP GET requests from the HTTP Protocol to request files from the server and reliably receive the requested files.

129. Additionally, to the extent it is argued that Ogdon does not teach requesting based on or according to "the playback times" of the streamlets, Ala-Honkola teaches this limitation as well. For example, Ala-Honkola teaches using "timing marks" indicating the "byte" corresponding to playback times of the file such that the client can request the "byte" (corresponding to the timing marks) to begin streaming at when switching streams during playback. EX1017, ¶ 31 ("Stream 1 . . . contains **timing marks** 6, 7, 8, 9 . . . embedded in stream 1 at a various locations, and **correlate the information in the two separate resolution streams**. Thus the **timing marks** of stream 1 in the example of FIG. 1 indicate the byte of the file where the stream is running at the time and the corresponding byte 6A, 7A, 8A,

9A, in stream 2 . . . the mark 7 indicating time 1000ms, it tells the corresponding byte 805000 in stream 2 to where the source of the transmission of the video transfers 11.”), ¶ 32 (“stream 2 contains **timing marks 10, 11, 12, 13**, which point to the location of corresponding information in stream 1, as shown by the **corresponding byte 10A, 11A, 12A, 13A**, in stream 1”), ¶ 38. In other words, Ala-Honkola teaches a client requesting according to the playback time (by requesting the byte corresponding to desired timing mark). Additionally, a GET Request, as taught by Ala-Honkola, includes a “Uniform Resource Identifier (URI) [], as a location (URL) [] or name (URN) [], for indicating the resource to which a method is to be applied.” EX1019, 6-7; EX1017, ¶¶ 34, 38.

130. A POSITA would have been motivated to make client streamlet requests “based on” or “according to” the playback times, as taught by Ala-Honkola, in the streamlet requests of Ogdon (*e.g.*, make specific requests for streamlets based on timing marks) because requesting according to specific playback times would allow a client requesting streamlets to avoid missing portions of a video being streamed, especially when making a change in quality, and would provide the viewer with a seamless viewing experience with a reasonable expectation of success. A POSITA would have had a reasonable expectation of success with such a combination because both Ogdon and Ala-Honkola are directed to similar systems

for adaptive streaming and such a modification would simply entail requesting files according to their playback time (e.g., based on timing indicators and/or corresponding bytes).

J. Claims 4, and 7 Would Have Been Obvious in view of Ogdon in view of Shteyn or, alternatively Ogdon in view of Ala-Honkola and Shteyn

131. The sections of Grounds 1 and 2 (Sections VIII.H-I) are incorporated into this section by reference.

Claims 4 and 7

132. As explained above in Sections VIII.H-I, Ogdon or Ogdon in view of Ala-Honkola teaches all limitations of claims 4 and 7. To the extent it is argued that Ogdon or Ogdon in view of Ala-Honkola lacks each of the streamlets in each of the plurality of different copies being a separate file stored by the video server and that the client requests identify said separate files stored by the video server corresponding to the requested streamlets, Shteyn teaches these limitations. Shteyn teaches “[a]n electronic file . . . **partitioned into a sequence of segments** at the **server** side.” EX1016, Abstract. Each segment (or “file”) is stored in the server as different encoded bitrate (bandwidth) and size (bytes), such as “part1” and “part1 alt.” *Id.*, 3:44-56 (“segment labeled ‘**part1**’ is in a preferred format . . . An alternative first part is labeled ‘**part1 alt**’ having a **different length**” in bytes and a “different

bandwidth requirement.”), 1:65-2:7 (“the **content file is split into multiple parts** . . . location of the whole file as well as of it parts **at the server**”), FIG. 2 (“(Preferred format) . . . <length> 1024 </length> . . . <min_bandwidth> 10,000 </min_bandwidth> . . . (Alternative format) . . . <length> 512 </length> . . . <min_bandwidth> 8,000 </min_bandwidth>”), 2:20-24 (“information contains references to the file location as well as references to the locations of the parts” and “intended bandwidth information is associated with the parts”), claims 1, 9 (“**storing** on one or more **server** computers **multiple alternative files** corresponding to a given segment”), 2:57-3:2, 4:20-21.

133. A POSITA would have understood that these alternative segment files stored with different byte lengths (sizes) and different bandwidth requirements would mean that each alternative segment is encoded at different bit rates because both are determinative of the encoded rate. For instance, the “Preferred format” with a length of 1024 and minimum bandwidth of 10,000 shows it is a higher quality encoded rate (larger size and requires more bandwidth) than the lower quality encoded rate or “Alternative format” with a length of 512 and minimum bandwidth of 8,000 (smaller size and thus requires less bandwidth). *Id.* Shteyn also describes that the different encoded parts for each segment can be the same format or different formats. EX1016, claims 8, 14, FIG. 2, 1:42-50.

134. A POSITA would have been motivated to modify the apparatus of Ogdon such that each segment of Ogdon is stored at the server(s) as a separate file to simplify streaming requests by simply requesting individual files using a simple GET request rather than requiring the GET requests to also include a RANGE request. A POSITA would have had a reasonable expectation of success with such a combination because both Ogdon and Shteyn are drawn to similar systems of client-server based streaming where video segments yield different portions of the video while across different copies corresponding alternative quality level segments yield the same portions of the video at a different bitrate. EX1016, 1:65, claims 1, 8, 12, 14, FIG. 2, 2:35-39, 3:31-36, 3:57-4:14, 4:20-31, 3:44-53, Abstract, FIG. 1. Implementing multiple sets of files would have been a straightforward modification for a POSITA, as requesting video segments by having multiple files for the segments or by requesting ranges of the video were two alternative design choices well known to a POSITA.

K. Claims 10 and 12 Would Have Been Obvious in view of Ogdon in view of Chou or, alternatively Ogdon in view of Ala-Honkola and Chou

135. The sections of Grounds 1 and 2 (Sections VIII.H-I) are incorporated into this section by reference.

Claim 10

136. As explained above in Sections VIII.H-I, Ogdon or Ogdon in view of Ala-Honkola teaches all limitations of claim 10. To the extent it is argued that Ogdon or Ogdon in view of Ala-Honkola lacks teaching initially requesting low quality streamlets to enable instant playback, Chou teaches this limitation.

137. Chou explains that start-up delay is the latency experienced after starting transmission from the beginning of the content which is undesirable for a viewer. EX1013, 2:59-64. Chou teaches providing at least two different data streams, one at a low resolution and lower bit rate, and another at a normal resolution and larger bitrate than the first, where “[t]he server **initially transmits the low resolution** stream” so that “the delay due to buffering is reduced to nearly zero,” and with the normal resolution stream being transmitted “[w]hen the client buffer has grown sufficiently large to guard against future underflow by the normal resolution stream.” *Id.*, 3:29-54.

138. A POSITA would have been motivated to modify the apparatus of Ogdon to initially request lower quality streamlets, such as taught by Chou, in order to have a quicker start-up time for the stream to minimize the wait for the user wishing to view the stream, which Chou observes can be “particularly annoying.” EX1013, 2:59-3:12. In addition, a POSITA would have understood that the client

could beneficially use the initial low-quality slice to determine network requirements for subsequent requests. A POSITA would have had a reasonable expectation of success with such a combination because it would have been a straightforward modification of Ogdon to specify that a lower quality of collections of segments be retrieved initially, and whereby Ogdon and Chou are drawn to similar systems of adaptive client-server based streaming of content having multiple qualities.

Claim 12

139. As explained above in Sections VIII.H-I, Ogdon or Ogdon in view of Ala-Honkola teaches all limitations of claim 12. To the extent it is argued that Ogdon or Ogdon in view of Ala-Honkola lacks teaching that the apparatus is a mobile computing device comprising a processor and a non-transitory data storage, Chou teaches these limitations.

140. Chou teaches that clients that stream video from a server include “a personal computer (PC)” and “may be practiced with other computer-system configurations, including hand-held devices.” EX1013, 5:4-15. Further, Chou teaches that such computing environments include a processor (processing unit) and non-transitory data storage (system memory, ROM, RAM). EX1013, 5:24-34 (computing device includes “processing unit 21, system memory 22 . . . read-only memory (ROM) 24 and random-access memory (RAM) 25”).

141. A POSITA would have been motivated to implement the system of Ogdon in a mobile hand-held computing device including a processor and non-transitory data storage, as taught by Chou, in order to allow a user more flexibility by streaming to a portable mobile device and to perform the required functions for streaming a video presentation and displaying the video to the user who is travelling. A POSITA would have had a reasonable expectation of success with such a modification because hand-held computing devices were well-known personal computing devices with well-known components including processors and non-transitory data storage.

L. Claims 8 and 14 Would Have Been Obvious in view of Ogdon in view of SMIL 2.0 or, alternatively Ogdon in view of Ala-Honkola and SMIL 2.0

142. The sections of Grounds 1 and 2 (Sections VIII.H-I) are incorporated into this section by reference.

Claims 8 and 14

143. As explained above in Sections VIII.H-I, Ogdon or Ogdon in view of Ala-Honkola teaches all limitations of claims 8 and 14. To the extent it is argued that Ogdon or Ogdon in view of Ala-Honkola lacks teaching that the media player upshifts to a higher quality one of the different copies when the factor is greater than

a first threshold and downshifts to a lower quality one of the different copies when the factor is less than a second threshold, SMIL 2.0 teaches these limitations.

144. For example, SMIL 2.0 teaches an element called “<switch>” that “allows an author to specify a set of **alternative** elements **encoded at different quality levels** from which only the first acceptable element is chosen”; these include: “[i]f the system bitrate is **5600 or higher**, the object dutchHQ.aiff is selected,” if the “system bitrate is at least **28800** but less than 56000,” then “dutchMQ.aiff is selected,” and **otherwise** “dutchLQ.aiff is selected.” EX1006, 61.

```
<switch>
  <audio src="dutchHQ.aiff" systemBitrate="56000" ... />
  <audio src="dutchMQ.aiff" systemBitrate="28800" ... />
  <audio src="dutchLQ.aiff" ... />
</switch>
```

Id., annotated Figure showing selection of high quality (green; 56000 minimum bitrate), medium quality (blue; 28800 minimum bitrate), or low quality below 28800 bitrate (red)); *see also id.*, 62 (“SMIL 2.0 player to determine the setting for system test attribute” and it “may be determined (and reevaluated) dynamically”)

145. A POSITA would have understood the above disclosures from SMIL 2.0 to teach a client application selecting a next segment at a different quality to “adapt to changing circumstances” to be repeatedly generating, by the media player,

a factor (*e.g.*, current bandwidth indicated by “systemBitrate”) relating to the performance of the network and upshifting to a higher quality one of the different copies (*e.g.*, dutchHQ) when the factor (client bitrate (systemBitrate)) is **greater** than a **first threshold** (56000), and downshifting to a lowest quality one of the different copies (*e.g.*, dutchLQ) when the factor is **less** than a **second threshold** (28800). A POSITA would have been motivated to upshift to a higher quality when current bandwidth exceeds a first threshold and downshift to a lower quality when a bandwidth drops below a second threshold, as taught by SMIL 2.0, in the system of Ogdon in order to ensure that the requested segments can be timely cached for playback such that a viewer can view the video stream uninterrupted. EX1004, 6:18-23 (“Thus, when the data required for a segment is not timely cached prior to its intended performance at a client’s node, alternate segment data is automatically requested from the communications network by the client node.”), 21:62-63 (“attempt to assure a timely caching of this next collection of segments for timely performance”). A POSITA would have had a reasonable expectation of success with such a modification because both Ogdon and SMIL are similarly directed to a client adaptively selecting appropriate quality levels of streamed content and because simply setting a first and second bandwidth threshold for when to upshift and downshift quality levels for the next segment would have been a simple and

straightforward modification of Ogdon and would have been consistent with the goals of Ogdon.

IX. CONCLUSION

146. In my opinion, and for the reasons provided above, all of the Challenged Claims are at least obvious over Ogdon alone or Ogdon in view of Ala-Honkola. In my opinion, claims 4 and 7 are also at least obvious over Ogdon in view of Shteyn or Ogdon in view of Ala-Honkola and Shteyn. In my opinion, claims 10 and 12 are also at least obvious over Ogdon in view of Chou or Ogdon in view of Ala-Honkola and Chou. In my opinion, claims 8 and 14 are also at least obvious over Ogdon in view of SMIL 2.0 or Ogdon in view of Ala-Honkola and SMIL 2.0.

147. 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 November 2, 2023.

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 Eastern 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 LTP 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

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

- 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
- Tau Beta Pi National Engineering Honor Society
 - 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 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