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 10,469,555
Issue Date: November 5, 2019
Title: APPARATUS, SYSTEM, AND METHOD FOR MULTI-BITRATE CONTENT STREAMING

Inter Partes Review No. IPR2024-00146

**DECLARATION OF HENRY HOUH, Ph.D.
IN SUPPORT OF PETITION FOR
INTER PARTES REVIEW OF
U.S. PATENT NO. 10,469,555**

TABLE OF CONTENTS

I. INTRODUCTION 1

II. BACKGROUND AND QUALIFICATIONS 1

III. MATERIALS CONSIDERED 10

IV. LEGAL STANDARDS 12

V. OVERVIEW OF THE ’555 PATENT 15

A. Prosecution History 20

B. Priority Date 20

VI. LEVEL OF ORDINARY SKILL IN THE ART 21

VII. CLAIM CONSTRUCTION 21

VIII. SUMMARY OF OPINIONS 22

A. State of the Art 23

B. Ogdon 24

C. Allen 25

D. SMIL 2.0 25

E. Analogous Art 26

F. Claims 18 and 19 are Anticipated by Ogdon 27

Claim 18 27

Claim 19: “The system of claim 18, wherein the streamlets in each of the low quality stream and the high quality stream corresponding to the same portion of the live event video have equal durations.” 33

G. Claims 1, 3-5, 7-11, 13-20, and 22-27 Would Have Been Obvious in view of Ogdon and Allen 34

Claim 1: 34

Claim 3: "The system of claim 1 wherein the streamlets in each of the high quality stream, the medium quality stream and the low quality stream are each encoded at a different one of the plurality of different bitrates." 47

Claim 4: 47

Claim 5: "The system of claim 1, wherein each of the first streamlets has a first duration that is the range of 0.1 to 5 seconds." 51

Claim 7: 53

Claim 8: "The system of claim 7, wherein the first streamlets of the low quality stream, the medium quality stream, and the high quality stream are available before the live event is complete."....54

Claim 9: "The system of claim 7, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream of the live event are available on a 10 second delay." 54

Claim 10: 55

Claim 11: "The content player device of claim 10 wherein each streamlet of the plurality of streamlets in the low quality stream, the medium quality stream, and the high quality stream has a duration that is the same as each other."....65

Claim 13: "The content player device of claim 10, wherein each streamlet of the plurality of streamlets in the low quality stream, the medium quality stream, and the high quality stream has a duration that is the range of 0.1 to 5 seconds." 65

Claim 14: "The content player device of claim 10, wherein the video is a video of a live event."....67

Claim 15: "The content player device of claim 14, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream are available before the live event is complete." 67

Claim 16: "The content player device of claim 15, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream of the live event are available on a ten second delay." 67

Claim 17: "The content player device of claim 16, wherein the streamlets from the low quality stream, the medium quality stream, and the high quality stream of the live event, when played back, appear live to a viewer." 67

Claim 18: 67

Claim 19: "the streamlets in each of the low quality stream and the high quality stream corresponding to the same portion of the live event video have equal durations." 69

Claim 20: "The system of claim 18 wherein the plurality of streams further comprise a medium quality stream encoded at a bit rate higher than the low quality stream and lower than the high quality stream." 69

Claim 22: 69

Claim 23: 70

Claim 24: "The system of claim 21, wherein all of the streamlets in each of the low quality stream, the medium quality stream and the high quality stream have equal durations." 71

Claim 25: "The system of claim 21, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream are available on a ten second delay before the live event is complete, wherein the streamlets from the low quality stream, the medium quality stream, and the high quality stream of the live event, when played back, appear live to a viewer." 71

Claim 26: 71

Claim 27: "The content player device of claim 26, wherein the plurality of streamlets in the low quality stream have a duration equal to the duration of the plurality of streamlets in the high quality stream." 73

H. Claims 1, 3-5, 7-11, 13-20, and 22-27 Would Have Been Obvious in view of Ogdon, Allen, and SMIL 2.0 73

Claims 1, 10, 11 18, 19, 24, 26, and 27: 74

Claims 5 and 13: 76

IX. CONCLUSION 76

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. 10,469,555 ("'555 Patent") (EX1001) and to provide my opinions regarding the patentability of claims 1, 3-5, 7-11, 13-20, and 22-27 of the '555 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 '555 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 ’555 Patent, including the claims of the patent in view of the specification, and I have reviewed the prosecution history of the ’555 Patent and numerous prior art and technical references from the time of the alleged invention. Of the materials cited as an exhibit to the ’555 Patent IPR petition, I reviewed the following:

Exhibit	Description
1001	U.S. Pat. 10,469,555 (“the ’555 Patent”)
1002	File History of U.S. Pat. 10,469,555
1004	U.S. Patent No. 6,161,137 to Ogdon et al. (“Ogdon”)
1005	International P.C.T. Publication WO 2002/075482 A2 (“Allen”)
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
1012	Respondents' Notice of Prior Art in 337-TA-1265
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

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 '555 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 '555 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 '555 Patent and that Sling TV L.L.C. purports to be an exclusive licensee of the '555

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 ’555 Patent. To the best of my knowledge, I do not have any financial interest in the ’555 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 ’555 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 '555 PATENT

33. The '555 Patent (application no. 16/252,365) was filed on January 18, 2019 and issued on November 5, 2019. EX1001, Cover. The '555 Patent purports to relate to "multi-bitrate content streaming," such as video, over the Internet. EX1001, Abstract, 1:31-34. The '555 Patent describes "a receiving module" to "capture media content," a streamlet module to "segment the media content and generate a plurality of streamlets," and "encoding module" to "generate a set of streamlets" such that the set of streamlets has a plurality of streamlets "having identical time indices and durations" and "a unique bitrate." *Id.*, Abstract.

34. One embodiment of the system of the ’555 Patent includes “a content server 102” and “end user 104” coupled by a data communications network (*e.g.*, the Internet 106) wherein the “end user station 104” may be a personal computer, entertainment system, or a portable electronic device configured to present content. *Id.*, FIG. 1, 6:36-47. The ’555 Patent describes encoding the same content file 200 into at least three different “quality” streams:

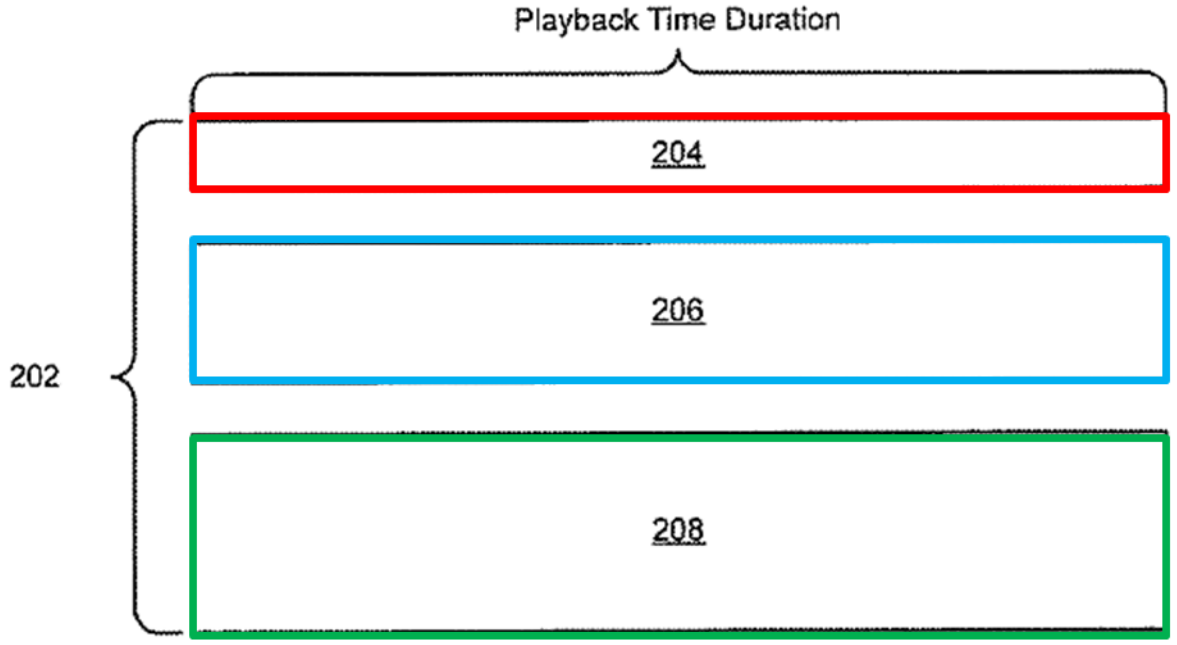

FIG. 2b

Id., FIG. 2b (annotated, low quality (red, 204), medium quality (blue, 206), and high quality (green, 208)), 7:25-31.

35. For example, "low quality stream 204 may be encoded and compressed to a bit rate of 100 kilobits per second (kbps), the medium quality stream 206 may be encoded and compressed to a bit rate of 200 kbps, and the high quality stream 208 may be encoded and compressed to 600 kbps." *Id.*, 7:31-36. Each stream (204, 206, and 208) is also "divided into a plurality of source streamlets 303" where "streamlet refers to any sized portion of the content file" and may be "an independent media object" where "streamlet 0 may have a time index of 00:00 representing the beginning of content playback, and streamlet 1 may have a time index of 00:02, and so on." *Id.*, 7:37-49.

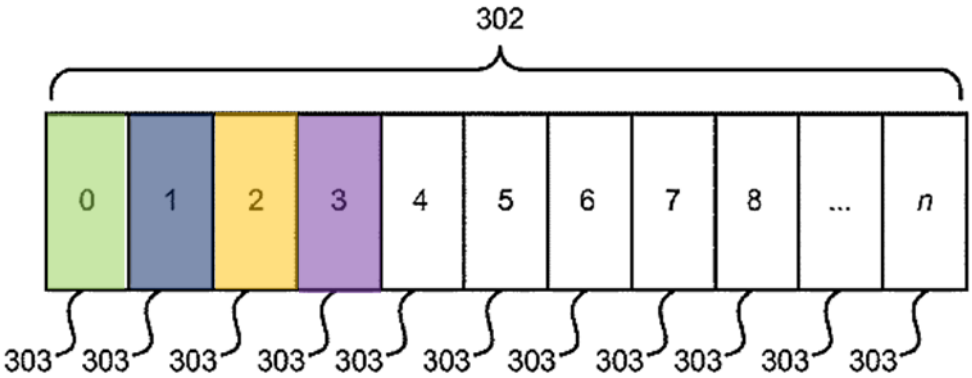

FIG. 3a

Id., FIG. 3a (annotated).

36. These streamlets form "sets" of streamlets 306 wherein a "set" is "a group of streamlets having identical time indices and durations but varying bitrates." *Id.*, 7:57-60.

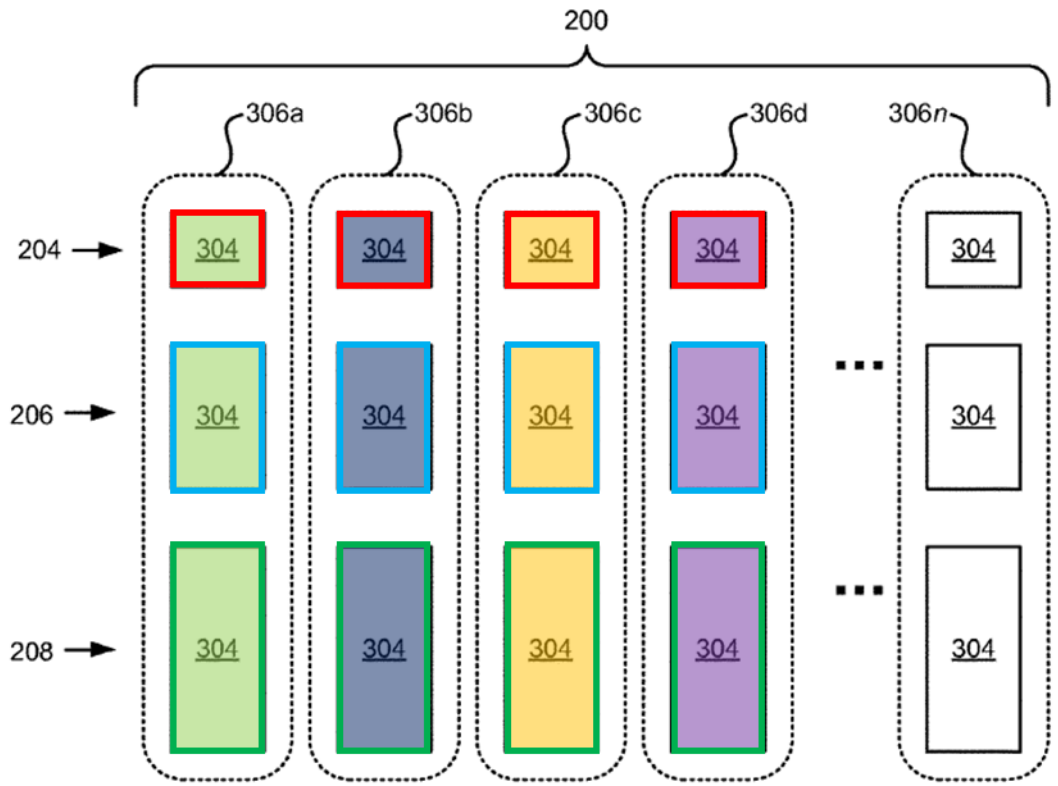

FIG. 3b

Id., FIG. 3b (annotated, showing low, medium, and high quality streamlets in each "set" of streamlets" 306a-d).

37. These sets of streamlets are stored in a streamlet database 408 and then a "client module 114 may request streamlets 304 using HTTP from the web server

116" or "a plurality of web servers 116." *Id.*, 9:1-4, 9:30-40. Further, the '555 Patent explains that the invention may be used to stream "live" content files on a short delay because "two-pass encoding to a plurality of streams 202 may be performed on each corresponding raw streamlet without waiting" for the end of a program and the streamlets may be streamed "over the internet shortly after the content module 112 begins capture of the content file 200." *Id.*, 10:44-56.

38. To stream content, the client module 114's "agent controller module 702 is configured to select a quality level of streamlets to transmit to the viewer" and "requests lower or higher quality streams based upon continuous observation of time intervals between successive receive times of each requested streamlet." *Id.*, 13:3-26. The "agent controller module 702 receives 1004 a streamlet" and "monitors 1006 the receive time of the requested streamlet" such as time intervals between successive receive times for each streamlet response and "calculates 1008 a performance ratio" and "obtain[s] a performance factor." *Id.*, 17:6-40, FIGs. 9 and 10. The agent control module 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.*, 17:41-18:14.

A. Prosecution History

39. I understand that the ’555 Patent was filed as Application No. 16/252,356 on January 18, 2019. On March 22, 2019, the Examiner issued a non-final rejection of all pending claims including non-statutory double patenting and prior art rejections over Xu et al. (US 7,369,610), Lango et al. (US 2005/0055425), Mehan (US 2003/0103571), Tillman et al. (US 6,496,980), Lee et al. (US 2003/0103571), Seazholtz (US 5,812,786), and Rahman (US 7,934,159). EX1002, 83-105.

40. On June 20, 2019, Applicant amended the claims (including canceling claims 10-30 and adding new claims 31-48) and traversed the Examiner’s rejection. *Id.*, 116-129. Applicant argued the filed terminal disclaimer obviated the non-statutory double patent rejection and argued that the cited prior art in the rejection lacked “groups of streamlets that encode the same portions of the video program at different bit rates.” *Id.*, 117. In response, the Examiner issued a Notice of Allowance on September 9, 2019. *Id.*, 622.

B. Priority Date

41. I do not offer any opinion as to whether the ’555 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 '555 Patent and the

prosecution history of the ’555 Patent, as understood by a POSITA at the time of the invention.

45. I understand that the ’555 Patent was among those asserted in the International Trade Commission (“ITC”) in Investigation No. 337-TA-1265 (ITC) (“the ITC Investigation”) against iFIT, Inc. and others. I also understand that Petitioner was not involved in the ITC Investigation. I understand that that in the ITC Investigation, the Chief Administrative Law Judge (“ALJ”) construed “streamlet” as “any sized portion of the content file.” EX1009, 38-43. The ALJ also construed “low quality stream,” “medium quality stream,” and “high quality stream” under their plain and ordinary meaning. *Id.*, 46-53. The ALJ also found that “end user station” and “content player device” required no construction. *Id.*, 71.

VIII. SUMMARY OF OPINIONS

46. In my opinion, at least claims 1, 3-5, 7-11, 13-20, and 22-27 (the “Challenged Claims”) of the ’555 Patent are invalid as obvious to a POSITA as of the Priority Date. Here I offer my opinion that the claims 18 and 19 are anticipated by Ogdon and that the Challenged Claims would at least have been obvious in view of Ogdon and Allen. It is also my opinion that the Challenged Claims would have been obvious in view of Ogdon, Allen, 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 '555 Patent admits in the "Description of Related Art" section that "streaming media" was known, including streaming of "audio/video" where "quality that can be received for real time presentation is constrained by the available bandwidth of the user's network connection." EX1001, 1:47-56. The '555 Patent further admits that streaming was used "to deliver content on demand (previously recorded) or from live broadcasts." *Id.*, 1:56-57.

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 (filed in 1999) describes "real time measurement and prediction of bandwidth for adaptive content delivery of rich media according to available user bandwidth." EX1007, Abstract. Chang discloses a client (via java applets) that performs real time bandwidth measurement according to user's available bandwidth and fetches the corresponding bandwidth sensitive track content from the server via HTTP requests.

Id., 7:43-53, 8:59-9:5, 9:45-51, 10:15-14, 10:35-58. In another example, Kliger (filed in 1997) teaches a media player device that requests from a server the appropriate bandwidth object depending on network bandwidth. EX1008, 3:25-32, 5:25-28, 9:32-10:4, 12:33:13:8, claim 3.

B. 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 ’555 Patent nor was it considered by the ALJ in the ITC action.

51. Ogdon discloses a system for distributing a presentation, during the performance of the presentation, over the Internet via webservers 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 a plurality of sequential presentation elements, collections, or subcollections of “one or more segments” where each segment 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 sequential segment (or collection of segments) 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. Allen

52. Allen (EX1005) was filed on March 15, 2002 and published on September 26, 2002. Allen is prior art under at least (pre-AIA) 35 U.S.C. § 102(b). Allen is not cited on the face of the ’555 Patent. United States Publication No. 2004/0117427 which claims priority to Allen is cited on the face of the ’555 Patent but neither were used in any prior art rejections. Allen was also not considered by the ALJ in the ITC Investigation.

53. Allen discloses streaming media to multiple users and tailoring the delivery stream to the capabilities of the user’s system. EX1005, 1:15-21. Allen explains that multi-bitrate streaming was well-known, including encoding copies of a video at multiple quality levels with different bitrates, such as low quality (56 kbps), medium quality (300 kbps) and high quality (600 kbps). *Id.*, 12:1-5.

D. SMIL 2.0

54. Synchronized Multimedia Integration Language 2.0 (“SMIL 2.0”) (EX1006) 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). SMIL 2.0 was thus publicly available more than one year prior to the earliest claimed priority date of April 30, 2004. 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 ’555 Patent and was not considered by the ALJ in the ITC Investigation.

55. SMIL 2.0 discusses elements “<seq>,” “<switch>,” and “systemBitrate” teaching three quality levels (high, medium, and low) and switching to a particular quality level based upon measured system bitrate. 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*.

E. Analogous Art

56. Each prior art reference is analogous art to the claimed invention in the’555 Patent. And each is in the same field of endeavor of client-server media streaming and, more specifically, streaming by a client from a server including having the data stream segmented into a plurality of streamlets at the server side

wherein the client requests the streamlets from the server and plays out the media. *Compare* EX1001, Title, Abstract, 1:31-34, 3:11-4:34, FIGs. 2-7, *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; EX1005, Abstract, 1:10-12:22; EX1006, 61-62, 123-126.

57. Additionally, each prior art reference is reasonably pertinent to any purported problem addressed in the '555 Patent. *Id*.; EX1001, Title, Abstract, 1:30-2:67.

F. Claims 18 and 19 are Anticipated by Ogdon

Claim 18

18[Pre]: "A system for adaptive-rate content streaming of live event video playable on one or more end user stations over the internet, the system comprising:"

58. In my opinion, whether or not the preamble is limiting, Ogdon discloses 18[Pre]. Ogdon discloses a system (including client node(s) 56 and webserver(s) 96a and 96b) for adaptive-rate content streaming of live event video (distributing video presentation during performance) playable on one or more end user stations (client node(s) 56) over the Internet. EX1004, Abstract ("distributing a performance of a presentation synchronously to a plurality of client nodes" via "the Internet . . . **during**

a performance[1] of the presentation" where "the client nodes receiving the presentation determine a particular variation of data presentation to receive from the network server nodes" depending on "characteristics of the network such as data transmission rate"), 3:38-41 ("**dynamically and adaptively switch** between . . . versions of the presentation according to network transmission characteristics at each client network node"), 7:40-48 ("Client sites 52, where audience members receive a presentation . . . has at least one of a client node 56 (e.g., a personal computer)" and "may receive video (and possibly audio as well) information from a communications network 70 such as the Internet"), 8:27-40 ("content webservers 96a, and alternate content web servers 96b" provide "presentation data to client sites 54 requesting such data via client nodes"), 10:7 ("**live** presentation"), 6:2-5 ("present invention is capable of delivering an entire collection of presentation segments to a client node **while the presentation is being performed**").

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

18[A]: "at least one storage device configured to store live event video,"

59. Ogdon discloses 18[A]. Ogdon discloses that the webservers store live event video. EX1004, 9:30-31 ("webservers 96 where the content for each presentation will reside"), 9:44-46 ("content manager 104 distributes presentation content (e.g., presentation segments) to the content webservers 96"), 10:7-13, 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").

18[B]: "the live event video encoded at a plurality of different bit rates creating a plurality of streams including at least a low quality stream and a high quality stream;"

60. Ogdon discloses 18[B]. Ogdon discloses that the live event video (video presentation) is encoded at a plurality of different bitrates (different versions or quality levels) creating a plurality of streams including, at least, a low quality stream (*e.g.*, limited animation video) and a high quality stream (*e.g.*, full animation video) because Ogdon discloses "[d]ifferent versions of the same presentation" with "different network requirements" such as "a first version" requiring "a network transmission rate sufficient **for real time or animated video**" and "another version"

requiring "a transmission rate sufficient for **graphic slides**." EX1004, 2:8-10, 2:30-66, Abstract ("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"), 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.

18[C]: "the low quality stream and the high quality stream each encoding the same portion of the live event video with a streamlet that is encoded a different one of the different bit rates;"

61. Ogdon discloses 18[C]. Ogdon further discloses that each stream (*e.g.*, low quality limited-animation video and high quality full-animation video) comprises elements, collections, or subcollections of streamlets (segments) where each corresponding segment at the high quality level and low quality level encode the same content (*i.e.*, same portion of the video) at different bitrates. 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**."), 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").

18[D]: "wherein the plurality of streamlets in the low quality stream and the plurality of streamlets in the high quality stream have durations that are equal to each other."

62. Ogdon discloses 18[D]. Ogdon discloses that plurality of streamlets (segments) in the low quality stream (*e.g.*, limited-animation video) and the plurality of streamlets (segments) in the high quality stream (*e.g.*, full-animation video) have durations that are equal to each other. First, the claims recite that collectively "the plurality of streamlets" in each quality level stream have durations that are equal to each other, and Ogdon discloses "[d]ifferent versions of the same presentation" (EX1004, 2:30) and that each version has segments that "correspond[] with a segment . . . having the same presentation order, in each of the other versions" (*id.*, 2:47-49) such that the plurality of streamlets that collectively make up the entire

video presentation stream for each version of the same video presentation would be equal to each other in duration. In other words, Ogdon discloses that the full video presentation stream (made up of a plurality of segments) is the "same" video presentation at each quality level and thus each quality level video presentation stream has durations equal to each other. Second, Ogdon discloses that each individual corresponding segment in each version of the video presentation also have the same presentation duration. EX1004, 2:49-55 ("corresponding segments (or subcollections thereof) in different versions have approximately the **same presentation duration**" so 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."). A POSITA would have understood "approximately the same presentation duration" to disclose both (1) durations that are precisely equal to each other, and (2) durations that are nearly equal to each other.

Claim 19: "The system of claim 18, wherein the streamlets in each of the low quality stream and the high quality stream corresponding to the same portion of the live event video have equal durations."

63. Ogdon discloses claim 19. Ogdon discloses that the streamlets (segments) in each of the low quality stream and the high quality stream correspond to the same portion of the live event video have equal durations. *See* 18[C]-18[D].

64. Additionally, the provisional application of Ogdon (U.S. 60/041,770) also discloses that "corresponding presentations segments in the collection 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) 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) have identical (*i.e.,* same or equal) time durations for each corresponding video segment version.

G. Claims 1, 3-5, 7-11, 13-20, and 22-27 Would Have Been Obvious in view of Ogdon and Allen

Claim 1:

1[Pre]: "A system for adaptive-rate content streaming of live event video playable on one or more end user stations over the Internet, the system comprising:"

65. In my opinion, whether or not the preamble is limiting, Ogdon teaches 1[Pre]. Ogdon discloses a system for adaptive-rate content streaming of a live event video (video presentation) that is playable on one or more end user stations (client node(s)) over the Internet. EX1004, 7:40-48 ("Client sites 52, where audience members receive a presentation . . . has at least one of a **client node 56** (e.g., a personal computer)" and "may receive **video** (and possibly audio as well) information from a communications network 70 such as the **Internet**"), 8:27-40 ("content webservers 96a, and alternate content web servers 96b" provide "presentation data to client sites 54 requesting such data via client nodes"), 7:53-63 ("client node 56" has "a network interface software package required for receiving, e.g., video presentation information from the communications network 70 . . . Internet" including "a network browser 78 . . . 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"), 3:38-41 ("**dynamically and adaptively** switch 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 webservers 96 to select an appropriate content webserver and an appropriate version of the next collection of segments to be retrieved."), FIGS. 1-2, 1:62-2:1 ("the present invention provides interactive and/or **real-time** presentations to presentation members that are geographically scattered"), 10:7 ("**live** presentation"), 6:2-5 ("present invention is capable of delivering an entire collection of presentation segments to a client node **while the presentation is being performed**"), Abstract ("distributing a performance of a presentation synchronously to a plurality of client nodes" via "the Internet . . . **during a performance** of the presentation"). Additionally, Patent Owner admits in the background section of the '555 Patent that it was known to use streaming "to deliver content on demand (previously recorded) or from live broadcasts." *See* Section VIII.A.

1[A]: "at least one storage device storing live event video,"

66. In my opinion, Ogdon teaches 1[A]. Ogdon discloses the webserver(s) store the live event video. EX1004, 9:30-31 ("webservers 96 where the content for each presentation will reside"), 9:44-46 ("content manager 104 distributes

presentation content (e.g., presentation segments) to the content webservers 96"), 10:7-13, 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[B]: "the live event video encoded at a plurality of different bitrates creating a plurality of streams including a low quality stream, a medium quality stream, and a high quality stream,"

67. In my opinion Ogdon alone would teach this limitation, but at the very least Ogdon in view of Allen teaches 1[B]. Ogdon discloses that the live event video (video presentation) is encoded at a plurality of different bitrates (different versions or quality levels) creating a plurality of streams because Ogdon discloses "[d]ifferent versions of the same presentation" with "different network requirements" such as "a first version" requiring "a network transmission rate sufficient for real time or **animated video**" and "another version" requiring "a transmission rate sufficient for **graphic slides**." EX1004, 2:8-10, 2:30-66, Abstract ("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"), 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"). 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 requested by the client based on client-determined bandwidth).

68. A POSITA would have understood Ogdon's disclosure of different versions of the same video presentation each having "different network requirements" to disclose digitally encoding the same raw uncompressed video content into two or more (*e.g.*, three) versions having different bitrates. It was well-known to a POSITA at the time of the alleged Priority Date that streaming different versions of content at different quality levels depending on client network requirements meant encoding the content into different quality levels with different bitrates. For example, a POSITA understood that if a higher quality and a lower quality of the same video were provided, the lower quality version had "fewer bits per frame and provides a video image much more quickly than" a higher quality

version "with a higher number of bits and hence higher quality video image." EX1013, Abstract, *see also id.*, 3:29-35 ("a server provides at least two different data streams. . . . a low resolution stream encoded at a bit rate below the transmission bit rate. . . . a normal resolution stream encoded at a bit rate equal to the transmission bit rate."), 10:16-21 ("quality (also referred to as resolution) is a measure of detail in an image . . . quality of an image is commonly measured in pixels per inch and in the number of bytes used to described the color values at each pixel"), 11:6-7 ("low bit rate encoding for the same content").

69. Additionally, to the extent Ogdon does not explicitly disclose encoding each of a low quality stream, a medium quality stream, and a high quality stream, a POSITA would have been motivated to combine Ogdon with Allen to arrive at this limitation. Allen teaches that it was known to encode video content into at least three different quality levels (or bitrates) for streaming in order to allow streaming to various clients with different network requirements including, for example, a low quality level (at 56 kbps), a medium quality level (at 300 kbps), and a high quality level (at 600 kbps). EX1005, 12:1-5. A POSITA would have understood that the lowest bitrate version (56 kbps) would have been a "low quality" stream (because it would have the fewest bits per second), and similarly that the 600 kbps stream would

be a high quality stream (because it would have the most bits per second) while the 300 kbps would be a medium quality stream (in between the low and high).

70. A POSITA would have been motivated to encode the video presentation of Ogdon, including each sequential segment of the video, into each of a low quality, medium quality, and high quality level bitrate stream, as taught by Allen, because providing three different quality levels (low at 56 kbps, medium at 300 kbps, and high at 600 kbps) would enable user client nodes with a wide variety of network bandwidth requirements to stream the video presentation—a stated goal of Ogdon. EX1004, Abstract ("client network nodes with varying available network bandwidths can be utilized for synchronously and simultaneously performing the presentation"). A POSITA would have had a reasonable expectation of success with such a combination because both Ogdon and Allen are drawn to similar systems of client-server based streaming and because simply encoding another copy at an additional quality level would have been a simple and straightforward modification for a POSITA.

1[C]: "the low quality stream, the medium quality stream, and the high quality stream each comprising a group of

streamlets encoded at a respective one of the plurality of different bitrates;"

71. In my opinion, Ogdon in view of Allen teaches 1[C]. *See* 1[B] (Allen teaching three quality levels (high, medium, and low)). Ogdon further discloses that each stream (at each corresponding quality level/bitrate) comprises a group (elements, collections, or subcollections) of streamlets (segments) encoded at a respective one of the bit rates. 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**."), 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").

72. Ogdon further discloses that each group comprises at least first and second streamlets (segments) because Ogdon teaches plural "ordered segments" and that each of the streamlets (segments) corresponds to a portion of the video because

Ogdon discloses that each "subcollection of segments (i.e. presentation elements) [are] ordered according to their presentation sequence," (EX1004, 2:44-45) and that the presentation is "an ordered series of presentation segments" (*id.*, 3:46-47). *See also id.*, 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"). Thus, Ogdon discloses, or renders obvious, at least a first and a second streamlet (segment) corresponding to different portions of the video presentation.

73. Additionally, as explained above in 1[B], Allen teaches encoding the same video at low, medium, and high quality levels. Since Ogdon contemplates a live video presentation that is segmented and stored at various quality levels (EX1004, Abstract, 1:62-2:1, 6:2-5, 10:7), a POSITA would have been motivated to encode each recorded video segment of Ogdon into each quality level in parallel in real-time prior to storing at the webservers (*see* 1[A]); *see also* EX1005, 5:15-21 ("considerable technology has developed for capturing analog video . . . then digitizing and encoding the video signal for streaming distribution over the Internet"), 3:16-18 ("redigitized video is then simultaneously processed in a plurality of encoders" to "provide output in a particular popular format and bit rate"). Encoding captured uncompressed video was well-known to a POSITA at the time

of the alleged priority date. EX1013, 7:43-55 ("The streaming media system 300 comprises an encoder 302 which may be coupled to camera 210 or other real time or uncompressed video sources . . . encodes and/or compresses the data . . . for live transmission such as video conferencing, the encoder buffer 304 may be a simple as a first-in first-out (FIFO) queue."). A POSITA would have understood this to be a convenient and practical way to generate different quality levels for each segment in real-time for distribution to client nodes.

74. A POSITA would have had a reasonable expectation of success with such a modification because Ogdon teaches corresponding segments at different quality levels and a POSITA would have known how to encode each raw video segment into a corresponding quality level (bitrate) on a segment-by-segment basis in parallel.

1[D]: "wherein at least one of the low quality stream, the medium quality stream, and the high quality stream is encoded at a bitrate of no less than 600 kbps;"

75. Ogdon in view of Allen teaches 1[D]. As explained above, Ogdon in view of Allen teaches encoding a high quality stream at a bitrate of 600 kbps. *See* 1[B]. Further, a POSITA at the time of the alleged priority date would have known that a video encoded at a bitrate of 600 kbps or more would be considered "high quality" video streaming.

1[E]: "wherein the amount of data in each streamlet corresponding to the same part of the live event video in the low quality stream, the medium quality stream, and the high quality stream varies according to the different bitrates; and the plurality of streamlets in the low quality stream, the medium quality stream, and the high quality stream having a duration that is the same as each other."

76. In my opinion, Ogdon in view of Allen teaches 1[E]. *See* 1[B] (Allen teaching low, medium, and high quality stream). Ogdon further teaches the amount of data in each streamlet corresponding to the same part of the live event video (*i.e.*, corresponding segments at each quality level) varies according to the different bitrates. EX1004, Abstract ("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"), 24:54-55 ("usually resulting in selection of alternative segment collections that are **smaller**"). More specifically, a POSITA would have understood that the same video portion (segment) (*e.g.* encoded at 56 kbps bitrate quality level taught by Allen) would contain fewer bits, and thus have a smaller data size, than the corresponding same segment at a medium quality level (*e.g.*, 300 kbps bitrate taught by Allen) and that both low and medium quality segments would be smaller in data size than the same corresponding segment at 600 kbps (high quality).

77. Ogdon further discloses that the plurality of streamlets (segments) in each of the quality level streams have a duration that is the same as each other. First, the claims recite that collectively "the plurality of streamlets" in each quality level stream have durations that are equal to each other, and Ogdon discloses "[d]ifferent versions of the same presentation" (EX1004, 2:30) and that each version has segments that "correspond[] with a segment . . . having the same presentation order, in each of the other versions" (*id.*, 2:47-49) such that the plurality of streamlets that collectively make up the entire video presentation stream for each version of the same video presentation would be equal to each other in duration. In other words, Ogdon discloses that full video presentation stream (made up of a plurality of segments) are the "same" video presentation at each quality level and thus each quality level video presentation stream have durations equal to each other. Second, Ogdon discloses that each individual corresponding segment in each version of the video presentation also have the same presentation duration. EX1004, 2:49-55 ("corresponding segments (or subcollections thereof) in different versions have approximately the **same presentation duration**" so 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."), 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**.").

78. Ogdon thus states that each corresponding segment at various versions should serve as "replacement" for one another and that the durations are "approximately the same presentation duration." A POSITA would have understood this teaching of "approximately the same" duration not to be limited to only durations that are close but not exactly the same, but rather encompassing durations that are either the same, or approximately the same—especially given additional evidence from Ogdon's provisional application and file history as discussed below. Thus, Ogdon discloses that each corresponding version of each segment is the same portion of the video and has the same duration because they are replacements for one another. A POSITA would have understood this disclosure to teach a same or equal duration in order to allow alternative versions of each segment to serve as a "replacement" for each other to provide seamless streaming for the user.

79. Additionally, the provisional application of Ogdon (U.S. 60/041,770) also teaches that "corresponding presentations segments in the collection have identical audio portions." EX1014, 35 (claim 25). A POSITA would have

understood this disclosure to teach that corresponding alternate video presentation segments can each have identical audio portions, which would mean that the alternate video presentation segments would also have identical (*i.e.,* same or equal) durations. And 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. A POSITA would have considered this a further teaching of identical (*i.e.,* same or equal) time durations for each corresponding video segment version.

80. Further, as described above with respect to limitation 1[C], a POSITA would have been motivated to encode each raw video segment of Ogdon into each corresponding quality level bitrate in real-time—which would generate corresponding segments of equal duration.

81. To the extent it is found that Ogdon does not disclose that the plurality of streamlets in each of the quality level streams have a duration that is the same as each other, a POSITA would have been motivated to make all of the corresponding segments in each version an equal duration of time to simplify the system and so that each corresponding streamlet in each version could serve as a replacement for that portion of presentation content so that when switching to a different version during the presentation the user still experiences a seamless presentation. Having

corresponding streamlets across different versions be of different playback durations would complicate the presentation of video and may result in an undesirable viewing experience because it would prevent seamless streaming when switching quality levels if playback commences with the beginning of each version file. *Id*. A POSITA would have had a reasonable expectation of success with such a modification because it would have been a straightforward and simple modification to make each segment an equal duration.

Claim 3: "The system of claim 1 wherein the streamlets in each of the high quality stream, the medium quality stream and the low quality stream are each encoded at a different one of the plurality of different bitrates."

82. In my opinion, Ogdon in view of Allen teaches claim 3. *See* 1[B]-1[C].

Claim 4:

4[A]: "The system of claim 1, further comprising: a plurality of web servers located at different locations across the internet, each web server configured to:"

83. In my opinion, Ogdon in view of Allen teaches 4[A]. Ogdon discloses a plurality of web servers located at different locations across the internet, including a first web server, (webserver 96a and webserver 96b). EX1004, 8:27-31 ("Content Webservers 96: One or more content network server sites 96 (also denoted content webservers 96a, and alternate content webservers 96b) for providing presentation data to client sites 54 requesting such data via client notes 56.").

4[B]: "receive at least one streamlet request over one or more internet connections from the one or more end user stations to retrieve the first streamlet storing a portion of the video, wherein the at least one streamlet request from the one or more end user stations includes a request for a currently selected first streamlet from one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to select a higher or lower bitrate version of the streams;"

84. In my opinion, Ogdon in view of Allen teaches 4[B]. *See* 1[B]. Ogdon discloses that the content webserver(s) (96) are each configured to receive at least one streamlet (segment) request over one or more Internet (network 70) connections from the one or more end user stations (client node(s) 56) to retrieve the first streamlet storing a portion of the video. EX1004, 6:41-44 ("each client node to request presentation content from a given set of communications network servers rather than having such servers push presentation content to the client node"), 7:10-13 ("the present invention employs a 'client-request' technology, where each presentation member's browser requests information from a communication network server"), 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"), 19:54-59 ("the client presentation software 88 is instructed by the presentation controlling host 200 . . . to retrieve and cache, via network 70, one or more initial presentation segments from

identified content webservers 96 where the presentation segments have been pre-stored."), 21:40-45 ("host 200 sends one or more commands to each copy of the client presentation software 88 indicating both the next collection of segments to be retrieved by the client nodes and the network 70 addresses of the primary and alternate webservers 96 from which to retrieve the segment collection."), 22:12-17 ("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 webservers 96 to select an appropriate content webserver and an appropriate version of the next collection of segments to be retrieved.").

85. Ogdon in view of Allen further teaches that the at least one streamlet request from the one or more end user stations (client node(s) 56) includes a request for a currently selected one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the client to select a higher or lower bitrate version of the streams. EX1004, 23:41-50 ("client node 56 provides the identity of the selected webserver and next collection of segments to the client node's browser 78, and the browser, in turn, sends a network 70 request to the selected web server for the selected (subversion) of segments" then "client presentation software 88 monitors the time elapsed before transmission of the

selected collection of segments is completed, and determines whether these segments are provided within an appropriate window of time that allows them to be presented during the performance of the presentation."), 23:51-24:6, 24:50-55 ("Accordingly, 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 usually resulting in selection of alternative segment collections that are smaller."); *See* 1[B].

4[C]: "retrieve from the storage device the requested first streamlet from the currently selected one of the low quality stream, the medium quality stream, and the high quality stream; and"

86. In my opinion, Ogdon in view of Allen teaches 4[C]. *See* 1[B]. Ogdon discloses that the webserver(s) 96 retrieve from the storage device the requested streamlet (segment) from the currently selected one of the low quality stream, the medium quality stream, and the high quality stream. EX1004, 19:54-67 (client nodes "retrieve" elements or subcollections from "content webservers 96 where the presentation segments have been pre-stored"); 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"); *See* 1[B].

4[D]: "send the retrieved first streamlet from the currently selected one of the different copies to the requesting one of the end user stations over the one or more network connections."

87. In my opinion, Ogdon in view of Allen teaches 6[D]. Ogdon discloses that the client receives, caches, and presents the requested streamlets (segments) from the currently selected one of the different copies (of low, medium or high quality stream as taught by Allen) that are sent by the webserver(s) to the requesting one of the end user stations (client node 56) over the one or more Internet network connections. EX1004, 7:59-63 ("client presentation software system 88 [] coordinates with the browser 78 for requesting, receiving and displaying presentation segments (from the network 70) as appropriate during the presentation"), 24:48-49 ("collection of segments being delivered prior to the time that these segments are to be presented on the client node 56"), 25:25-27 ("steps 552 through 560 are iteratively performed until all segments of the current collection of segments are presented to the client"); *See* 1[B].

Claim 5: "The system of claim 1, wherein each of the first streamlets has a first duration that is the range of 0.1 to 5 seconds."

88. In my opinion, Ogdon in view of Allen teaches claim 5. A POSITA considering Ogdon would have been motivated to make the first durations (of each

of the first segments) in the range of 0.1 to 5 seconds. For example, a POSITA would have been motivated to make the first duration (of each of the first segments) 1 second or 2 seconds because this would minimize download time and allow playback to begin quickly while also allowing the client to make a bandwidth determination and provide sufficient time for the client to request further sequential segments to queue for playback. Additionally, it would have been "obvious to try" for a POSITA to make the first duration (of the first segment) in the range of 0.1 to 5 seconds because this would be a POSITA choosing between one of a finite number of possible solutions. Namely, a POSITA would have to assign some duration to the first segment such that the segments are sufficiently long to allow for quick playback without requesting a large number of files but sufficiently short in duration to allow for switching to different quality levels as necessary without excessive delay—this duration would have to be on the order of single digit seconds (*e.g.*, 1-5 seconds), or low double digit seconds. Therefore, it would have been obvious for a POSITA to try making the duration of the first segment between 0.1 to 5 seconds) as a finite number of possible solutions. A POSITA would have had a reasonable expectation of success with such modifications because the segments all have *some* duration and merely adjusting the duration the first segment so that the first segment duration

between 0.1 to 5 seconds in duration would have been a simple and straightforward modification for a POSITA.

Claim 7:

7[A]: "The system of claim 1, further comprising: a first web server configured to:"

89. In my opinion, Ogdon in view of Allen teaches 7[A]. *See* claim 4[A].

7[B]: "receive at least one streamlet request over one or more internet connections from the one or more end user stations to retrieve the first streamlet storing the first portion of the live event video, wherein the at least one streamlet request from the one or more end user stations includes a request for a currently selected first streamlet from one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to select a higher or lower bitrate version of the live event video;"

90. In my opinion, Ogdon in view of Allen teaches 7[B]. *See* claim 4[B].

7[C]: "retrieve from the storage device the requested first streamlet from the currently selected one of the low quality stream, the medium quality stream, and the high quality stream; and"

91. In my opinion, Ogdon in view of Allen teaches 7[C]. *See* claim 4[C].

7[D]: "send the retrieved first streamlet from the currently selected one of the low quality stream, the medium quality stream, and the high quality stream to the requesting one of the end user stations over the one or more network connections."

92. In my opinion, Ogdon in view of Allen teaches 7[D]. *See* claim 4[D].

Claim 8: "The system of claim 7, wherein the first streamlets of the low quality stream, the medium quality stream, and the high quality stream are available before the live event is complete."

93. In my opinion, Ogdon in view of Allen teaches claim 8. Ogdon discloses that the first streamlets (segments) of each quality level (*e.g.*, the low quality stream, the medium quality stream, and the high quality stream as taught by Allen) are available before the live event is complete. *See* 1[Pre]; 1[B]; EX1004, 7:61-63 ("requesting, receiving and displaying presentation segments (from the network 70) as appropriate **during the presentation**"), 15:52-58 (explaining that data may be available only **during** a presentation performance), 19:56-59 ("retrieve and cache, via network 70, one or more initial presentation segments from identified content webservers 96 where the presentation segments have been pre-stored").

Claim 9: "The system of claim 7, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream of the live event are available on a 10 second delay."

94. In my opinion, Ogdon in view of Allen teaches claim 9. As explained above, Ogdon discloses that the live stream is available before the event is complete. *See* claim 8. Ogdon further teaches that video presentations "are capable of being transmitted to various network 70 sites for subsequently time-delay delivery if desired." EX1004, 10:16-19. A POSITA would have been motivated to build in a

reasonable delay, for example ten seconds, to allow sufficient buffering such that the client would be unlikely to experience interruptions, but also still provide a stream that is still very close to the user experiencing the event in as close to "real time" as practicable as if attending in person. A POSITA would have had a reasonable expectation of success with this modification because it would simply entail ensuring a sufficient buffer delay of 10 seconds and would have been a straightforward modification.

Claim 10:

10[Pre]: "A content player device to stream a video over a network from a server for playback of the video, the content player device comprising:"

95. In my opinion, whether or not the preamble is limiting, Ogdon teaches 10[Pre]. Ogdon discloses a content player device (client node(s) 56) to stream a video (video presentation) over a network (Internet) from a server (content webserver(s) 96) for playback of the video. *See* 1[Pre].

10[A]: "a processor;

96. In my opinion, Ogdon teaches 10[A]. Ogdon discloses a processor at client node 56. EX1004, 7:45 ("client node 56 (e.g., a personal computer)"). A POSITA would have understood that a "personal computer" discloses a processor because a computer requires a processor to perform computing functions. For

example, it was well-known to a POSITA at the time of the alleged Priority Date that a "conventional personal computer" would include a "processing unit." EX1013, 5:23-27.

97. To the extent it is found that Ogdon does not disclose a processor, a POSITA would have been motivated to include a processor in the client node of Ogdon's system in order to perform the required functions for streaming a video presentation and displaying the video to the user at the client site. Processors were well known in the art. A POSITA would have had a reasonable expectation of success with such a modification because personal computers use processors to perform computing functions, and modifying the personal computer of Ogdon to include a processor would have been a routine exercise for a POSITA.

10[B]: "a digital processing apparatus memory device comprising non-transitory machine-readable instructions that, when executed, cause the processor to:"

98. In my opinion, Ogdon teaches 10[B]. Ogdon discloses a digital processing apparatus memory device comprising non-transitory machine-readable instructions (software package) that, when executed, causes the processor to perform functions, such as receiving video presentation information. EX1004, 7:45 ("client node 56 (e.g., a personal computer)"), 7:53-63 ("client node 56" has "a network interface software package required for receiving, e.g., video presentation

information from the communications network 70 . . . Internet" including "a network browser 78 . . . 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"). For example, it was well-known to a POSITA at the time of the alleged priority date that a "conventional personal computer" would store and execute programs using "system memory" including ROM and RAM. EX1013, 4-34.

99. A POSITA would have understood that a client node personal computer running software, as disclosed in Ogdon, discloses a digital processing apparatus memory device comprising non-transitory machine-readable instructions (software) that, when executed, cause the processor to perform functions.

100. To the extent it is found that Ogdon does not disclose this limitation, a POSITA would have been motivated to include a digital processing apparatus memory device comprising non-transitory machine-readable instructions that, when executed, cause the processor to perform functions in order to allow the client node to execute programs to request, receive, and play back the video presentations. Digital processing apparatus memory devices were well-known in the art to include machine-readable instructions (software) that cause a processor to perform tasks

related to video presentations. A POSITA would have had a reasonable expectation of success with such a modification because personal computers require such memory for executing instructions (software) to cause processers to perform computing functions, and modifying Ogdon to include such a memory with instructions would have been a routine exercise for a POSITA.

10[C][1]: "establish one or more network connections between the client module and the server,"

101. In my opinion, Ogdon teaches 10[C][1]. Ogdon discloses establishing one or more network connections between the client module (client node(s)) and the server (webserver(s)) because at least one connection is necessary for the client module to retrieve elements from the webservers. 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 webservers 248 for dynamic content."), 19:53-58 ("Following the activation of a connection between the client node 56 and a presentation controlling host 200 . . . client presentation software 88 . . . retrieve[s] and cache[s], via network 70, one or more initial presentation segments from identified content webservers 96"), 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."). Further, it was well-known to a POSITA at the time of the alleged priority date that a "conventional personal computer" would include "means for establishing communications over [a] network." EX1013, 6:24-25.

10[C][2]: "wherein the server is configured to access at least one of a plurality of groups of streamlets;"

102. In my opinion, Ogdon teaches 10[C][2]. Ogdon discloses that the server (webserver(s)) is configured to access at least one of a plurality of groups (collections or subcollections) of streamlets (segments). EX1004, 9:30-31 ("webservers 96 where the content for each presentation will reside"), 9:44-46

("content manager 104 distributes presentation content (e.g., presentation segments) to the content webservers 96"), 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.").

10[C][3]: "wherein the video is encoded at a plurality of different bitrates to create a plurality of streams including at least a low quality stream, a medium quality stream, and a high quality stream,"

103. In my opinion, Ogdon in view of Allen teaches 10[C][3]. *See* 1[B].

10[C][4]: "wherein each of the low quality stream, the medium quality stream, and the high quality stream comprises a streamlet that encodes the same portion of the video at a different one of the plurality of different bitrates;"

104. In my opinion, Ogdon in view of Allen teaches 10[C][4]. *See* 1[C], 1[E]. Ogdon further discloses that each stream (*e.g.*, low, medium, and high quality levels as taught by Allen) comprises elements, collections, or subcollections of streamlets (segments) where each corresponding segment at each quality level encode the same portion of the video at different bitrates. 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**."), 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").

10[C][5]: "wherein at least one of the low quality stream, medium quality stream, and high quality stream is encoded at a bit rate of no less than 600 kbps; and"

105. In my opinion, Ogdon in view of Allen teaches 10[C][5]. *See* 1[D].

10[C][6]: "wherein the streamlet encoding the same portion of the video in the low quality stream has an equal playback duration as the streamlet encoding the same portion of the video in the high quality stream;"

106. In my opinion, Ogdon in view of Allen teaches 10[C][6]. *See* 1[E].

10[D]: "select a specific one of the streams based upon a determination by the client module to select a higher or lower bitrate version of the streams;"

107. In my opinion, Ogdon in view of Allen teaches 10[D]. *See* 10[C][3]. Ogdon further discloses selecting a specific one of the quality streams based upon a determination (*e.g.*, based on network data transmission characteristics at the client

node(s)) by the client module (client node) to select a higher or lower bitrate version of the streams. EX1004, 6:41-44 ("each **client node to request** presentation content from a given set of communications network servers rather than having such servers push presentation content to the client node"), 7:10-13 ("the present invention employs a '**client-request' technology**, where each presentation member's browser requests information from a communication network server"), 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"), 19:54-59 ("the client presentation software 88 is instructed by the presentation controlling host 200 . . . to retrieve and cache, via network 70, one or more initial presentation segments from identified content webservers 96 where the presentation segments have been pre-stored."), 21:40-45 ("host 200 sends one or more commands to each copy of the client presentation software 88 indicating both the next collection of segments to be retrieved by the client nodes and the network 70 addresses of the primary and alternate webservers 96 from which to retrieve the segment collection."), 22:12-17 ("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 webservers 96 **to select** an appropriate content webserver and

an appropriate version of the next collection of segments to be retrieved."), 23:41-50 ("client node 56 provides the identity of the selected webserver and next collection of segments to the client node's browser 78, and the browser, in turn, sends a network 70 request to the selected web server for the selected (subversion) of segments" then "client presentation software 88 monitors the time elapsed before transmission of the selected collection of segments is completed, and determines whether these segments are provided within an appropriate window of time that allows them to be presented during the performance of the presentation."), 23:51-24:6, 24:50-55 ("Accordingly, 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 usually resulting in selection of alternative segment collections that are smaller."), Abstract ("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"), 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").

10[E]: "place a streamlet request to the server over the one or more network connections for the selected stream;"

108. In my opinion, Ogdon teaches 10[E]. Ogdon discloses placing a streamlet request to the server over the one or more network connections for the selected stream. *See* 10[D]; EX1004, 6:41-44 ("each client node to request presentation content from a given set of communications network servers rather than having such servers push presentation content to the client node"), 7:10-13 ("the present invention employs a 'client-request' technology, where each presentation member's browser requests information from a communication network server"), 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").

10[F]: "receive the requested first streamlet from the server via the one or more network connections; and provide the received first streamlet for playback of the live event video."

109. In my opinion, Ogdon teaches 10[F]. Ogdon discloses receiving the requested first streamlet from the server via the internet connection and provide the received first streamlet for playback of the live event video. 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"), 23:45-50 ("client presentation software 88 monitors the time elapsed before transmission of the selected collection of segments is completed, and determines whether these segments are provided within an appropriate window of time that allows them to be presented during the performance of the presentation.").

Claim 11: "The content player device of claim 10 wherein each streamlet of the plurality of streamlets in the low quality stream, the medium quality stream, and the high quality stream has a duration that is the same as each other."

110. In my opinion, Ogdon in view of Allen teaches claim 11. *See* claim 1[E].

Claim 13: "The content player device of claim 10, wherein each streamlet of the plurality of streamlets in the low quality stream, the medium quality stream, and the high quality stream has a duration that is the range of 0.1 to 5 seconds."

111. In my opinion, Ogdon in view of Allen teaches claim 13. *See* claim 5. Further, a POSITA would have been motivated to make each streamlet of the plurality of streamlets in each quality level have a duration that is the range of 0.1 to 5 seconds in order to simplify the system and ensure that each segment is of

sufficiently short duration such that they system can rapidly switch between quality levels as necessary.

112. Alternatively, it would have been "obvious to try" for a POSITA to make each duration of each segment in the range of 0.1 to 5 seconds because this would be a POSITA choosing between one of a finite number of possible solutions. Namely, a POSITA would have to assign some duration to each segment such that the segments are sufficiently long to allow for quick playback without requesting a large number of files but sufficiently short in duration to allow for switching to different quality levels as necessary without excessive delay—this duration would have to be on the order of single digit seconds (*e.g.*, 1-5 seconds), or low double digit seconds. Therefore, it would have been obvious for a POSITA to try making the duration of each segment between 0.1 to 5 seconds as a finite number of possible solutions. *Id*. A POSITA would have had a reasonable expectation of success with such modifications because the segments all have *some* duration and merely adjusting the duration each segment to have a duration between 0.1 to 5 seconds would have been a simple and straightforward modification for a POSITA.

Claim 14: "The content player device of claim 10, wherein the video is a video of a live event."

113. In my opinion, Ogdon in view of Allen teaches claim 14. *See* claim 1[Pre].

Claim 15: "The content player device of claim 14, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream are available before the live event is complete."

114. In my opinion, Ogdon in view of Allen teaches claim 15. *See* claim 8.

Claim 16: "The content player device of claim 15, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream of the live event are available on a ten second delay."

115. In my opinion, Ogdon in view of Allen teaches claim 16. *See* claim 9.

Claim 17: "The content player device of claim 16, wherein the streamlets from the low quality stream, the medium quality stream, and the high quality stream of the live event, when played back, appear live to a viewer."

116. In my opinion, Ogdon in view of Allen teaches claim 17. *See* claim 1[Pre], claims 15-16.

Claim 18:

18[Pre]: "A system for adaptive-rate content streaming of live event video playable on one or more end user stations over the internet, the system comprising:"

117. In my opinion, Ogdon teaches 18[Pre]. *See* claim 1[Pre]; Section VIII.F: 18[Pre].

18[A]: "at least one storage device configured to store live event video,"

118. In my opinion, Ogdon in view of Allen teaches 18[A]. *See* claim 1[A]; Section VIII.F: 18[A].

18[B]: "the live event video encoded at a plurality of different bit rates creating a plurality of streams including at least a low quality stream and a high quality stream;"

119. In my opinion, Ogdon in view of Allen teaches 18[B]. *See* claim 1[B]; Section VIII.F: 18[A].

18[C]: "the low quality stream and the high quality stream each encoding the same portion of the live event video with a streamlet that is encoded a different one of the different bit rates;"

120. In my opinion, Ogdon in view of Allen teaches 18[C]. *See* claim 1[C], 1[E]; Section VIII.F: 18[C].

18[D]: "wherein the plurality of streamlets in the low quality stream and the plurality of streamlets in the high quality stream have durations that are equal to each other"

121. In my opinion, Ogdon in view of Allen teaches 18[D]. *See* claim 1[E]; Section VIII.F: 18[D].

Claim 19: "the streamlets in each of the low quality stream and the high quality stream corresponding to the same portion of the live event video have equal durations."

122. In my opinion, Ogdon in view of Allen teaches claim 19. *See* 18[C]-18[D].

Claim 20: "The system of claim 18 wherein the plurality of streams further comprise a medium quality stream encoded at a bit rate higher than the low quality stream and lower than the high quality stream."

123. In my opinion, Ogdon in view of Allen teaches claim 20. *See* 1[B] (Allen teaching a medium quality stream (300 kbps) encoded at a bit rate higher than the low quality stream (56 kbps), and lower than the high quality stream (600 kbps)).

Claim 22:

22[A]: "The system of claim 18, further comprising: a first web server configured to:"

124. In my opinion, Ogdon in view of Allen teaches 22[A]. *See* 7[A].

22[B]: "receive at least one streamlet request over one or more internet connections from the one or more end user stations to retrieve a streamlet storing a portion of the video, wherein the at least one streamlet request from the one or more end user stations includes a request for a currently selected one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the client module to select a higher or lower bitrate version of the streams;"

125. In my opinion, Ogdon in view of Allen teaches 22[B]. *See* 7[B].

22[C]: "retrieve from the storage device the requested streamlet from the currently selected one of the low quality stream, the medium quality stream, and the high quality stream; and"

126. In my opinion, Ogdon in view of Allen teaches 22[C]. *See* 7[C].

22[D]: "send the retrieved streamlet from the currently selected one of the low quality stream, the medium quality stream, and the high quality stream to the requesting one of the end user stations over the one or more network connections."

127. In my opinion, Ogdon in view of Allen teaches 22[D]. *See* 7[D].

Claim 23:

23[A]: "The system of claim 18, further comprising: a plurality of web servers located at different locations across the internet, each web server configured to:"

128. In my opinion, Ogdon in view of Allen teaches 23[A]. *See* 4[A].

23[B]: "receive at least one streamlet request over one or more internet connections from the one or more end user stations to retrieve a streamlet storing a portion of the video, wherein the at least one streamlet request from the one or more end user stations includes a request for a currently selected one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the client module to select a higher or lower bitrate version of the streams;"

129. In my opinion, Ogdon in view of Allen teaches 23[B]. *See* 4[B].

23[C]: "retrieve from the storage device the requested streamlet from the currently selected one of the low quality

stream, the medium quality stream, and the high quality stream; and"

130. In my opinion, Ogdon in view of Allen teaches 23[C]. *See* 4[C].

23[D]: "send the retrieved streamlet from the currently selected one of the different copies to the requesting one of the end user stations over the one or more network connections."

131. In my opinion, Ogdon in view of Allen teaches 23[D]. *See* 4[D]

Claim 24: "The system of claim 21, wherein all of the streamlets in each of the low quality stream, the medium quality stream and the high quality stream have equal durations."

132. In my opinion, Ogdon in view of Allen teaches claim 24. *See* claim 19.

Claim 25: "The system of claim 21, wherein the streamlets of the low quality stream, the medium quality stream, and the high quality stream are available on a ten second delay before the live event is complete, wherein the streamlets from the low quality stream, the medium quality stream, and the high quality stream of the live event, when played back, appear live to a viewer."

133. In my opinion, Ogdon in view of Allen teaches claim 25. *See* claim 9.

Claim 26:

26[Pre]: "A content player device to stream a video over a network from a server for playback of the video, the content player device comprising:"

134. In my opinion, Ogdon teaches 26[Pre]. *See* claim 10[Pre].

26[A]: "a processor;"

135. In my opinion, Ogdon teaches 26[A]. *See* claim 10[A].

26[B]: "a digital processing apparatus memory device comprising non-transitory machine-readable instructions that, when executed, cause the processor to:"

136. In my opinion, Ogdon in view of Allen teaches 26[B]. *See* claim 10[B].

26[C][1]: "establish one or more network connections between the client module and the server,"

137. In my opinion, Ogdon in view of Allen teaches 26[C][1]. *See* claim 10[C][1].

26[C][2]: "wherein the server is configured to access at least one of a plurality of groups of streamlets;"

138. In my opinion, Ogdon in view of Allen teaches 26[C][2]. *See* claim 10[C][2].

26[C][3]: "wherein the video is encoded at a plurality of different bitrates to create a plurality of streams including at least a low quality stream and a high quality stream,"

139. In my opinion, Ogdon in view of Allen teaches 26[C][3]. *See* claim 10[C][3].

26[C][4]: "the low quality stream and the high quality stream each representing the same portion of the video with a streamlets encoded at a different one of the plurality of different bitrates; and"

140. In my opinion, Ogdon in view of Allen teaches 26[C][4]. *See* claim 10[C][4].

26[C][5]: "wherein the streamlet representing the same portion of the video in the low quality stream and the streamlet representing the same portion of the video in the high quality stream have durations equal to each other;"

141. In my opinion, Ogdon in view of Allen teaches 26[C][5]. *See* claim 10[C][6], 18[D].

26[D]: "select a specific one of the streams based upon a determination by the client module to select a higher or lower bitrate version of the streams;"

142. In my opinion, Ogdon in view of Allen teaches 26[D]. *See* claim 10[D].

26[E]: "place a streamlet request to the server over the one or more network connections for the selected stream;"

143. In my opinion, Ogdon in view of Allen teaches 26[E]. *See* 10[E].

26[F]: "receive the requested streamlets from the server via the one or more network connections; and provide the received streamlets for playback of the video."

144. In my opinion, Ogdon in view of Allen teaches 26[F]. *See* 10[F].

Claim 27: "The content player device of claim 26, wherein the plurality of streamlets in the low quality stream have a duration equal to the duration of the plurality of streamlets in the high quality stream."

145. In my opinion, Ogdon in view of Allen teaches claim 27. *See* 18[D].

H. Claims 1, 3-5, 7-11, 13-20, and 22-27 Would Have Been Obvious in view of Ogdon, Allen, and SMIL 2.0

146. As explained above, it is my opinion that Ogdon in view of Allen teaches claims 1, 3-5, 7-11, 13-20, and 22-27. I incorporate my opinions in Section

VII.F into this section by reference. To the extent that Patent Owner argues that Ogdon in view of Allen fails to teach certain limitations, Ogdon in view of Allen and SMIL 2.0 teaches these limitations.

Claims 1, 10, 11 18, 19, 24, 26, and 27:

147. As explained above, it is my opinion that Ogdon in view of Allen teaches all limitations of claims 1, 10, 18, and 26.

148. To the extent it is argued that Ogdon in view of Allen lack certain limitations, for example that the plurality of streamlets have durations that are equal to each other and that streamlets in each of the quality levels corresponding to the same portion of the live event video have equal durations (as described in limitations 1[F], 10[C][6], 11, 18[D], 19, 24, 26[C][5] and 27), SMIL 2.0 teaches these limitations. For example, SMIL 2.0 teaches using a SMIL 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" EX1006, 61.

149. SMIL 2.0 also teaches using a SMIL element called "<seq>" which "defines a sequence" such that "media elements play one after the other" (EX1006, 158) and controlling duration of such media elements using the "dur" attribute (*id.*, 125-128). In one example, SMIL 2.0 teaches providing three sequential media elements and three alternative sequential media elements (annotated below as purple, yellow, and red) each having an equal playback duration of 5 seconds due to the "dur=5s":

```
<switch>
  <seq systemRequired="BrushMedia">
    <brush dur="5s" color="#0000FF" region="colorbox"/>
    <brush dur="5s" color="#00FF00" region="colorbox"/>
    <brush dur="5s" color="#FF0000" region="colorbox"/>
  </seq>
  <seq>
   <img dur="5s" src="blue.jpg"  region="colorbox"/>
   <img dur="5s" src="green.jpg" region="colorbox"/>
   <img dur="5s" src="red.jpg"   region="colorbox"/>
  </seq>
</switch>
```

EX1006, 273 (annotated).

150. In other words, SMIL 2.0 teaches a first segment and alternative first segment (each annotated as purple) and each with an equal fixed duration of five seconds (and likewise for second and third segments). And SMIL also teaches each sequential streamlet (first, second, and third) also having a same or equal duration (5 seconds). A POSITA would have been motivated to ensure that each segment in Ogdon had the same or equal duration, *e.g.*, 5 seconds as taught by SMIL 2.0, in

order simply they system and to ensure that when a switch is made to an alternative segment the alternative segment is a perfect replacement for preferred segment so that when switching to a different version during the presentation the user still experiences a seamless presentation. A POSITA would have had a reasonable expectation of success with such a combination because both Ogdon and SMIL 2.0 are drawn to similar systems of client-server based streaming including allowing the client to determine which alternative files to choose based on system attributes and because ensuring each segment is the same duration of 5 seconds would have been a straightforward modification for a POSITA.

Claims 5 and 13:

151. Ogdon in view of Allen and SMIL 2.0 teaches a streamlet duration of 5 seconds. *See* ¶¶ 146-150.

IX. CONCLUSION

152. In my opinion, and for the reasons provided above, the Challenged Claims are obvious over at least Ogdon in view of Allen or Ogdon in view of Allen and SMIL 2.0 combinations.

153. 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 October 24, 2023.

Exhibit A

Henry H. Houh

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Lexington, MA 02420
henry.houh@gmail.com
cell: 781-325-8273

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 & Sutfliffe LLP, O'Melveny & Myers LLP, Orrick, Herrington & Sutcliffe LLP, Paul Hastings LLP, Paul, Weiss, Rifkind, Wharton & Garrison LLP, Perkins Coie LLP, Quinn Emanuel Urquhart & Sullivan, LLP, Sidley Austin LLP, Smith Baluch LLP, Sterne, Kessler, Goldstein & Fox PLLC, Troutman Sanders LLP, Venable LLP, Weil, Gotshal &

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

BlocksCAD Inc. (H3XL spin-out)

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

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

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

Eons

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

BBN Technologies

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

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

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

Commonwealth Capital

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

Empirix, Inc./Teradyne, Inc.

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

3Com Corporation/NBX Corporation

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

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

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

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

Agora Technology Group, Incorporated

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

AT&T Bell Laboratories, Holmdel, NJ

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

Honors

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

Patents and Patent Publications

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

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

Trials, Testimony and Depositions

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

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

- Verizon Wireless v. Barkan Wireless IP Holdings LP, submitted IPR declarations
- Verizon Wireless and Samsung Electronics America Inc. v. Barkan Wireless IP Holdings LP, IPR2019-199, IPR2019-200, IPR2019-234, IPR2019-631, IPR2019-632, submitted IPR declarations
- Samsung Electronics America Inc. v. Barkan Wireless IP Holdings LP, IPR2019-100, submitted IPR declaration
- Cisco Systems Inc. v. Meetrix IP LLC, IPR2019-539, IPR2019-540, IPR2019-541, IPR2019-542, IPR2019-543, IPR2019-544, submitted IPR declarations
- GMG Products LLC v. Traeger Pellet Grills LLC, PGR2019-24, PGR2019-34, PGR2019-35, PGR2019-36, submitted PGR declaration and was deposed
- Uniloc 2017 LLC v. Google LLC, 2:18-cv-00502-JRG-RSP, U.S. District Court for the Eastern District of Texas, Marshall Division, submitted declaration in support of claim construction
- Microsoft Corporation v. Uniloc 2017 LLC, IPR2020-00102, IPR2020-00103, submitted IPR declarations
- Microsoft Corporation and HP Inc. v. Synkloud 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 deposedPeloton 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