**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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**BEFORE THE PATENT TRIAL AND APPEAL BOARD**

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WEBGROUP CZECH REPUBLIC, A.S. and NKL ASSOCIATES S.R.O.,

Petitioners,

v.

DISH TECHNOLOGIES L.L.C.,

Patent Owner.

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Case No. IPR2025-00470

U.S. Patent No. 11,677,798

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# DECLARATION OF REZA REJAIE, Ph.D. IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 11,677,798

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## EXHIBIT LIST

| Exhibit Number | Description |
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| 1001 | U.S. Patent No. 11,677,798 (the "'798 Patent") |
| 1002 | File History of U.S. Patent No. 11,677,798 |
| 1003 | Declaration of Dr. Reza Rajaie including Curriculum Vitae ("Rejaie declaration") |
| 1004 | U.S. Patent No. 7,447,791 ("Leaning") |
| 1005 | WO 2004/030310 ("Reme") |
| 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 | HTTP 1.1 Protocol |
| 1012 | U.S. Patent No. 6,002,440 to Dalby ("Dalby") |
| 1013 | U.S. Patent No. 6,553,413 ("Leighton") |
| 1014 | Article entitled "Video streaming: Concepts, algorithms, and systems" |
| 1015 | Reza Rejaie Dissertation entitled "An End-to-End Architecture for Quality Adaptive Streaming Applications in the Internet" |
| 1016 | U.S. Patent No. 6,389,473 ("Carmel") |
| 1017 | Article entitled "Design Issues for Layered Quality-Adaptive Internet Video Playback" |
| 1018 | Article entitled "Quality Adaptation for Congestion Controlled Video Playback over the Internet" |
| 1019 | Article entitled "PALS: Peer-to-Peer Adaptive Layered Streaming" |
| 1020 | <RESERVED> |
| 1021 | <RESERVED> |

**TABLE A: LISTING OF CLAIMS**

| Claim Designation | Claim Language |
|---|---|
| **Claim 1** | |
| 1[Pre] | A system for adaptive-rate content streaming of digital content playable on one or more end user stations over the Internet, the system comprising: |
| 1[A] | at least one storage device storing digital content, |
| 1[B] | the digital content encoded at a plurality of different bit rates creating a plurality of streams including a first bit rate stream, a second bit rate stream, and a third bit rate stream, |
| 1[C] | wherein the first bit rate stream, the second bit rate stream, and the third bit rate stream each comprise a group of streamlets encoded at a respective one of the plurality of different bit rates, each group of streamlets comprising at least first and second streamlets, each of the streamlets corresponding to a portion of the digital content; |
| 1[D] | wherein at least one of the first bit rate stream, the second bit rate stream, and the third bit rate stream is encoded at a bit rate of no less than 600 kbps; and |
| 1[E] | wherein the first streamlet of each of the groups of streamlets has the same first duration and encodes the same first temporal portion of the digital content in each of the first bit rate stream, the second bit rate stream, and the third bit rate stream, and wherein the first streamlet of the first bit rate stream encodes the same first temporal portion of the digital content at a different bit rate than the first streamlet of the second bit rate stream and the first streamlet of the third bit rate stream. |
| **Claim 2** | |
| 2[A] | The system of claim 1, further comprising: a plurality of servers located at different locations across the Internet, each server configured to: |
| 2[B] | receive at least one streamlet request over one or more network connections from one or more end user stations to retrieve the first streamlet storing a portion of the digital content, 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 first bit rate stream, the second bit rate stream, and the third bit rate stream |

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| | based upon a determination by the end user station to select a higher or lower bit rate copy of the streams; |
| 2[C] | retrieve from the at least one storage device the requested first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; and |
| 2[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. |
| **Claim 3** | |
| [3] | The system of claim 2, wherein the second streamlet of each of the groups of streamlets each has the same second duration and corresponds to the same second portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the second streamlet of the first bit rate stream having the same bit rate as the first streamlet of the first bit rate stream. |
| **Claim 4** | |
| [4] | The system of claim 3, wherein the first and second durations are different. |
| **Claim 5** | |
| 5[A] | The system of claim 1, further comprising: a first server configured to: |
| 5[B] | receive at least one streamlet request over one or more network connections from the one or more end user stations to retrieve the first streamlet storing the first temporal portion of the digital content, 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 first bit rate stream, the second bit rate stream, and the third bit rate stream based upon a determination by the end user station to select a higher or lower bit rate copy of the digital content; |
| 5[C] | retrieve from the at least one storage device the requested first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; and |
| 5[D] | send the retrieved first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream to the requesting one of the end user stations over the one or more network connections. |

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| **Claim 6** | |
| [6] | The system of claim 5, wherein the digital content comprises a live event video of a live event, and the first streamlets of the first bit rate stream, the second bit rate stream, and the third bit rate stream are available before the live event is complete. |
| **Claim 7** | |
| [7] | The system of claim 6, wherein the streamlets from the first bit rate stream, the second bit rate stream, and the third bit rate stream of the live event, when played back, are presented in a live stream to a viewer. |
| **Claim 8** | |
| [8] | The system of claim 7, wherein the first server is further configured to: receive at least one virtual timeline request over the one or more network connections from the one or more end user stations to retrieve a virtual timeline; and send the virtual timeline to the requesting one of the end user stations over the one or more network connections. |
| **Claim 9** | |
| [9] | The system of claim 1, further comprising: an encoding module configured to receive the digital content and encode the streamlets of the first bit rate. |
| **Claim 10** | |
| [10] | The system of claim 9, wherein the encoding module is configured to encode the streamlets of the multiple copies of the digital content in each of the different bit rates using a multi-pass encoding process. |
| **Claim 11** | |
| 11[Pre] | An end user station comprising: |
| 11[A] | a processor; |
| 11[B] | a digital processing apparatus memory device comprising non-transitory machine-readable instructions that, when executed, cause the processor to: |
| 11[C][1] | establish one or more network connections between the end user station and at least one server, |
| 11[C][2] | wherein the at least one server is configured to access at least one of a plurality of groups of streamlets of digital content; |
| 11[C][3] | wherein the digital content is encoded at a plurality of different bit rates to create a plurality of streams including at least a first bit rate stream, a second bit rate stream, and a third bit rate stream, |

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| 11[C][4] | wherein each of the first bit rate stream, the second bit rate stream, and the third bit rate stream comprises a group of streamlets encoded at the same respective one of the different bit rates, each group comprising at least first and second streamlets, each of the streamlets corresponding to a portion of the digital content; |
| 11[C][5] | wherein at least one of the first bit rate stream, the second bit rate stream, and the third bit rate stream is encoded at a bit rate of no less than 600 kbps; and |
| 11[C][6] | wherein the first streamlets of each of the first bit rate stream, the second bit rate stream and the third bit rate stream each has an equal playback duration and each of the first streamlets encodes the same portion of the digital content at a different one of the different bit rates; |
| 11[D] | determine whether to select a higher or lower bit rate copy of the stream and based on that determination, select a specific one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; |
| 11[E] | place a first streamlet request to the at least one server over the one or more network connections for the first streamlet of the selected stream; |
| 11[F] | receive the requested first streamlet from the at least one server via the one or more network connections; and provide the received first streamlet for output of the digital content to a presentation device. |
| **Claim 12** | |
| 12[A] | The end user station of claim 11, wherein the non-transitory machine-readable instructions further comprise instructions that cause the processor to: |
| 12[B] | place a second streamlet request to the at least one server over the one or more network connections for the second streamlet of the selected stream; |
| 12[C] | receive the requested second streamlet from the at least one server via the one or more network connections; and |
| 12[D] | arrange the first streamlet and second streamlet in order of ascending presentation time for output of the digital content to the presentation device. |
| **Claim 13** | |
| [13] | The end user station of claim 11, wherein at least some streamlets are requested from the at least one server via a hypertext transfer protocol (HTTP) GET request. |

| **Claim 14** | |
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| [14] | The end user station of claim 11, wherein the at least one server comprises at least two servers and wherein at least one streamlet is requested from a first server of the at least one server and at least one other streamlet is requested from a second server of the at least one server other than the first server. |
| **Claim 15** | |
| [15] | The end user station of claim 11, wherein each of the streamlets is requestable by the processor without regard to whether the processor has previously requested other streamlets of the digital content. |
| **Claim 16** | |
| [16] | The end user station of claim 11, wherein at least a plurality of streamlets are separate files stored by the at least one server. |
| **Claim 17** | |
| 17[A] | The end user station of claim 11, wherein the non-transitory machine-readable instructions further comprise instructions that cause the processor to: |
| 17[B] | place a second streamlet request to the at least one server over the one or more network connections for a second streamlet of a different bit rate stream, wherein the different bit rate stream comprises a different stream than the selected stream; |
| 17[C] | receive the requested second streamlet from the at least one server via the one or more network connections; |
| 17[D] | arrange the first streamlet and second streamlet in order of ascending presentation time for output of the digital content to the presentation device. |
| **Claim 18** | |
| 18[A] | The end user station of claim 16, wherein the non-transitory machine-readable instructions further comprise instructions that cause the processor to: |
| 18[B] | determine an anticipated inability to receive the digital content at the second bit rate of the second bit rate stream at a rate sufficient for presenting the digital content as the digital content is received, and in response to the determining the anticipated inability, requesting a third streamlet of the first bit rate stream, the third streamlet immediately |

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| | subsequently adjacent to the second streamlet of the digital content during presentation. |
| **Claim 19** | |
| [19] | The end user station of claim 18, wherein the second streamlet of each of the groups of streamlets each has the same second duration and corresponds to the same second portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the second streamlet of the first bit rate stream having the same bit rate as the first streamlet of the first bit rate stream. |
| **Claim 20** | |
| [20] | The end user station of claim 12, wherein the streamlets of the first bit rate stream, the second bit rate stream, and the third bit rate stream of the live event are available on a ten second delay. |
| **Claim 21** | |
| [21] | The end user station of claim 12, wherein the processor providing the first received streamlet for playback comprises outputting the first streamlet to a presentation device connected to the end user station. |
| **Claim 22** | |
| 22[Pre] | A process executable by one or more servers to stream digital content for playback by one or more end user stations, the process comprising: |
| 22[A] | storing, by the one or more servers, a plurality of streams including a first bit rate stream, a second bit rate stream, and a third bit rate stream, |
| 22[B] | wherein the first bit rate stream, the second bit rate stream, and the third bit rate stream each comprise a group of streamlets encoded at a respective one of a plurality of different bit rates, each group comprising at least first and second streamlets, each of the streamlets corresponding to a portion of the digital content; |
| 22[C] | wherein at least one of the first bit rate stream, the second bit rate stream, and the third bit rate stream is encoded at a bit rate of no less than 600 kbps; and |
| 22[D] | wherein the first streamlet of each of the groups of streamlets has the same first duration and encodes the same first temporal portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the first streamlet of the first bit rate stream having a different one of the different bit rates than the first streamlet of the second bit rate stream and the first streamlet of the third bit rate stream; |

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| 22[E] | receiving at least one streamlet request over one or more network connections from the one or more end user stations to retrieve the first streamlet storing the first temporal portion of the digital content, |
| 22[F] | 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 first bit rate stream, the second bit rate stream, and the third bit rate stream based upon a determination by the end user station to select a higher or lower bit rate copy of the digital content; |
| 22[G] | retrieving from the storage device the requested first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; and |
| 22[H] | sending the retrieved first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream to the requesting one of the end user stations over the one or more network connections. |
| **Claim 23** | |
| [23] | The method of claim 22, wherein a second streamlet of each of the groups of streamlets each has a same second duration and corresponds to a same second temporal portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the second streamlet of the first bit rate stream having the same bit rate as the first streamlet of the first bit rate stream. |
| **Claim 24** | |
| [24] | The method of claim 23, wherein the first and second durations are different. |
| **Claim 25** | |
| [25] | The method of claim 22, wherein the digital content is a live event, and wherein the first streamlets of the first bit rate stream, the second bit rate stream, and the third bit rate stream are available before the live event is complete. |

# I. INTRODUCTION

1. I have been retained by Webgroup Czech Republic, A.S. ("Petitioner") as an independent expert consultant in this proceeding before the United States Patent and Trademark Office ("PTO") against DISH Technologies, L.L.C. ("Patent Owner") regarding U.S. Patent Number 11,677,798 ("the '798 Patent") (EX 1001).[1]

2. I have been asked to consider whether certain references disclose or render obvious the features recited in claims 1-25 (collectively, the "Challenged Claims") of the '798 Patent. My opinions are set forth below. Based on my experience and expertise, it is my opinion that the prior art renders obvious all limitations of the Challenged Claims, as I discuss in detail below.

3. I am being compensated at a rate of $650 per hour for my work in this proceeding. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

4. All of my opinions stated in this Declaration are based on my own personal knowledge and professional judgment. I am over 18 years of age and, if I

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[1] Where appropriate, I refer to exhibits that I understand are to be attached to the petition for *Inter Partes* Review of the '798 Patent.

am called upon to do so, I would be competent to testify as to the matters set forth in this Declaration.

## I. BACKGROUND AND QUALIFICATIONS

5. As a graduate student, and in my work as a research professional at the time of the presumed priority date, I was actively engaged in several research and development projects related to internet video streaming. Therefore, I believe that I am uniquely qualified to describe the state of the relevant art at the presumed priority date for the ’798 Patent.

6. I am currently a full professor and department head of the Computer Science Department at the University of Oregon. I have worked as faculty member at the University of Oregon since fall of 2002, and I have developed and taught various undergraduate and graduate level courses and seminars in different areas of computer networks. I also played a leading role in creating the PhD program in computer networks in the computer science department at the University of Oregon. I also played a leading role in creating the University of Oregon’s PhD program in computer networks and its bachelor’s, master’s and certificate degrees in cybersecurity.

7. Before joining the University of Oregon, I was a senior technical staff member at AT&T Research Labs at Menlo Park, California from 1999 to 2002. While at AT&T Research Labs I continued to conduct research in adaptive internet

video streaming and video proxy caching. My work at that time primarily focused on architectural issues and advanced development of related prototype systems.

8. Overall, I have 30 years of experience in conducting research in different areas of computer networks including, but not limited to, Multimedia Networking, Congestion Control, Peer-to-Peer Networks, Peer-to-Peer Video Streaming, Internet Measurement, Social Computing, Networked Systems, and Cybersecurity. I have also conducted interdisciplinary research with social scientists and psychologists. I have published 80 peer reviewed articles in major scientific journals and for presentation at technical conferences. My publications have been cited more than 9600 times and several of my publications are cited as the authoritative reference regarding their corresponding topics.

9. I am also a founding associate director of the Oregon Cybersecurity Center of Excellence (OCCoE). As a state-funded center, OCCoE focuses on all cybersecurity challenges across the state and is co-led by three major public universities in Oregon, namely Oregon State University, the University of Oregon, and Pacific State University. Additionally, I currently oversee all OCCoE activity at the University of Oregon.

10. I have been a visiting professor at major European universities (such as Sorbonne University) and research institutions (IMDEA Networks). My research has been funded by many competitive grants including, but not limited to, the

National Science Foundation, the National Institute of Health as well as state agencies and industry organizations. I have received several awards as a result of my research activities, including an NSF CAREER award, becoming an IEEE Fellow, becoming a Distinguished Member of the Association of Computing Machinery ("ACM"), and receiving the European Union Marie Curie Fellowship.

11. I have supervised the research of many graduate students at the University of Oregon, including several PhD dissertations and masters' theses. I have served as a member of many committees and boards, including as a member of the technical program committee for numerous professional conferences and technical workshops, as a member of various journal editorial boards, on multiple NSF review panels, and in advisory boards, as detailed in my CV.

12. I received my master's and PhD degrees from the University of Southern California (USC) in 1996 and 1999, respectively. My PhD thesis was supervised by Professor Deborah Estrin and Professor Mark Handley. During my graduate studies at USC, I conducted research in the area multimedia storage management at USC for two years (1994 to 1996) and in Internet video streaming at Information Sciences Institute (ISI) for three years (1996 to 1999). I completed my bachelor's degree in electrical engineering at Sharif University of Technology, Tehran, Iran, in 1991.

13. Over the past 23 years, I have developed and taught a wide range of undergraduate and graduate courses and seminars related to computer networks at the University of Oregon including Introduction to Computer Networks, Distributed Systems, Operating Systems, Internet Multimedia, Network Measurement, Peer-to-Peer Networking, Online Social Networking, and Computer Organization.

14. Additionally, between 1994 and 2004, I conducted seminal research that led to authoritative publications in several areas of Internet video streaming, including the following:

15. *Storage Manager for Streaming Media*: I was part of a team that developed a scalable storage manager called MITRA. We incorporate novel technical to control the layout of stored video on a cluster of hard disks to maximize the number of concurrent video streams that can be supported by a given hard disk cluster. This journal paper has received 94 citations.

16. *Congestion Control for Internet Video Streaming*: I designed and extensively evaluated one of the first congestion control techniques, called Rate Adaptation Protocol or RAP, for Internet streaming over UDP transport protocol. This study was published in 1999 and has been cited more than 1200 times.

17. *Quality Adaptive Streaming*: I proposed a novel quality adaptation technique for streaming layered (hierarchically) encoded video through congestion-controlled connection over the internet. This study was published at a conference in

1999 and later in a journal in 2000. Together, these two publications have been cited more than 600 times.

18. *Quality Adaptive Video Proxy Caching*: I designed, implemented, and evaluated the first proxy caching mechanism for video streaming over the Internet. My proposed technique leverages proxy storage to enhance the quality of streamed video to clients despite any bottleneck bandwidth from the server. This project resulted in three publications in 1999, 2000 and 2001 that are collectively cited more than 680 times.

19. *Multi-Source Internet Video Streaming*. I designed and evaluated the first pull-based technique for streaming quality adaptive video from multiple sources to a single client. This study was initially published in 2003 and cited more than 290 times. Another version of this study was published in 2005 and was cited more than 100 times.

20. *Architectural Issues*. I have published three papers that explored different components of a client-server architecture for non-interactive (*i.e.*, playback to lecture-mode live) and adaptive internet video streaming. These publications illustrate how congestion control, error control and quality adaptation mechanisms can be integrated in an application-specific manner to support adaptive internet streaming applications.

21. *PhD Dissertation*. My PhD Dissertation at USC, titled "An End-to-End Architecture for Quality Adaptive Streaming Applications in The Internet" is composed of a few of the above studies and captures a wide range of related design issues and prior work to internet video streaming in 1999.

22. *Peer-to-peer Video Streaming*. I have conducted several seminal studies on peer-to-peer streaming of live video over the internet between 2006 and 2009 that received more than 850 citations.

## II. LEGAL STANDARDS

23. In forming my opinions and considering the subject matter of the '798 Patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

24. I understand that the claims define the invention. I also understand that an unpatentability analysis is a two-step process. First, the claims of the patent are construed to determine their meaning and scope. Second, after the claims are construed, the content of the prior art is compared to the construed claims.

25. I understand that a claimed invention is only patentable when it is new, useful, and non-obvious in light of the prior art. That is, the invention, as defined by the claims of the patent, must not be anticipated, or rendered obvious by, the prior art.

### A. Claim Construction

26. I understand that the United States Patent and Trademark Office interprets claim terms in an *inter partes* review proceeding under the same claim construction standard that is used in a United States federal court. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of one of ordinary skill in the art at the time of the alleged invention.

27. I understand that claim terms are generally given their ordinary and customary meaning as understood by one or ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claim terms are generally not limited by the embodiments described in the specification.

28. I have been informed that in general, a preamble limits the invention if it recites essential structure or steps, or if it is necessary to give life, meaning, and vitality to the claim. I have further been informed that a preamble is not limiting where a patentee defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention. I have further been informed that dependence on a particular disputed preamble phrase for antecedent basis may limit claim scope because it indicates a reliance on both the preamble and claim body to define the claimed invention. I have further been informed that clear reliance on the preamble during prosecution to distinguish the

claimed invention from the prior art transforms the preamble into a claim limitation because such reliance indicates use of the preamble to define, in part, the claimed invention.

### B. Anticipation Under 35 U.S.C. § 102

29. I understand that under 35 U.S.C. § 102, a patent claim is invalid if its subject matter was patented or described in a printed publication before the effective filing date of the claimed invention. I have been told that this is referred to as invalidity by anticipation. I have been informed that a patent claim is anticipated under § 102 if a single prior art reference discloses all limitations of the claimed invention.

### C. Obviousness Under 35 U.S.C. § 103

30. I understand that a claim is invalid as obvious under 35 U.S.C. 103 (pre-AIA) if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention to a person of ordinary skill in the art. I have been informed that the following matters are relevant to determining whether the claimed invention would have been obvious: (1) the scope and content of the prior art, (2) the difference or differences between the patent claim and the prior art, (3) the level of ordinary skill in the art at the time the invention of the patent, and (4) any secondary considerations or objective indicia of non-obviousness.

31. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. When a claim simply arranges prior art elements with each performing the same function it had been known to perform and yields no more than one would expect from such an arrangement, then such a combination is obvious. When a patent claims a structure already known in the prior art altered by the mere substitution of one element for another known in the field, the combination is likely to be obvious unless the combination yields an unpredictable result.

32. I have been informed that when a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation, such a variation is likely unpatentable. For the same reason, if a technique has been used to improve one device, and one of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. I have been informed that one question to consider is whether the improvement is more than predictably using prior art elements according to their established functions.

33. I have been informed that it may often be necessary, in a validity analysis, to consider whether there was an apparent reason to combine the known

elements in the fashion claimed by the patent at issue. This can be accomplished by looking to interrelated teachings of multiple patents or other publications or pieces of prior art; the effects of demands known to the design community of present in the marketplace; and the background knowledge possessed by one of ordinary skill in the art.

34. I have been informed that a validity analysis it is appropriate to take account of the inferences and creative steps that a person of ordinary skill in the art would employ. And I have been informed that a person of ordinary skill in the art is a person of ordinary creativity, not an automaton.

35. I have been informed that a claim composed of several elements is not proved obvious merely by demonstrating that each element was, independently, known in the prior art. I have been informed that it can be important to identify a reason that would have prompted a person of ordinary skill in the art in the relevant field to combine the elements in the way the claimed invention does. I understand that one way that subject matter can be proved obvious is by noting there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I have been informed that any need or problem known in the field of endeavor at the time of the claimed invention and addressed by the patent can provide a reason for combining the elements of the prior art in the manner recited by the claim.

36. I have been informed that one should not assume that a person of ordinary skill in the art attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem. Instead, I have been informed that since familiar items may have obvious uses beyond their primary purposes, in many cases a person of ordinary skill in the art will be able to fit the teachings of multiple prior art references together like pieces of a puzzle.

37. I have been informed that, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable, solutions, persons of ordinary skill in the art have good reason to pursue the known options within their technical grasp. If this leads to the anticipated success, the product was likely not accomplished by innovation but by using ordinary skill and common sense. I have been informed that, in such an instance, the fact that the combination was obvious to try may show that the combination was obvious.

38. I have been informed that, when determining whether a claimed combination would have been obvious, the correct analysis is not whether a person of ordinary skill in the art, writing on a blank slate, would have chosen the particular combination of elements described in the claim. Instead, I have been informed that the correct analysis considers whether one of ordinary skill, facing the wide range of needs created by developments in the fields of endeavor, would have seen a benefit to selecting the combination claimed.

39. I have been informed that, when determining whether a claimed invention is obvious, any "secondary considerations" of non-obviousness identified by the patentee should also be considered. These secondary considerations can include: (1) commercial success of the invention, casually related to the invention itself rather than to companion factors, such as advertising or attractive packaging; (2) the prior art taught away from the technical direction followed to arrive at the claimed invention; (3) a long-felt but unsatisfied need for the invention while the needed implementing arts and elements had long been available; (4) the invention achieves results unexpected to those skilled in the art; (5) copying of the invention by competitors as distinguished from their independent development; (6) unsuccessful attempts by those skilled in the art to make the invention; (7) acquiescence by the industry to the patent's validity by honoring the patent through taking licenses or not infringing the patent, or both; and (8) skepticism, disbelief in or incredulity by those skilled in the art that the patentee's approach worked.

40. I have been informed that, for the above information to impact the obviousness of a patent claim, there must be a nexus between the alleged secondary considerations and the claims. In addition, I have been informed that the burden of introducing evidence of secondary considerations generally is on the Patent Owner. If the Patent Owner or its expert should assert secondary considerations of non-

obviousness, I reserve the right to provide a Declaration addressing assertions of non-obviousness due to secondary considerations.

# II. ’798 PATENT

## A. Background of Technology

41. In this section, I describe the state of the art as it pertains to adaptive rate streaming over the Internet at the time of the presumed priority date for the ’798 Patent. While most of the discussion focuses on Internet video streaming, all the principles and practices are similarly applicable to streaming either audio or video, or both. This is one reason that some prior art references refer to this topic as multimedia (*e.g.*, audio and/or video) streaming rather than video streaming or audio streaming.

42. The ’798 Patent states that the field of the invention “particularly relates to adaptive-rate shifting of streaming content over networks such as the Internet.” EX1001, 1:31-34. The following is an overview of adaptive Internet video streaming systems at the presumed priority date (April 30, 2004) that discusses the key elements of such a system, the specific functionality of each element, the interactions among the elements, and state of the art for these elements. “Internet video streaming” broadly refers to systems for delivery of video over the Internet. “Adaptive Internet video streaming” broadly refers to delivering video at bit rates that can be adjusted depending on the available bandwidth of the network.

43. During the decade between 1994 and 2004, there were a significant number of research and development (R&D) projects as well as publicly available applications *(e.g.*, RealNetworks) for Internet video streaming. As a graduate student and then a research professional during this decade, I was actively engaged in several R&D projects related to Internet video streaming, including efforts to adapt a video stream based on available bandwidth.

44. **Overview**. Client-server (also called point-to-point or unicast) video "streaming" systems allow delivery of later parts of a video from a server application/computer to a client application/computer while earlier parts of the video are being displayed by the client, thereby accommodating simultaneous delivery and playback of a video. In such a system, the server and client may be generic computers (or computing devices) that are equipped with the following components: 1) a CPU (or processor) to execute a program; 2) short-term memory to support basic operations and buffer video data before its transmission at the server side and before its playback at the client side; 3) long-term storage space (*i.e.*, hard disk) to store individual segments of a video; and 4) at least one network interface with Internet connectivity.

45. Streaming applications have historically used transport protocols that result in unpredictable variations in available bandwidth (or throughput) of the connection between the client device and the server. Long before April 30, 2004, the

presumed priority date of the '798 Patent, it was well known in the art of video streaming over the Internet that there was a need for technologies to cope with these unpredictable variations of throughput, while ensuring for the user steady/stable playback of video with consistent quality.

46. In an ideal user experience, the streaming system will stream the highest quality version of the multimedia content to the client device without causing playback delays. To do so, the server's connection to the Internet should be sufficiently robust to support streaming of the video to all concurrent clients while an individual client's Internet connection should be capable of supporting a bitrate at least as large as the bitrate of the lowest quality version of the video at the server. A client also requires having a displaying capability where client player software plays out the delivered video for the end user. Client player software may also offer VCR functions to the client within the limitation of delivered data (*e.g.*, rewinding through delivered and stored data is feasible but fast forwarding beyond the content received at the client's buffer is not).

47. Once a client requests a video, one (or multiple) server program(s) on one (or multiple) server computers sequentially transmit packets associated with the video to the client application over the Internet. A client application sequentially receives and decodes individual packets, buffers those packets in the client's short

term memory, and then feeds them to the client's player software in the appropriate sequence at a proper time.

48. At the presumed priority date of the '798 Patent, a POSITA would have understood that client-server video streaming typically involved the following steps:

- Encoding a video at the server;
- Packetizing the video at the server;
- Storing the packetized video at the server;
- The client requesting the video from the server;
- Transporting (i.e., delivery of) the video's packets from the server to the client through the Internet; and
- Decoding, buffering and playing the video's packets at the client.

I will describe below each one of these steps and explain how they relate to adaptive video streaming as of the presumed priority date.

49. **Requesting a Live or Recorded Video**. A client application typically connects to a web server at a known Internet address, browses through a playlist of available videos, selects a particular video, and explicitly requests that the server stream that video to the client. Such a playlist may contain basic information about each listed video (*e.g.*, duration, rating, whether live or recorded, etc.).

50. A video available from a server might be pre-recorded or a feed from a live event. The entire content of a pre-recorded video is available at a server and can be encoded, packetized and stored at the server ahead of time and then streamed to

a client at a later time. In contrast, the content of a live video feed gradually becomes available to a server and thus it must be encoded, packetized and streamed "on the fly" for live events. Since encoding and packetization requires some processing time (and often relies on a portion of video), live streaming requires a T second delay between the server receiving a segment of the live feed and the client displaying that segment. T is a design parameter that depends on how fast the server can encode and packetize a video segment. This delay allows the server to receive and buffer a T second segment of the video, and then encode and packetize that segment before streaming. This implies that the client views the video stream with at least a T second delay (in addition to the delivery time over the network) from delivery of the live feed at the server.

51. A key implication of this difference between streaming recorded and live video is that a recorded video can be streamed at a rate faster than the video bitrate by sending future packets (that is, yet-to-be displayed packets) when network bandwidth allows. However, faster delivery is not feasible for live streaming beyond the T seconds' worth of available packets. Apart from this key difference, all other aspects of streaming live and recorded videos (*e.g.*, encoding, packetization, decoding, transport, playing) are similar. *See, e.g.*, EX1015 at 23-24.

52. **Encoding**. A video can be encoded (or compressed) using one of many standard or proprietary encoding schemes. Some of the standardized video encoding

schemes that were known to a POSITA at the presumed priority date included H.261, MPEG-1, MPEG-2, H.263, and MPEG-4. *See, e.g.,* EX1014, 836-838.

53. These schemes typically encode video into frames and may offer parameters to specify the spatial or temporal resolution/quality as well as inter-dependency of frames (*e.g.*, I, P, and B frames in MPEG coding). These parameters collectively determine the quality and the resulting average bitrate (or bandwidth) for the encoded video stream over the Internet (or any other packet switched network) that, at the time of the presumed priority date of the ’798 patent, could vary from 10 KB/sec to as high as 20 MB/sec. *See, e.g.,* EX1014, 837.

54. **Packetization**. Frames of an encoded video are partitioned into individual packets based on their size and inter-dependency, among other factors. A major guiding principle for packetization of video content that existed at the time of the presumed priority date is called application-level framing (ALF). ALF indicates that the content should be partitioned into packets based on an application’s semantics/needs. For example, ALF suggests that a payload of individual packets should be independently decodable (*i.e.*, decoding the payload of a packet does not depend on the payload of adjacent packets). *See, e.g.,* EX1014 at 851.

55. Individual packets have a specific structure that contains some metadata (in the packet header) as well as the content (the packet payload). This structure and their associated fields can be customized for a specific encoding

scheme and delivery protocol. Clearly any packetization scheme is limited to the maximum packet size that can be sent over the Internet. This maximum packet size is known as the maximum transmission unit (MTU). The MTU was 1500 bytes in early 2000 and remains the same today. A range of issues related to packetization of encoded frames and their implications on decoding are discussed in EX1014. *See, e.g.*, EX1014, 849-851.

56. Each packet has a "playout time" (or timestamp) which is the time offset for playing the first byte/frame in the packet. Each packet also has a certain "playout duration" which is the time that it takes for the client's player to display the content of the packet. The playout time of packet P is equal to the playout time of packet P-1 plus the playout duration of packet P-1. Depending on the details of the encoding scheme used, the playout duration of different packets may or may not be the same length. A simple design option is to assume that all packets have the same playout duration. *See, e.g.*, EX1016 U.S. Patent No. 6,389,473 (Carmel) at 3:40-42 ("Preferably, dividing the stream into the sequence of slices includes dividing the stream into a sequence of time slices, each having a predetermined duration associated therewith.")

57. **Storage**: It was well known to a POSITA at the presumed priority date that all packets of encoded video (possibly with various encoding schemes) can be stored in long-term storage (*e.g.*, a hard disk) as separate files with some

organization for naming and storing these files at the server side. For example, all the packets associated with a video (*e.g.*, the film *Top Gun*) can be named based on their playout time and stored in a folder that has the same name as the video along with the encoding scheme used (*e.g.*, TopGun-MPEG1). Alternatively, it was also understood that one may want to store a group of consecutive packets in a single file to reduce the number of stored files. *See*, *e.g*., EX1016 U.S. Patent No. 6,389,473 (Carmel), Abstract (describing a streaming method that involves "dividing the stream into a sequence of slices" that "are encoded in a corresponding sequence of files"). Storing individual (or a group of) packets as a separate file with a clearly defined naming convention allows the server to easily access, fetch and transmit individual packets upon request

58. A video server often maintains a directory (or playlist) of all the available stored videos, their different encodings and associated bitrates, and their locations on the hard disks along with other metadata information (*e.g.*, version, content owner, access privilege, etc.).

59. **Transportation/Delivery**. The Internet provides a best-effort service for delivery of packets between two computers (*e.g.*, a server and a client). This in turn has two important implications: i) packets might be lost during delivery and thus each application should incorporate an error control mechanism for recovery of important lost packets, and ii) Internet resources are shared and individual

applications should implement a congestion control mechanism to adaptively determine their fair share of bandwidth for each connection and set their transmission rate accordingly.

60. The communication channel between a server and a client application was typically established at the presumed priority date through one of two commonly used transport protocols over the Internet, namely, the User Datagram Protocol (UDP) and the Transmission Control Protocol (TCP). UDP is a lightweight transport protocol that does not provide error or congestion control mechanisms. TCP provides loss recovery and congestion control for all packets.

61. **Error Control**. When a video streaming system relies on the UDP transport protocol, a lost packet may be detected and retransmitted by the server application if there is sufficient time for its delivery prior to its playout time. Such a retransmission-based loss recovery (*i.e.*, error control) is performed in an application/encoding scheme-specific manner. Depending on the encoding scheme, omitting the content of a lost packet may (or may not) have a significant adverse effect on the quality of the delivered video to a client. Therefore, lost packets may be selectively retransmitted by the server when the packet content is important for the quality of the video and there is sufficient time for its delivery as a retransmitted packet prior to its playout time. *See, e.g.*, EX1017, 445-446.

62. The TCP transport protocol, on the other hand, detects and retransmits all the lost packets regardless of their content or playout time. Therefore, unlike UDP, TCP does not need to facilitate application-specific retransmission of lost packets.

63. **Congestion Control**. TCP also implements a congestion control mechanism that continuously adjusts its transmission rate (or throughput). If a video streaming system relies on UDP, however, it must separately implement a congestion control mechanism in the application on top of UDP. A few such congestion control mechanisms for video streaming on top of UDP were proposed in the late 1990s, including the Rate Adoption Protocol (RAP) and the TCP Friendly Rate Control (TFRC) protocol. These congestion control mechanisms dynamically determine proper transmission rate (or available bandwidth) for the server. Therefore, the available bandwidth of a congestion-controlled connection (implemented either directly through TCP or on top of UDP) exhibit variations that are not known before packet transmission.

64. **Quality Adaptation**. A basic challenge in Internet video streaming is to match the average bitrate of an encoded video with the unknown and variable bandwidth of a client's connection. If the connection bandwidth is lower than the average video bitrate, the client's buffer frequently "dries up" which causes interruption in video playback. On the other hand, if the connection bandwidth is

higher than the average video bitrate, the server can stream a higher quality video without interruption and thus provide a better experience to the client. To address this issue, a POSITA understood by the presumed priority date that Internet video streaming should be quality adaptive. *See, e.g*., EX1018 at 189-190. Quality adaptation can be implemented in the server or client (*i.e*., a push vs. pull approach) to monitor bandwidth of the server-client connection and gradually adjust the quality of the video stream accordingly. At the time of the presumed priority date, there existed known strategies to adjust the quality of video streaming during a session including by switching between different encodings of a video (EX1014, 843-844; EX1018, 190; EX1015, 86, EX1016, 10:62-11:22) or adding/dropping a layer of a hierarchically encoded video. (EX1017, 447-449; EX1018, 190-192; EX1015, 86-95). Clearly, adjusting the quality of a video during a streaming session should be performed in a seamless fashion to avoid a gap or a duplicate in video playout. More specifically, if the quality of a video is adjusted at a particular playout time, the packet associated with this video quality and playout time (from either the added/dropped layer or a different version of the video) should be buffered and fed to the player.

65. **Single vs. Multiple Servers**. It was widely understood at the presumed priority date that video can be streamed from a single or multiple servers to a single (or many) client(s). The single server case is the basic client-server streaming

scenario that was described earlier. In multiple server streaming, a request for a video may be sent to a group of servers and simply be assigned to a single server (within this group) that is most appropriate (*i.e.*, closer to the client or less loaded) for serving this request. *See, e.g*., EX1014, 859 ("CDNs improve end-user performance by caching popular content on edge servers located closer to users"). This strategy is often used for load balancing across multiple servers. Once a particular server is selected from the group, the streaming process is the same as in the single server configuration.

66. Alternatively, a video can be concurrently streamed from multiple servers to a single client (*i.e*., through a separate connection from each server to the client). In this scenario, a pull-based quality adaptation scheme at the client can be used to determine the video quality that can be collectively delivered from all servers based on the aggregate bandwidth of all connections. *See, e,g*., EX1019 ("the receiver should effectively monitor and manage the delivery of segments from multiple senders"). The quality adaptation mechanism can periodically coordinate specific packets that should be delivered from individual servers.

67. **Decoding, Buffering & Playing**. Information about the encoding and packetization schemes that are used by the server should be provided to the client's player program so that the player program can properly unpack and decode content of individual received packets during a session. When a client receives the first

packet of a video stream, it usually delays initiating the playback of a video (*i.e.*, feeding the packets to the player) until it receives and buffers a few seconds' worth of packets. This slightly delays the start of displaying the video, but the buffered data enables the player to absorb short-lived and minor variations in the delivery rate of packets from the server without causing any noticeable disruption in video playback for the user. More specifically, when packets arrive at a faster rate than they are being played, the client buffer gradually fills up with received (but unplayed) packets. In contrast, when packets arrive at a slower rate than they are being played, the client buffer gradually drains. Once the client starts playing the video, each packet must be played at its playout time (*i.e.*, timestamp). The client may also provide VCR-like functionalities (fast forward, rewind, stop, and start) within the playout time of buffered data. The client can also save received packets in its storage and replay them at a later time.

### B. Overview of the '798 Patent

68. The '798 Patent (Application Serial No. 17/962,231) was filed on October 7, 2022 and issued on June 13, 2023. EX1001, Cover. It purports to relate to "multi-bitrate content streaming," such as video, over the Internet. *Id.*, Abstract, 1:34-37. The '798 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.

69. One embodiment of the system of the '798 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, 6:36-54. The '798 Patent describes encoding the same content file 200 into at least three different "quality" streams:

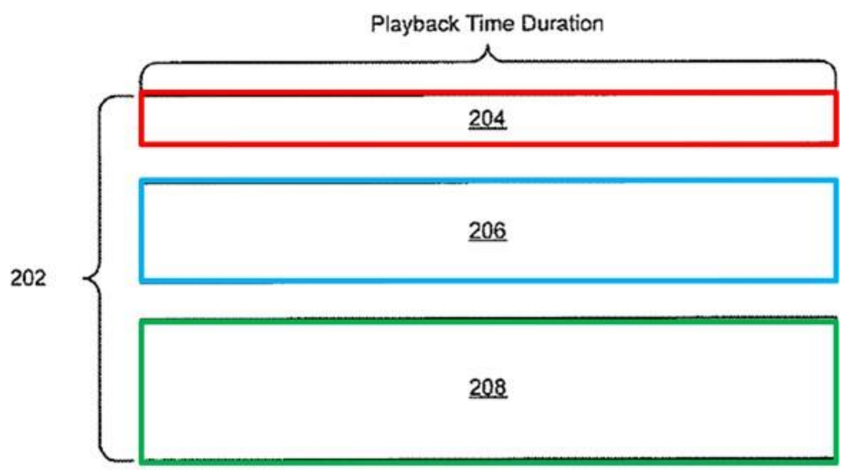



FIG. 2b

*Id.*, FIG. 2b (annotated, low quality (red, 204), medium quality (blue, 206), and high quality (green, 208)), 7:28-34.

70. 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.*, 7:34-39.

71. 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 00:002, and so on." *Id.*, 7:40-52.

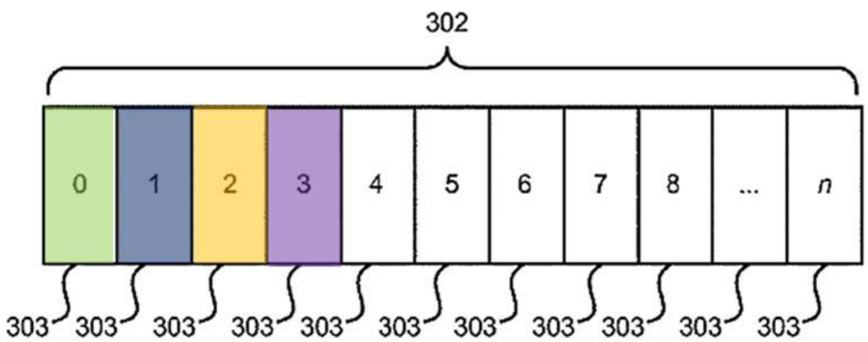



FIG. 3a

*Id.*, FIG. 3a (annotated).

72. 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.*, 7:60-62.

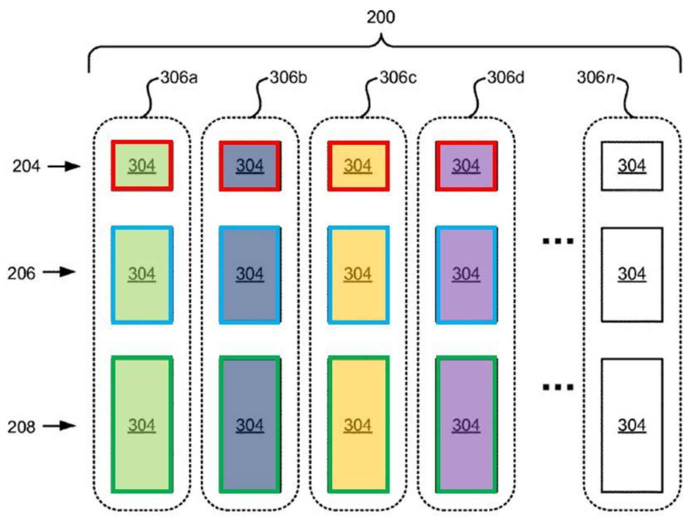



FIG. 3b

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

73. 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.*, 9:4-7, 9:34-44. Further, the '798 Patent explains that the invention may be used to stream "live" content files on a short delay. *Id.*, 10:48-60.

74. 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.*, 13:5-28.

### C. Prosecution History of the ’798 Patent

75. The ’798 Patent was filed as Application No. 17/962,231 on October 7, 2022. EX1002, 175. On January 5, 2023, Applicant filed a terminal disclaimer to obviate a double patenting rejection over prior U.S. Patent No. 11,470,138. *Id.*, 183-184. On January 30, 2023, the Examiner issued a Notice of Allowance. *Id.*, 203.

76. I assume for the purpose of this declaration, an April 30, 2004 priority date for each of the Challenged Claims based on the filing date of Provisional Application No. 60/566,831.

### D. Person of Ordinary Skill in the Art at the Time of the Alleged Invention

77. I am informed that patentability must be analyzed from the perspective of "one of ordinary skill in the art" in the same field as the ’798 Patent at the time of the invention. As previously discussed, the relevant time of the invention is the patent's priority date, which is April 30, 2004. I am also informed that several factors are considered in assessing the level of ordinary skill in the art, including (1) the types of problems encountered in the art; (2) the prior art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the education level of active workers in the field.

78. A person of ordinary skill in the art pertinent to the ’798 Patent would have had at least a bachelor's in electrical engineering/computer

engineering/computer science or equivalent, and two years of experience with networking or media streaming. Additional education could substitute for professional experience and vice versa. A person of ordinary skill in the art would also be able to understand and apply the prior art discussed herein.

79. Although I surpass this definition of one ordinary skill in the art now and at the priority date of the ’798 Patent, my analysis regarding the ’798 Patent has been based on the perspective of one or ordinary skill in the art as of the priority date of the ’798 Patent.

80. I am also familiar with the knowledge of the person of ordinary skill in the art as of the priority date of the ’798 Patent. I am able to opine on how the person of ordinary skill in the art would have understood the disclosure and claims of the ’798 Patent, the disclosures of the prior art, the motivation to combine the prior art, and what combinations of prior art would have been obvious to one of ordinary skill in the art.

## III. CLAIM CONSTRUCTION

81. As discussed above, I have been informed that for purposes of *inter partes* reviews, the standard for claim construction of terms within the claims of the patent is the same as that applied in federal district court litigation. I have been asked to assume that the claim terms have their plain and ordinary meaning to a person skilled in the art in light of the specification and the prosecution history.

82. As of this time, I am not aware of any term that requires specific construction for my opinions. To the extent Patent Owner suggests a construction for a term, I reserve the right to respond to those opinions.

## III. OVERVIEW OF THE PRIOR ART

83. Below, I discuss the references I rely on in my declaration.

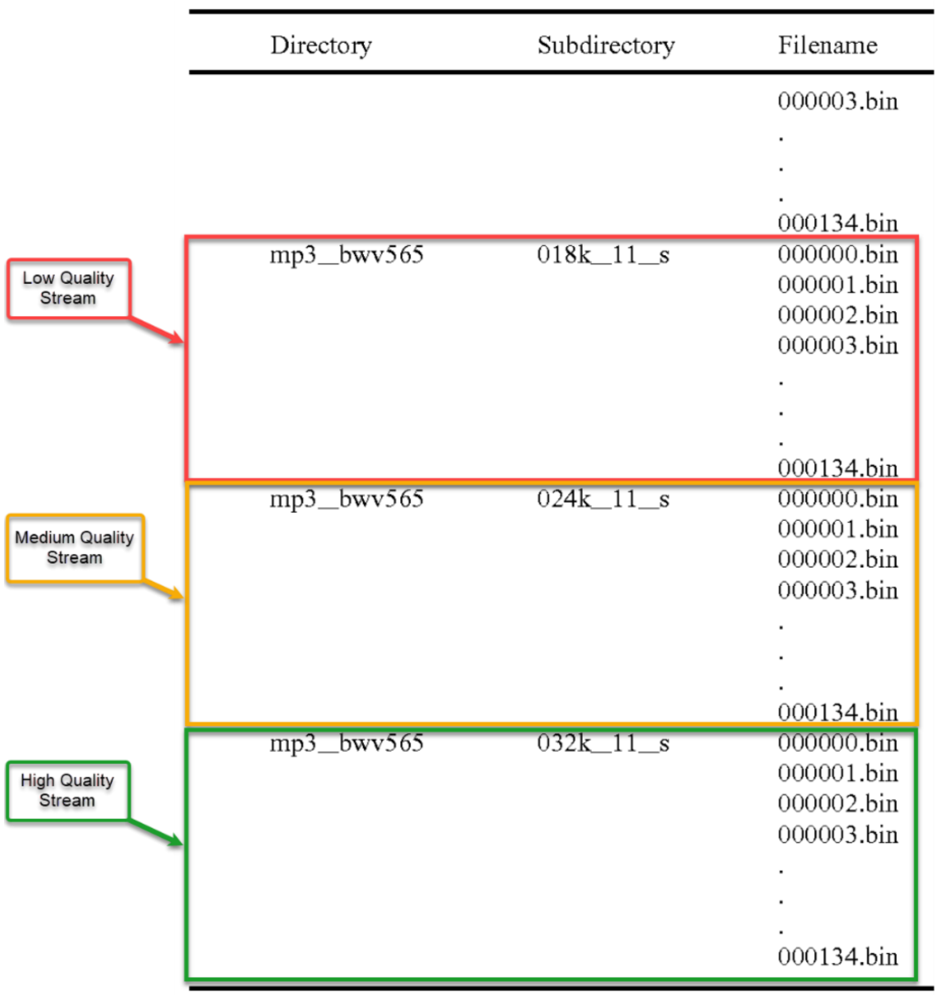
### A. Leaning (EX1004)

84. Leaning was filed Dec. 14, 2001, and published April 1, 2004. I understand it is prior art.

85. Leaning describes technology for transmitting and receiving audio and video content across the internet. Leaning discloses streaming (*e.g.*, transmitting and receiving, via the Internet) of content as sets of files, individually called sub-files, that are each a successive temporal piece of the content being streamed. Each of the sets of sub-files corresponds to a different quality of the same content and a recipient (*e.g.*, a client computer or terminal) can change between quality versions of the content by requesting the sub-file, from a different set of sub-files, for the next temporal portion of the content.

86. Accordingly, Leaning describes a client and server connected by a network (*e.g.*, the Internet) wherein the client measures the actual data rate for content being received from the server and based on that measurement, determines a quality level (*e.g.*, a corresponding directory of sub-files) from which to request

the next sequential sub-file of the content or media stream. EX1004, Abstract, 5:28-51. And Leaning expressly discloses content (*e.g.*, audio and/or video streams) that are stored (*e.g.*, on a web server) as three or more different quality versions (*e.g.*, high, medium, and low) with each version temporally divided into sub-files that each represent the same portion of the media across the different versions. EX1004, 5:28-6:33.



| Directory | Subdirectory | Filename |
|---|---|---|
| | | 000003.bin |
| | | . |
| | | . |
| | | . |
| | | 000134.bin |
| mp3__bwv565 | 018k__11__s | 000000.bin |
| | | 000001.bin |
| | | 000002.bin |
| | | 000003.bin |
| | | . |
| | | . |
| | | . |
| | | 000134.bin |
| mp3__bwv565 | 024k__11__s | 000000.bin |
| | | 000001.bin |
| | | 000002.bin |
| | | 000003.bin |
| | | . |
| | | . |
| | | . |
| | | 000134.bin |
| mp3__bwv565 | 032k__11__s | 000000.bin |
| | | 000001.bin |
| | | 000002.bin |
| | | 000003.bin |
| | | . |
| | | . |
| | | . |
| | | 000134.bin |



EX1004, 6:1-29 (annotated, showing an excerpt of a table with each of the subdirectories containing the sub-files for three different versions of the same audio media (mp3_bwv565, encoded at 18, 24, and 32 kbps) with each subdirectory containing the same number of sub-files with the same names (*e.g.*, 000000.bin-000134.bin) in the same order).

**B. Reme (EX1005)**

87. Reme was filed on September 15, 2003 and published on April 8, 2004. I understand it is prior art.

88. Reme is directed to a technique for streaming content to a user via the Internet and configured to switch among a plurality of pre-encoded versions of the content, where each version corresponds to a different encoding rate and hence to a different quality (*e.g.*, encoding video rates at 30 kbps, 300 kbps, and 5 Mbps). EX1005, Abstract, 3:15-17, 5:1-12. Reme discloses that its streaming system allows for automatically "selecting the version of the content which encoding rate best matches" the transmission rate of the network connection between the client and the server and that it may "switch from one version to another in order to take into account the modifications of the state of the transmission network." EX1005, 5:7-12.

**C. Leighton (EX1007)**

89. Leighton was filed on June 28, 2000, and issued on April 22, 2003. I understand it is prior art.

90. Leighton is directed to a network architecture for hosting and distributing content to clients across the globe. EX1007, Abstract. Leighton discloses a network with "a set of servers operating in a distributed manner," including several "hosting servers" that are used to transmit content to clients using those hosting servers that are near the client machines. EX1007, Abstract. Additionally, Leighton's architecture includes a web server 12 that is "one of a plurality of [web] servers which are accessible by clients." EX1007, 5:2-4. In processing a client's HTTP request for content, Leighton's system "determine[s] where in the network [(*e.g.*, Internet)] a user is located, and then [directs] the user to a … server 40 that is close-by." EX1007, 9:46-50.

**D. SMIL 2.0 (EX1006)**

91. Synchronized Multimedia Integration Language 2.0 ("SMIL 2.0") is an XML markup language for streaming presentation of multimedia 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). I understand it is prior art. SMIL 2.0 is not cited on the face of the '798 Patent.

92. SMIL 2.0 includes elements for use in streaming video content, such as "<seq>", "<switch>", and "systemBitrate" elements, which allow for three content quality levels (high, medium, and low) and a client device that is able to switch between quality level based upon measured system bitrate. SMIL 2.0

discloses that, using the "<seq>" element, a client can request and play media elements (*e.g.*, successive temporal portions of a video) sequentially. 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 and select the file for streaming that is most suitable for the "systemBitrate" (*e.g.*, the bandwidth at the client device). *Id*.

**E. Dalby**

93. Dalby (EX1012) was filed on December 1, 1997 and published on December 14, 1999. I understand it is prior art. Dalby is not cited on the face of the '798 Patent. Dalby discloses methods of encoding a video signal including multiple passes through the encoder. EX1012, Abstract, 4:43-5:27, FIG.3.

**F. Analogous Art**

94. Leaning, Reme, Leighton, Dalby and the '798 Patent are analogous art because all five are directed to systems and techniques to improve performance in streaming systems using multiple copies of a video. EX1001, Title, Abstract, 1:31-34, 3:11-4:34, FIGs. 2C, 4, and 7, *with* EX1004, Abstract, 4:3-5:51, 6:50-7:34, FIGs. 1-5; EX1005, Abstract, 2:7-14, 3:11-24, 4:22-5:12.

95. Like the '798 Patent, Leaning and Reme involve 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, 1:34-37, 3:7-4:37, FIGs. 4 and 7, *with* EX1004, Abstract, 6:5-7:5, 8:1-9:8, FIGs. 1-5; EX1005, EX1005, Abstract, 2:7-14, 3:11-24, 4:22-5:12. Likewise, Dalby is in the field of video-encoding, and has been cited by US5712946A on the subject of recording/reproducing video signals with a plurality of playback speeds. EX1012.

96. Leaning, Leighton, SMIL 2.0, and the ’798 patent are all three are directed to systems and techniques to improve performance in client-server based streaming over the internet. EX1001, 6:35-8:15; EX1004, Abstract; EX1006, 104-107 (describing “The SMIL 2.0 Media Object Models,” including video files, which SMIL 2.0 enables clients to download using several HTTP links associated with different “temporal subparts” of the video); EX1013, 2:51-56 and 3:33-45 (Disclosing a “network architecture [that] is used to speed-up the delivery of richer Web pages” by servicing clients’ HTTP requests with “servers located close to end users.”).

## IV. SUMMARY OF OPINIONS ON UNPATENTABILITY

In the analysis that follows, I identify the following combinations of prior art that, in my opinion, anticipate and/or render obvious the Challenged Claims.

| Ground | Basis | Reference(s) | Claims |
|---|---|---|---|
| 1 | § 103 | Leaning in view of Leighton | 1-9, 11-25 |
| 2 | § 103 | Leaning in view of Leighton and Reme | 1-9, 11-25 |
| 3 | § 103 | Leaning in view of Leighton and SMIL 2.0 | 1-9, 11-25 |
| 4 | § 103 | Leaning in view of Leighton and Dalby | 1-25 |

### A. <u>Ground 1</u>: Claims 1-9 and 11-25 Are Obvious in view of Leaning and Leighton

#### 1. Claim 1

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

97. In my opinion, to the extent the preamble is limiting, Leaning discloses this limitation.

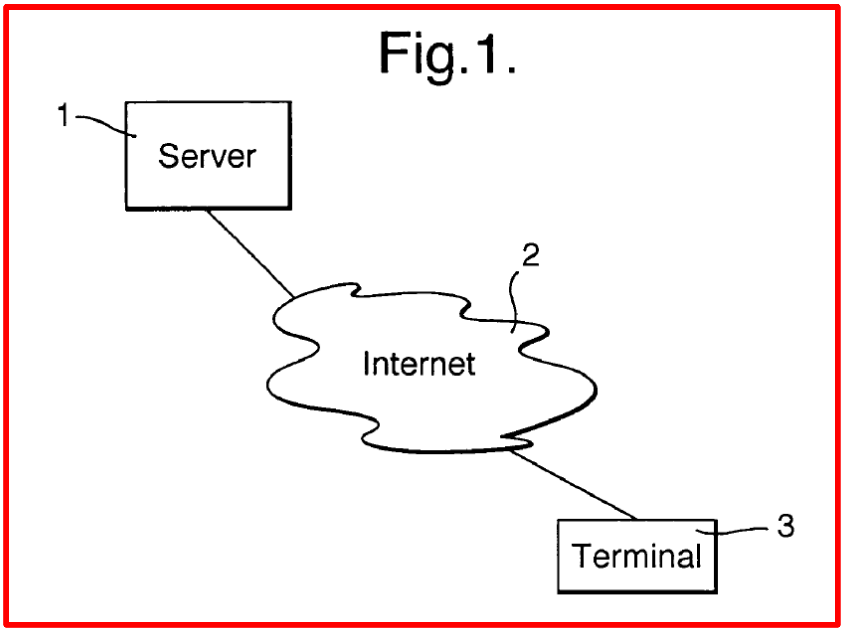
98. Leaning discloses a "system…[which] has as its object the delivery, to a user, of digitally coded audio signals (for example, of recorded music or speech) via a telecommunications network to a user terminal where the corresponding Sounds are to be played to the user…." EX1004, 2:4-9. Leaning discloses that a "Provision may be made for ***switching between alternative*** sub-file sets representing alternative delivery modes or ***data rates***. EX1004, Abstract.

99. Leaning discloses a "server [which] stores ***two or more versions of the recording, recorded at different compression rates*** (for example at compressions

***corresponding to (continuous) data rates*** of 8, 16, 24 and 32 kbit/s respectively) ***and the player program is able to switch automatically between them***." EX1004, 5:28-32. And Leaning discloses that this "system may be used to convey video signals [or] audio signals." 2:9-10.

100. Leaning discloses that "a user terminal where the corresponding sounds are to be played to the user." EX1004, 2:7-8. "[T]he terminal [] may typically take the form of a conventional desktop computer….If desired, the terminal could take the form of a handheld computer, or even be incorporated into a mobile telephone." EX1004, 3:42-47.

101. Additionally, Leaning discloses transmission "via a telecommunications network." EX1004, 2:7; *see also* 2:11-12 ("the network is the ***internet*** or other packet network operating . . ."), 3:50-60 ("a 'web browser' program such as Netscape Navigator or Microsoft Explorer, and a further program 38 which will be referred to here as "the player program' [] provides the functionality necessary for the playing of audio files in accordance with this embodiment of the invention").




**b. 1[A]: "at least one storage device storing digital content,"**

102. In my opinion, Leaning discloses this limitation.

103. As I mentioned above, Leaning discloses at a server storing the video. EX1004, 6:27-30 ("the ***server stores two or more versions of the recording…loaded onto the server*** in separate directories corresponding to the different rate, as in the following example structure, where '008k', '024k' in the directory name indicates a rate of 8 kbit/s or 24 kbit/s and so on.").

**c. 1[B]: "the digital content encoded at a plurality of different bit rates creating a plurality of streams including a first bit rate stream, a second bit rate stream, and a third bit rate stream,"**

104. In my opinion, Leaning discloses this limitation.

105. Leaning discloses that the recording, or audio/video digital content, is digitally encoded at a plurality of different bitrates (different compression rates) creating a plurality of streams including a first low quality bitrate stream (*e.g.*, 8 or 16 kbit/s), a second medium quality bitrate stream (*e.g.*, 24 kbit/s), and a third high quality bitrate stream (*e.g.*, 32 kbit/s). EX1004, 6:27-30 ("the server stores two or more versions of the recording, recorded at ***different compression rates*** (for example at compressions corresponding to (continuous) data rates of ***8, 16, 24 and 32 kbit/s respectively***)…loaded onto the server in separate directories corresponding to the different rate, as in the following example structure, where '008k', '024k' in the directory name indicates a rate of 8 kbit/s or 24 kbit/s and so on."), claim 4.

106. As Leaning state, the "***same principle*** may be applied to the delivery of ***video recordings***. . . the file is a video file (e.g. in H.261 or MPEG format) and the player program incorporates a video decoder. The manner of partitioning the file into sub- files is unchanged. As in the audio case, there may be ***two or more recordings corresponding to different data rates, selected by the control mechanism already described***." EX1004, 12:48-60

**d. 1[C]: "wherein the first bit rate stream, the second bit rate stream, and the third bit rate stream each comprise a group of streamlets encoded at a respective one of the plurality of different bit rates, each group of streamlets comprising at least first and second streamlets, each of the streamlets corresponding to a portion of the digital content;"**

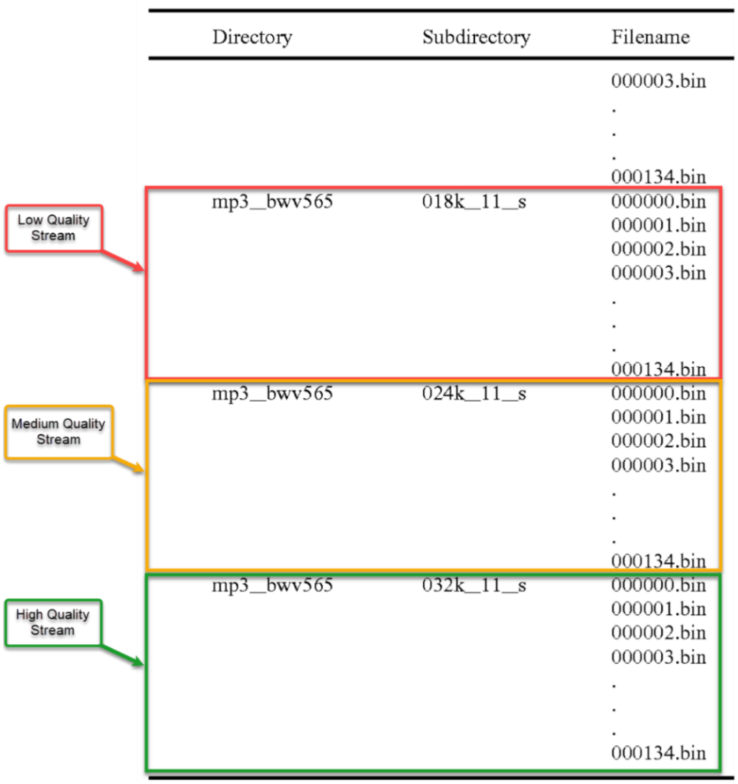
107. In my opinion, Leaning discloses this limitation.

108. Leaning discloses the first bitrate stream (*e.g.*, 8 or 16 kbit/s), the second bitrate stream (*e.g.*, 24 kbit/s), and the third bitrate stream (*e.g.*, 32 kbit/s) each comprise a group of streamlets (subfiles) wherein each streamlet (subfile) in each group of streamlets is encoded at a respective one of the plurality of different bitrates (8, 16, 24, or 32 kbit/s), wherein each group of streamlets comprises at least first (*e.g.*, 000000.bin) and second (*e.g.* 000001.bin) streamlets each corresponding to a portion (temporal portion) of the video. EX1004, Abstract ("dividing the material into a ***sequence of sub-files*** each of which is independently requested by the terminal…switching between ***alternative sub-file sets*** representing ***alternative delivery modes of data rates***.")

109. As shown in the annotated excerpt below (EX1004, 6:1-29), and a high quality stream encoded at 32 kbps ("032k_11_s" (indicated in green)). each of the directories (*e.g.*, for each the different quality versions of the stream) contains a group of streamlets, or a set of sub-files (*e.g.*, "000000.bin" to "000134.bin"), encoded at a bitrate that corresponds to the directory into which they are loaded.

110. Thus, Leaning discloses at least a low quality stream encoded at 18kbps ("018k_11_s" (indicated in red)), a medium quality stream encoded at 24kbps ("024k_11_s" (indicated in orange)), and a high quality stream encoded at 32 kbps ("032k_11_s" (indicated in green)). each of the directories (*e.g.*, for each the

different quality versions of the stream) contains a group of streamlets, or a set of sub-files (*e.g.*, "000000.bin" to "000134.bin"), encoded at a bitrate that corresponds to the directory into which they are loaded.




| Directory | Subdirectory | Filename |
|---|---|---|
| | | 000003.bin<br>.<br>.<br>.<br>000134.bin |
| mp3_bwv565 | 018k_11_s | 000000.bin<br>000001.bin<br>000002.bin<br>000003.bin<br>.<br>.<br>.<br>000134.bin |
| mp3_bwv565 | 024k_11_s | 000000.bin<br>000001.bin<br>000002.bin<br>000003.bin<br>.<br>.<br>.<br>000134.bin |
| mp3_bwv565 | 032k_11_s | 000000.bin<br>000001.bin<br>000002.bin<br>000003.bin<br>.<br>.<br>.<br>000134.bin |

111. Leaning discloses that each group of streamlets consists of at least two streamlets, each of which corresponding to a portion of the digital content. Leaning discloses "The present invention is concerned with the delivery, over a telecommunications link, of digitally coded material for presentation to a user . . . there is provided a terminal for playing audio or video material which is stored on a remote server as a ***set of files representing successive temporal portions***

of the said material…the invention provides a method of transmitting digitally coded audio or video material comprising: ***partitioning the material into a plurality of discrete files each representing successive temporal portions of the said material***; storing the files at a first station; and at a second station - a) transmitting to the first station requests for **successive** respective ones of the files; b) receiving the files; and c) decoding the files for replay of the material." EX1004, 1:11-51. Further, "the file ***is divided into smaller files*** before being stored on the server 1. We prefer that each of these smaller files is of a size corresponding to a fixed playing time, perhaps four seconds. . . . divided into ***135 smaller files*** each representing four seconds' playing time. In this example these are given file names which include a serial number indicative of their sequence in the original file, for example: ***000000.bin 000001.bin*** 000002.bin 000003.bin..000134.bin…'sub-files' is used here to distinguish them from the original file containing the whole recording: it should however be emphasised that, as far as the server is concerned, each sub-file' is just a file like any other file)." EX1004, 2:57-3:10; *see also id.* 5:41-6:27 (describing the same set of 135 sub-files (000000.bin, 000001.bin, 000002.bin, 000134.bin) each encoded at a different bitrate including low, medium, and high quality (8k, 16k, 18k, 24k, and 32k) and listed in an index file and saved in the directory appropriate for their bitrates), claims 1 and 11.

**e. 1[D]: "wherein at least one of the first bit rate stream,**

**the second bit rate stream, and the third bit rate stream is encoded at a bit rate of no less than 600 kbps; and"**

112. In my opinion, Leaning renders obvious this limitation.

113. As explained above, Leaning teaches two or more streams encoded at different bitrates including one example with at least three streams encoded at 16, 24, and 32 kbit/s, respectively. *See* 1[PRE]-1[C]. Further, Leaning's example bitrates of 16, 24, and 32 kbit/s, respectively, are for audio encodings—which a POSITA would have understood generally require less data to stream than video encodings and thus typically have lower bitrates. As described previously, Leaning also teaches that alternative embodiments could include video encodings. EX1004, 2:9-11.

114. The '798 Patent admits that its teaches would compress or encode the videos for its video streams using existing, prior art, encoding formats. EX1001, 7:23-27 (disclosing that content (*e.g.*, video encodings) "may be compressed using ***standard or proprietary encoding schemes***. Examples of encoding schemes capable of use with the present invention include, but are not limited to, DivX, Windows Media Ivdeo, Quicktime Sorenson 3, On2, OGG Vorbis, MP3 or Quicktime 6.5/MPEG-4 encoded content."). Likewise, Leaning discloses encoding the video content for its streams using the H.261 and MPEG video coding formats. EX1004, 12:48-54. Importantly, it would be known to a POSITA at the presumed time of

invention that the H.261 video format was already being used to stream video content at a bitrate equal to, or greater than, 600 kbps. EX1014, 837 (explaining that H.261 was adopted as a standard in 1990, which was designed to operate up to 30 times the baseline ISDN data rate of 64 kbps (*e.g.*, 1,920 kbps)). My opinion is based on my personal knowledge of the state of the art at the presumed time of invention and is further corroborated by the prior art documents, which are written publications, that I cite in this declaration. See, e.g., EX1014, 837.

115. Based on my personal knowledge and experience, and as corroborated by Leaning, it is my opinion that a POSITA would have understood that a user streaming video encodings at the time of the presumed priority date would generally prefer higher bitrate encoding if supported by the user's network requirements, such as 1,920 kbps, to enjoy high quality viewing. EX1004, 13:42-14:64. (describing a video file ("mpg_name") that is encoded at 96 kbps and at 128 kbps and partitioned into two corresponding sets of sub-files (stored in directories "mpg_name/096k_x1/" and "mpg_name/0128k_x1/", respectively)).

116. A POSITA would have been motivated to encode a video embodiment of Leaning (including the corresponding sets of sub-files) into each of a low quality, medium quality, and high quality level bitrate stream (low at 30 kbps, medium at 300 kbps, and high at 1,920 kbps), using the H.261 video codec disclosed by Leaning, because it would enable client terminals with a wide variety of network

bandwidth requirements to stream the video and would have allowed for those with user terminals with high bandwidth connections to stream at 1,920 kbps and enjoy higher resolution viewing and a better user experience. A POSITA would have had a reasonable expectation of success with such an embodiment of Leaning's disclosure because Leaning expressly teaches the use of the H.261 video codec, which was known to support bitrates of up to 1,920 kbps at the presumed time of invention and because simply encoding one of the video streams at a particular bitrate, such as the 1,920 kbps of the H.261 video format, would have been a simple and straightforward implementation of Leaning's teachings for a POSITA to make when switching from the audio to video embodiments of Leaning.

**f. 1[E] "wherein the first streamlet of each of the groups of streamlets has the same first duration and encodes the same first temporal portion of the digital content in each of the first bit rate stream, the second bit rate stream, and the third bit rate stream, and wherein the first streamlet of the first bit rate stream encodes the same first temporal portion of the digital content at a different bit rate than the first streamlet of the second bit rate stream and the first streamlet of the third bit rate stream."**

117. In my opinion, Leaning discloses this limitation.

118. Leaning further discloses that the first streamlet (subfile such as 000000.bin) of each of the groups (different sets of encoded subfiles) of streamlets has the same (or equal) first duration (of four seconds) and encodes the same first

temporal portion of the digital content (audio and/or video) in each of the first, second, and third bit rate streams (8, 16, 24, 32, kbit/s), and wherein the first streamlet of the first bitrate stream (*e.g.*, subfile 000000.bin in16 kbit/s) encodes the same first temporal portion of the digital content at a different bitrate than the first streamlet of the second bitrate stream (*e.g.*, subfile 000000.bin in 24 kbit/s) and the first streamlet of the third bitrate stream (*e.g.*, subfile 000000.bin in32 kbit/s). *See* 1[B]-1[C]; EX1004, Abstract.

119. Leaning also "***prefer[s] that each of these smaller files is of a size corresponding to a fixed playing time, perhaps four seconds***" such that, for example, a "file of 9 minutes duration would be ***divided into 135 smaller files each representing four seconds' playing time***". EX1004, 2:58-64.

| Directory | Subdirectory | Filename |
|---|---|---|
| mpg_name | 096k_x1 | 000000.bin |
| | | 000001.bin |
| | | . . . |
| | | 000134.bin |
| | 096k_x5 | 000000.bin |
| | | . . . |
| | | 000134.bin |

*Id.*, 13:50-60.

120. Indeed, each of the ".bin" files created from that file would correspond to a fixed playing time and an order in the sequence indicated by the file names of the sub-files. 2:57-3:19 (The sub-files "are given file names … indicative of their sequence in the original file, for example: ***000000***.bin ***000001***.bin ***000002***.bin" and so on.) (emphases added). Accordingly, for a video file encoded and partitioned into

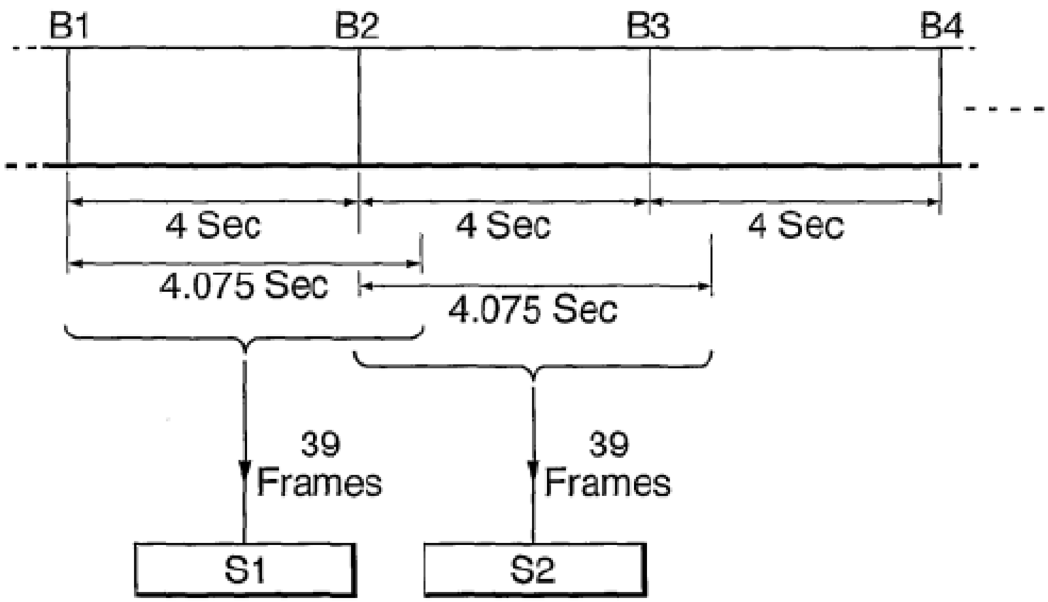
several streamlets of sub-files, each streamlet at a different bitrate, the first sub-file (***000000***.bin) in each of the sets of sub-files represents the same ***fixed playing time*** (e.g., the first four seconds) of the original video file.

121. Additionally, to facilitate rate switching, "it is, if not actually essential, ***highly desirable*** that the sub-file boundaries ***are the same for each rate***, so that the first sub-file received for a new rate ***continues from the same point in the recording that the last sub-file at the old rate ended***." EX1004, 9:64-10:4 (emphases added). Leaning again teaches that "***every sub-file*** [be configured to] represent the ***same*** fixed time period," describing it as "the most convenient" way to provide sub-file boundaries [that] are the same for each rate." EX1004, 9:64-10:4 (emphases added).

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

122. EX1004, 5:55-6:29 (annotated, showing each of the directories containing the different versions of the same recording (encoded at 8, 16, 24, and 32 kbit/s) and each containing the same set of subfiles (000000.bin-000134.bin) in the same order).

Fig.4.




**2. Claim 2**

**a. 2[A]: "The system of claim 1, further comprising: a plurality of servers located at different locations across the Internet, each server configured to:"**

123. In my opinion, Leaning in view of Leighton renders obvious this limitation.

124. Leaning discloses at least one web server. EX1004, 2:40-49 (explaining that the server of Leaning is "merely an ordinary 'web server'"), 3:19-4:3 (describing loading subfiles "onto a web server").

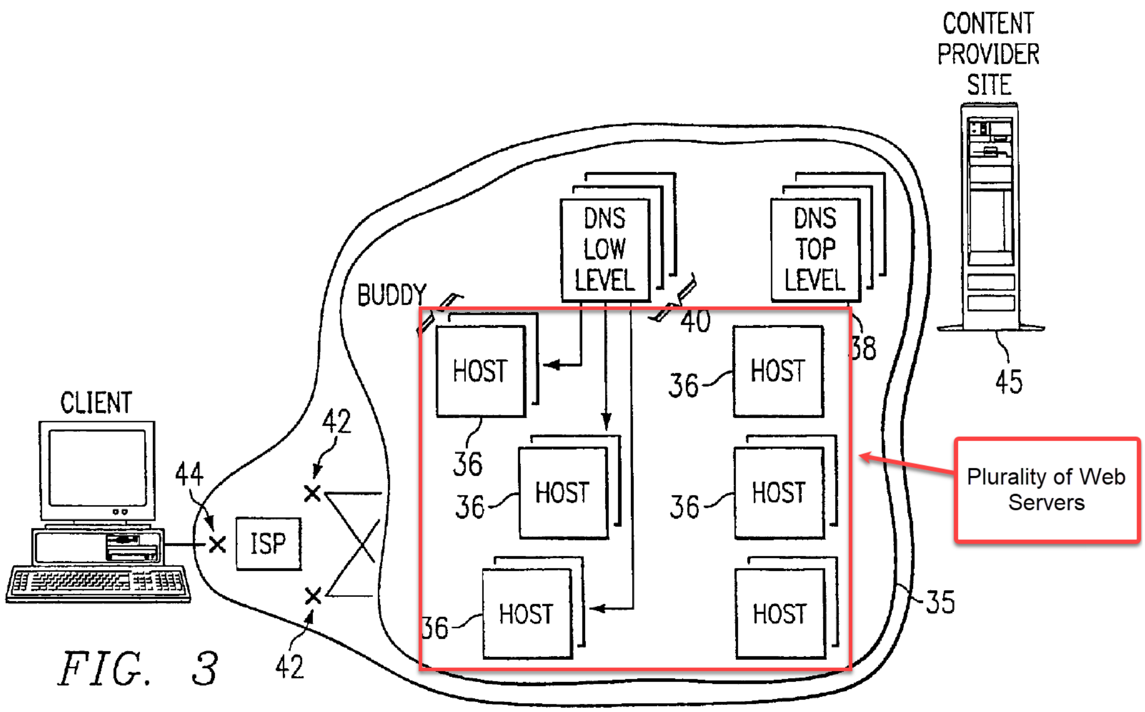
125. To the extent it is argued that Leaning only teaches a single web server containing the subfiles, Leighton's network architecture includes a plurality of web servers, which "supports hosting and content distribution on a truly global scale." Ex 1013, Abstract.

126. It would have been obvious to combine the network architecture in Leighton, which includes a plurality of web servers, with the streaming system of Leaning.

127. A POSITA would have been motivated to combine Leighton's teaching of a network architecture with multiple web servers at different locations on the internet, into the combination of Leaning's streaming system.

128. This is because, a POSITA would have been motivated to provide multiple web servers, as taught by Leighton, containing the same sets of subfiles for streams in order to have redundancy in the system and allow for better geographic distribution of the subfiles based on location of the terminals making requests.

129. As described below, Leighton expressly teaches storing multiple copies of the same content on several different web servers, which are each located at different addresses on the network:




130. EX1007, FIG. 3 (annotated). To improve the overall user streaming experience, a POSITA would have been motivated to create a multi-web server network architecture, as taught by Leighton, in a system for client-server streaming of content files, as taught by Leaning, in order to provide an improved download time and minimize delays perceived by the user at the client (*e.g.*, using several web servers at different locations on the network and requesting content from the web server closest to the user on the network).

131. A POSITA would have had a reasonable expectation of success with such a combination because (1) both Leaning and Leighton are drawn to similar systems of client-server communication of content via HTTP requests sent, via the

internet, to a web server, (2) doing so would have been a simple matter of storing the same files on multiple servers, and (3) because it would have been a known process (*e.g.*, storing copies of the same sub-files on multiple web servers, each at different locations) with predictable and known results (*e.g.*, more reliable, and efficient streaming service).

**b. 2[B]: "receive at least one streamlet request over one or more network connections from one or more end user stations to retrieve the first streamlet storing a portion of the digital content, 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 first bit rate stream, the second bit rate stream, and the third bit rate stream based upon a determination by the end user station to select a higher or lower bit rate copy of the streams;"**

132. In my opinion, Leaning discloses this limitation.

133. Leaning teaches that the conventional web servers are each configured to receive at least one streamlet (sub-file) request over one or more Internet connections from a respective one of the one or more end user stations (terminal) to retrieve the first streamlet (sub-file) storing a portion of the video. EX1004, Abstract ("Delivery of recorded audio or video material over a telecommunications link from a server [to a terminal] is accomplished by dividing the material **into a *sequence of sub-files each of which is independently requested by the terminal*,** which thereby has control of the rate of delivery. Provision may be made for switching between

alternative sub-file sets representing alternative delivery modes or data rates."), 1:28-19 ("According to one aspect of the invention there is provided a terminal for playing audio or video material which is stored on a remote server as a set of files representing successive temporal portions of the said material, the terminal comprising: a telecommunications interface for communication with the server; a buffer for receiving the files from the telecommunications interface; means for playing the contents of the buffer; and control means responsive to the state of the buffer to generate request messages for further files for replenishment of the buffer."), 2:23-26 ("The function of the server 1 is to store data files, to receive from a user terminal a request for delivery of a desired data file and, in response to such a request, to transmit the file to the user terminal via the network."), 4:27-5:10 ("The player program, having received the URL, adds to this the filename of the first sub-file, to produce a complete address for the sub-file - i.e. www.serverl.com/mp3_bwv565/000000.bin....The program constructs a request message for the file having this URL and transmits it to the server 1 via the communications interface 35 and the internet 2. . . We envisage that ***the player program would send the requests*** directly to the communications interface, rather than via the browser. The server responds by transmitting the required sub-file….***The player program increments the filename to 000001.bin and requests***, receives, decodes and stores this second sub-file as described in (4) and (5) above….This process is repeated until a 'file not found error' is returned.").

134. Leaning further teaches that the at least one streamlet (sub-file) request from the one or more end user stations (terminals) 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. *See* 1b; EX1004, Abstract, 5:28-6:32 (describing creating sub-file sets at different bitrates to be requested by a terminal), 6:50-7:34 ("Initially the player program will begin by requesting, from the directory specified in the link file, the index file, and stores locally a list of available data rates for future reference. . . . It then begins to request the audio sub-files as described earlier, from the first-mentioned 'rate' directory in the index file - viz. 024k_ll_s . . . The process from then on is that the player program measures the actual data rate being received from the server, averaged over a period of time (for example 30 seconds). It does this by timing every URL request; the transfer rate achieved (number of bits per second) between the client and server is determined….The actual rate change is effected simply by the player program changing the relevant part of the sub-file address for example, changing '008k' to '024k' to increase the data rate from 8 to 24 kbit/s, and changing the current rate parameter to match. As a result, the next request to the server becomes a request for the higher (or lower) rate, and the sub-

file from the new directory is received, decoded and entered into the buffer."), Claim 1 (17:12-30) ("A terminal for playing audio or video material which is stored on a remote server as a set of files representing successive temporal portions of the said material . . ."), Claim 9 (18:27-35) ("monitoring the received data rate at the second station; and in the event that the measured rate is below that needed for the set to which the currently requested field belongs, performing mode switching to provide that subsequent said request messages shall request files from a set corresponding to a lower data rate."), Claim 8 (18:10-26) ("storing a plurality of sets of files, which sets correspond to respective different delivery modes, and including, at the second station, effecting mode switching by providing that subsequent request messages shall request files from a set different from the set to which the immediately preceding request related."), Claim 10 (18:36-45) ("monitoring the received data rate at the second station; and in the event that the measured rate is sufficient to support delivery of files of a higher data rate than that of the set to which the currently requested file belongs, performing mode switching to provide that subsequent said request messages shall request files from a set corresponding to a higher data rate.").

#### c. 2[C] "retrieve from the at least one storage device the requested first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; and"

135. In my opinion, Leaning discloses this limitation.

136. Leaning discloses that the web server(s) retrieve from at least one storage device the requested first streamlet (subfile) from the currently selected one of the first, second, and third bitrate stream. *See* 2[B]; EX1004, 2:23- 26 ("The function of the server 1 is to ***store data files***, to receive from a user terminal a request for delivery of a desired data file and, ***in response to such a request, to transmit the file*** to the user terminal via the network.").

**d. 2[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."**

137. In my opinion, Leaning discloses this limitation.

138. Leaning discloses that the server sends the retrieved first streamlet (subfile) from the currently selected one of the different copies to the requesting one of the end user stations (terminals) over the one or more network (Internet) connections. *See* 2[B]-2[C]; EX1004, 2:23-26 ("The function of the server 1 is to store data files, to receive from a user terminal a request for delivery of a desired data file and, in response to such a request, to ***transmit the file to the user terminal via the network***.").

**3. Claim 3: "The system of claim 2, wherein the second streamlet of each of the groups of streamlets each has the same second duration and corresponds to the same second portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the second streamlet of the first bit rate stream having the same**

**bit rate as the first streamlet of the first bit rate stream."**

139. In my opinion, Leaning discloses this limitation.

140. Leaning discloses that the second streamlet (subfile, *e.g.*, 000001.bin) of each of the groups of streamlets (sets of subfiles encoded at different bitrates) has the same second duration (*e.g.*, 4 seconds) and encodes the same second portion of the digital content in the first, second, and third bit rate stream. *See* 1[E].

141. Further, Leaning discloses that the second streamlet (subfile; *e.g.*, 000001.bin) of the first bitrate stream has the same bitrate as the first streamlet (subfile; *e.g.*, 000000.bin) of the first bitrate stream because every subfile in each quality level has the same (continuous) bitrate. EX1004, 5:28-29 ("the server stores two or more versions of the recording, recorded at ***different compression rates*** (for example at compressions corresponding to (***continuous***) data rates of 8, 16, 24 and 32 kbit/s"), 5:43-48 ("encoding the same PCM file several times at different rates. He then partitions each source file into sub-files, as before. These can be loaded onto the server in separate directories corresponding to the different rate, as in the following example structure, where '008k', '024k' in the directory name indicates a rate of 8 kbit/s or 24 kbit/s and so on.").

**4. Claim 4: "The system of claim 3, wherein the first and second durations are different."**

142. In my opinion, Leaning discloses this limitation.

143. Leaning further discloses that, while it is preferred that all of the streamlets or subfiles are the same duration (*e.g.*, four seconds), Leaning also teaches that making each subfile (including the first and second subfiles) the same duration "is not the only way of achieving this" (EX1004, 10:1-4) and teaches that each subfile "can be a fixed number of bits, or a fixed playing time length (or neither of these)" (*id.*, 9:57-59). Thus, Leaning teaches that subfiles (such as subfile 1 and subfile 2) may be different durations at least in the case of "neither of [fixed size or fixed duration]" because the subfiles would not have a fixed time length and, for example, subfile 1 (000000.bin) may be a different time duration than subfile 2 (000001.bin.). EX1004, claim 22.

**5. Claim 5:**

**a. 5[A]: "The system of claim 1, further comprising: a first server configured to :"**

144. In my opinion, Leaning discloses this limitation. *See* 2[A].

**b. 5[B]: "receive at least one streamlet request over one or more network connections from the one or more end user stations to retrieve the first streamlet storing the first temporal portion of the digital content, 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 first bit rate stream, the second bit rate stream, and the third bit rate stream based upon a determination by the end user station to select a higher or lower bit rate copy of the digital content;"**

145. In my opinion, Leaning discloses this limitation. *See* 1[E] and 2[B]; .

**c. 5[C]: "retrieve from the at least one storage device the requested first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; and"**

146. In my opinion, Leaning discloses this limitation. *See* claim 2[C].

**d. 5[D]: "send the retrieved first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream to the requesting one of the end user stations over the one or more network connections."**

147. In my opinion, Leaning discloses this limitation. *See* claim 2[D].

**6. Claim 6: "The system of claim 5, wherein the digital content comprises a live event video of a live event, and the first streamlets of the first bit rate stream, the second bit rate stream, and the third bit rate stream are available before the live event is complete."**

148. In my opinion, Leaning discloses this limitation.

149. Leaning discloses that the digital content can be a live event video of a live event, and the first streamlets (first subfiles) of the first bit rate stream, the second bit rate stream, and the third bit rate stream are available before the live event is complete (encoded on the fly) and presented as live. EX1004, 6:46-47 ("'Mode' indicates 'recorded' (as here) or '***live***' (to be discussed below)."), 14:65-15:22 ("The files to be delivered have been referred to as 'recordings'. However, it is ***not necessary that the entire audio or video sequence should have been encoded***

***- or even exist - before delivery is commenced***. Thus a computer could be provided to receive a ***live feed***, to code it using the chosen coding scheme, ***and generate the sub-files 'on the fly' and upload them to the server, so that, once a few sub-files are present on the server, delivery may commence***….The same system can be used for a ***live audio (or video) feed***. It is in a sense still 'recorded' - the difference being primarily that ***delivery and replay commence before recording has finished***, although naturally there is an inherent delay in that one must wait until at least one sub-file has been recorded and loaded onto the server 1."); Section VIII.A.

**7. Claim 7: "The system of claim 6, wherein the streamlets from the first bit rate stream, the second bit rate stream, and the third bit rate stream of the live event, when played back, are presented in a live stream to a viewer."**

150. In my opinion, Leaning discloses this limitation. *See* claim 6.

151. As I mentioned above, Leaning discloses a live stream, or live feed. EX1004, 14:65-15:22 ("The files to be delivered have been referred to as 'recordings'. However, it is not necessary that the entire audio or video sequence should have been encoded—or even exist—before delivery is commenced. Thus a computer could be provided to receive a live feed, to code it using the chosen coding scheme, and generate the sub-files 'on the fly' and upload them to the server, so that, once a few sub-files are present on the server, delivery may commence....The same system can be used for a **live audio (or video) feed**. It is in a sense still 'recorded' –

the difference being primarily that delivery and replay commence before recording has finished, although naturally there is an inherent delay in that one must wait until at least one sub-file has been recorded and loaded onto the server 1.")

152. And Leaning further discloses methods for ensuring that "the playing operation [does not] run[] slightly faster or slower than the recording operation"—in other words, that the recording and playing feed are simultaneous, synchronous, live. *See id*. 16:64-17:10.

**8. Claim 8: "The system of claim 7, wherein the first server is further configured to: receive at least one virtual timeline request over the one or more network connections from the one or more end user stations to retrieve a virtual timeline; and send the virtual timeline to the requesting one of the end user stations over the one or more network connections."**

153. In my opinion, Leaning discloses this limitation.

154. Leaning discloses that the first web server is further configured to: receive at least one virtual timeline (menu of available recordings (menu.htm)) request over the one or more network (Internet) connections from the one or more end user stations (terminals) to retrieve a virtual timeline (menu.htm); and send the virtual timeline to the requesting one of the end user stations over the one or more network connections. EX1004, 3:38-41 ("It is also convenient that the web server stores one or more ***(html) menu pages (e.g. menu.htm)*** containing a ***list of recordings available, with hyperlinks to the corresponding link pages***."), 4:3-22

("1. The user uses the browser to ***retrieve and display the menu page menu.htm*** from the server 1. 2. The ***user selects one of the hyperlinks*** within the menu page which causes the browser to retrieve from the server, and display, the link page for the desired recording - in this example the file mp3_bwv565_link.htm. The actual display of this page is unimportant (except that it may perhaps contain a message to reassure the user that the system is working correctly). What is important about this page is that it contains a command (or 'embed tag') to invoke in the processor 30 a secondary process in which the player program 37 is executed. The invocation of a secondary process in this manner is well-known practice (such a process is known in Netscape systems as a 'plug-in' and in Microsoft systems as 'ActiveX'). Such commands can also contains [sic] parameters to be passed to the secondary process and in the system of Figure 1 the command contains the server URL of the recording, which, for the Bach piece, would be http:\\www. server 1.com/mp3_bwv565."), 7:40-8:65 (flowchart showing request and retrieval of virtual timeline including "[Terminal] Request http:\\server1.com/***menu.htm***…[Server] Send http:\\server1.com/***menu.htm***…[Terminal] Display ***menu.htm***"); *See* Section VII (proposed construction for "virtual timeline").

155. In my opinion, at the alleged time of invention, a POSITA would have understood, in light of the specification of the '798 Patent, that a "virtual timeline" may comprise a file (such as Leaning's "menu.htm") configured to present a playlist

to the end user that is sent by the server to a client device (*e.g.*, an end user station). *See* EX1001, 12:34-40 ("In one embodiment, the virtual timeline 600 comprises at least one quantum media extension 602. The quantum media extension (hereinafter 'QMX') 602 describes an entire content file 200. Therefore, the virtual timeline (hereinafter 'VT') 600 may comprise a file that is configured to define a playlist for a user to view.")

156. Additionally, Leaning teaches use of a second "virtual timeline," referred to as an "index file," that "provide[s] a list of the data rates that are available" and the sequentially-named files that correspond to each data rate. EX1004, 5:49-6:29. Leaning's index file, therefore, is also a "virtual timeline" because it is a content file that is configured to define a playlist for a user to view.

157. Leaning expressly discloses that the end user device's player program requests from the server "the index file, and stores locally a list of available data rates for future reference[,]" which allows it to "begin[] to request" sub-files encoded a particular data rate and play them out automatically and sequentially. EX1004, 6:30-58. Leaning further describes arranging the streamlets (sub-files) requested from the server using the virtual timeline (*e.g.*, the "menu.htm" and/or "index file") because Leaning describes arranging the sub-files for playback in sequential order. See EX1001, Abstract ("Delivery of recorded audio or video material over a telecommunications link from a server is accomplished by dividing the material into

***a sequence of sub-files*** each of which is independently requested by the terminal, which thereby has control of the rate of delivery."), 5:14-16 ("The sub-file naming convention used here, of a simple fixed length ***sequence of numbers*** starting with zero, is preferred as it is simple to implement").

### 9. Claim 9: "The system of claim 1, further comprising: an encoding module configured to receive the digital content and encode the streamlets of the first bit rate."

158. In my opinion, Leaning discloses this limitation.

159. Leaning discloses an encoding module configured to receive the digital content and encode the streamlets of the first bit rate. EX1004, 5:41-44 ("the person preparing the file for loading onto the server prepares several source files - by ***encoding the same PCM file several times at different rates***."), 11:42-43 ("easily solved by ***encoding each sub-file separately***, as if it were a single recording").

### 10. Claim 11:

#### a. 11[Pre]: "An end user station comprising:"

160. Regardless of whether the preamble is limiting, in my opinion, Leaning discloses this limitation.

161. Leaning discloses an end user station (terminal 3). *See* 1[Pre].

#### b. 11[A]: "a processor;"

162. In my opinion, Leaning discloses this limitation.

163. Leaning discloses a processor at terminals 3. EX1004 3:47-51 ("Thus Figure 2 shows such a terminal with ***a central processor 30***, memory 31, a disk store 32, a keyboard 33, video display 34, communications interface 35, and audio interface ('sound card') 36. For video delivery, a video card would be fitted in place of, or in addition to, the card 36."), FIG. 2 (showing CPU 30 on user terminals).

#### c. 11[B]: "a digital processing apparatus memory device comprising non-transitory machine-readable instructions that, when executed, cause the processor to:"

164. In my opinion, Leaning discloses this limitation.

165. Leaning discloses a digital processing apparatus memory device (memory 31) comprising non-transitory machine-readable instructions (software for player program and browser) that, when executed, causes the processor to perform functions, such as receiving video presentation information. EX1004, 3:47-60 ("Thus Figure 2 shows such a terminal with a ***central processor 30***, ***memory 31***, . . . In the disk store are programs which may be retrieved into the memory 31 for ***execution by the processor 30, in the usual manner***. These programs include a communications program 37 for call-up and display of html pages - that is, a 'web browser' program such as Netscape Navigator or Microsoft Explorer, and a further program 38 which will be referred to here as 'the player program' which provides

the functionality necessary for the playing of audio files in accordance with this embodiment of the invention."), FIG. 2 (showing CPU 30 on user terminals).

**d. 11[C][1]: "establish one or more network connections between the end user station and at least one server,"**

166. In my opinion, Leaning discloses this limitation.

167. Leaning discloses establishing one or more network (Internet) connections between the end user station (terminal 3) and the server (server 1). EX1004, 2:21-22 ("server 1 is connected via the internet 2 to user terminals 3"), 3:47-49 ("Thus Figure 2 shows such a terminal with a central processor 30, memory 31, a disk store 32, a keyboard 33, video display 34, ***communications interface 35***), FIGs. 1-2.

**e. 11[C][2]: "wherein the at least one server is configured to access at least one of a plurality of groups of streamlets of digital content;"**

168. In my opinion, Leaning discloses this limitation.

169. Leaning discloses that the server is configured to access at least one of a plurality of groups (sets) of streamlets (subfiles) of the digital content. *See* 1[B]-1[C]; EX1004, 6:13-26 ("the server stores two or more versions of the recording, recorded at different compression rates (for example at compressions corresponding to (continuous) data rates of 8, 16, 24 and 32 kbit/s respectively) . . . In order to provide for rate switching, the person preparing the file for loading onto the server

prepares several source files - by ***encoding the same PCM file several times at different rates. He then partitions each source file into sub-files, as before***. These can be ***loaded onto the server in separate directories*** corresponding to the different rate, as in the following example structure, where '008k', '024k' in the directory name indicates a rate of 8 kbit/s or 24 kbit/s and so on.").

**f. 11[C][3]: "wherein the digital content is encoded at a plurality of different bit rates to create a plurality of streams including at least a first bit rate stream, a second bit rate stream, and a third bit rate stream,"**

170. In my opinion, Leaning discloses this limitation. *See* 1[B].

**g. 11[C][4]: "wherein each of the first bit rate stream, the second bit rate stream, and the third bit rate stream comprises a group of streamlets encoded at the same respective one of the different bit rates, each group comprising at least first and second streamlets, each of the streamlets corresponding to a portion of the digital content;"**

171. In my opinion, Leaning discloses this limitation. *See* 1[C].

**h. 11[C][5]: "wherein at least one of the first bit rate stream, the second bit rate stream, and the third bit rate stream is encoded at a bit rate of no less than 600 kbps; and"**

172. In my opinion, Leaning discloses this limitation. *See* 1[D].

**i. 11[C][6]: "wherein the first streamlets of each of the first bit rate stream, the second bit rate stream and the third bit rate stream each has an equal playback duration and each of the first streamlets encodes the same portion of the digital content at a different one of**

**the different bit rates;"**

173. In my opinion, Leaning discloses this limitation. *See* 1[E].

**j. 11[D]: "determine whether to select a higher or lower bit rate copy of the stream and based on that determination, select a specific one of the first bit rate stream, the second bit rate stream, and the third bit rate stream;"**

174. In my opinion, Leaning discloses this limitation.

175. Leaning further discloses determining whether to select a higher or lower bit rate copy of the stream and based on that determination, selecting a specific one of the first bit rate stream, the second bit rate stream, and the third bit rate stream. *See* 2[B]; EX1004, Abstract, 5:28-5:51 (describing creating subfile sets at different bitrates for a requesting terminal), 6:50-7:34 ("Initially the player program will begin by requesting, from the directory specified in the link file, the index file, and stores locally a list of available data rates for future reference….It then begins to request the audio sub-files as described earlier, from the first- mentioned 'rate' directory in the index file - viz. 024k_ll_s . . . The process from then on is that the ***player program measures the actual data rate being received from the server, averaged over a period of time (for example 30 seconds)***. It does this by timing every URL request; the transfer rate achieved (number of bits per second) between the client and server is ***determined***. The actual rate change is effected simply by the player program changing the relevant part of the sub-file address for example, changing '008k' to

'024k' to increase the data rate from 8 to 24 kbit/s, and changing the current rate parameter to match. As a result, ***the next request to the server becomes a request for the higher (or lower) rate***, and the sub-file from the new directory is received, decoded and entered into the buffer."), Claims 8 (18:23-26) ("effecting mode switching by providing that subsequent request messages shall request files from a set different from the set to which the immediately preceding request related"), 9 (18:31-35) ("in the event that the measured rate is below that needed for the set to which the currently requested field belongs, performing mode switching to provide that subsequent said request messages shall request files from a set corresponding to a lower data rate"), and 10 (18:40-45) ("in the event that the measured rate is sufficient to support delivery of files of a higher data rate than that of the set to which the currently requested file belongs, performing mode switching to provide that subsequent said request messages shall request files from a set corresponding to a higher data rate").

#### k. 11[E]: "place a first streamlet request to the at least one server over the one or more network connections for the first streamlet of the selected stream;"

176. In my opinion, Leaning discloses this limitation.

177. Leaning discloses placing a first streamlet (subfile) request to the server over the one or more network (Internet) connections for the first streamlet of the selected stream. *See* 2[B], 11[D]; EX1004, 4:28-5:10 ("The player program, having

received the URL, adds to this the filename of the first sub-file, to produce a complete address for the sub-file - i.e. www.serverl.com/mp3_bwv565/000000.bin. The program ***constructs a request message for the file having this URL and transmits it to the server 1*** via the communications interface 35 and the internet 2…We envisage that the ***player program would send the requests*** directly to the communications interface, rather than via the browser. The server responds by transmitting the required sub-file. . . . The player program increments the filename to 000001.bin and requests, receives, decodes and stores this second sub-file as described in (4) and (5) above. This process is repeated until a 'file not found error' is returned.").

**l. 11[F]: "receive the requested first streamlet from the at least one server via the one or more network connections; and provide the received first streamlet for output of the digital content to a presentation device."**

178. In my opinion, Leaning discloses this limitation.

179. Leaning discloses receiving the requested first streamlet from the server via the one or more network (Internet) connections and providing the received first streamlet for playback of the video to a presentation device. EX1004, 1:50-51 ("receiving the files; and decoding the files for replay of the material"), Claim 1.

**11. Claim 12:**

**a. 12[A]: "The end user station of claim 11, wherein the**

**non- transitory machine-readable instructions further comprise instructions that cause the processor to:"**

180. In my opinion, Leaning discloses this limitation. *See* 11[Pre], 11[B].

**b. 12[B]: "place a second streamlet request to the at least one server over the one or more network connections for the second streamlet of the selected stream;"**

181. In my opinion, Leaning discloses this limitation.

182. Leaning discloses placing a second streamlet (subfile) request to the at least one server over the one or more network connections for the second streamlet of the selected stream. *See* 11[E]; EX1004, 4:57-59 ("The player program increments the filename to 000001.bin and requests, receives, decodes and stores this second sub-file as described in (4) and (5) above.").

**c. 12[C]: "receive the requested second streamlet from the at least one server via the one or more network connections; and"**

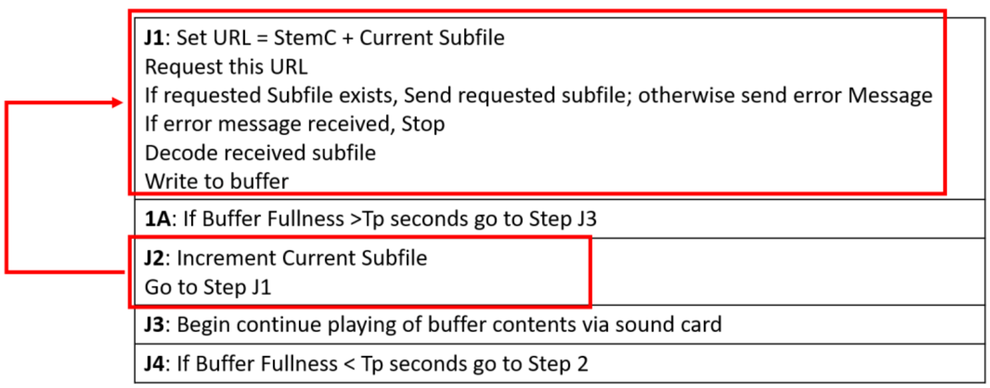
183. In my opinion, Leaning discloses this limitation.

184. Leaning discloses receiving the requested second streamlet from the at least one server via the one or more network connections. *See* 11[F]; EX1004, 4:57-59 ("The player program increments the filename to 000001.bin and requests, receives, decodes and stores this second sub-file as described in (4) and (5) above.").

**d. 12[D]: "arrange the first streamlet and second streamlet in order of ascending presentation time for output of the digital content to the presentation device."**

185. In my opinion, Leaning discloses this limitation.

186. Leaning discloses arranging the first streamlet and second streamlet in order of ascending presentation time for output of the digital content to the presentation device. EX1004, 4:57-59 ("The player program increments the filename to 000001.bin and requests, receives, decodes and stores this second sub-file as described in (4) and (5) above.").



| |
|---|
| **J1**: Set URL = StemC + Current Subfile<br>Request this URL<br>If requested Subfile exists, Send requested subfile; otherwise send error Message<br>If error message received, Stop<br>Decode received subfile<br>Write to buffer |
| **1A**: If Buffer Fullness >Tp seconds go to Step J3 |
| **J2**: Increment Current Subfile<br>Go to Step J1 |
| **J3**: Begin continue playing of buffer contents via sound card |
| **J4**: If Buffer Fullness < Tp seconds go to Step 2 |

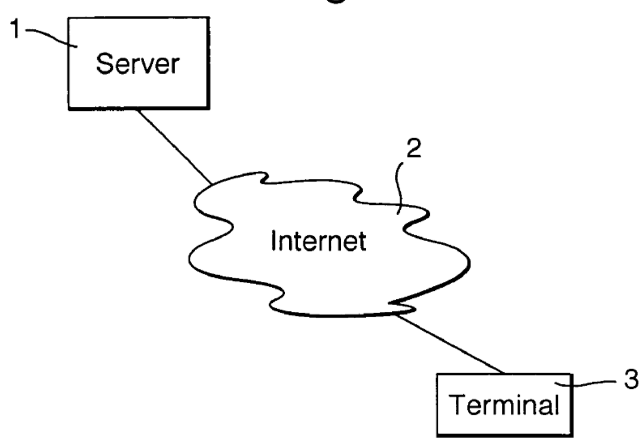
EX1004, 8:15-8:32 (formatted excerpt of flowchart, annotated to show incrementing subfile, requesting, writing the received subfile to buffer, and repeating until end—thus arranging first, second, and further subfiles according to ascending presentation time).

### 12. Claim 13: "The end user station of claim 11, wherein at least some streamlets are requested from the at least one server via a hypertext transfer protocol (HTTP) GET request."

187. In my opinion, Leaning discloses this limitation.

188. Leaning teaches that the client requests may be made by transmitting HTTP GET requests. Leaning discloses that its server 1, as represented in the below Fig. 1, "receive[s] from a user terminal a request for delivery of a desired data file and, in response to such a request, to transmit the file to the user terminal via the network" and "the network is the internet or other packet network operating in accordance with the Hypertext Transfer Protocol" (HTTP). EX1004, 2:11-13, 2:23-27.

Fig.1.




189. Leaning also discloses that the player program requests subfiles from the conventional web server using "the Hypertext Transfer Protocol" and cites to RCFs for HTTP 1.0 and HTTP 1.1 protocols. EX1004, 2:5-35. Leaning also provides a request example of "http://www.server1.com/mp3_bwv565/000003.bin

where 'www.serverl.com' is the URL of the server 1" which requests file "000003.bin" stored on server 1 by its URL. EX1004, 3:28-31.

190. A POSITA would have known that the only way to request and receive the "000003.bin" file using HTTP in the example provided was by a request-URI (*i.e.*, "http://www.server1.com/mp3_bwv565/000003.bin" URL) to the server via an "HTTP GET" request. Thus, a POSITA considering the disclosures of Leaning (*i.e.*, operating via HTTP between a client and an ordinary web server to request and receive files) would have understood that HTTP required ordinary web servers to support HTTP GET requests and thus would have understood Leaning's disclosure of a terminal using HTTP to request subfiles from a server to include teaching the use of HTTP GET requests. EX1011, 5.11 ("The methods GET and HEAD MUST be supported by all general-purpose servers").

191. A POSITA would also have known that HTTP requests made via providing a URL for items on a server are commonly made by a client transmitting "HTTP GET" requests. *See* EX1011, 9.3 (HTTP 1.1 protocol describing "GET" as the means by which to "retrieve whatever information (in the form of an entity) is identified by the Request-URI"). In fact, the '798 Patent itself admits that HTTP GET requests were "standard." EX1001, 14:14-15. A Request-URI stands for Request-Uniform Resource Identifier and "Uniform Resource Identifiers are simply formatted strings which identify—via name, location, or any other characteristic—a

resource" (EX1011, 3.2) such that an HTTP GET request is "used to identify a resource on an origin server or gateway" (EX1011, 5.1.2). Thus, in my opinion, a POSITA would have understood the above teachings from Leaning to teach that the player program makes HTTP GET requests for each sequential subfile.

192. Further, to the extent it is deemed necessary, it is my opinion that a POSITA would have been motivated to modify Leaning to make its requests for subfiles from servers via standard HTTP GET requests because GET requests are identified in the HTTP protocol (EX1011, 9.3), and thus the only solution for requesting files from a server with a reasonable expectation of success. There also would have been a reasonable expectation of success because HTTP was a universally known and used protocol and GET requests are a standard method within that protocol for requesting files from a server.

**13. Claim 14: "The end user station of claim 11, wherein the at least one server comprises at least two servers and wherein at least one streamlet is requested from a first server of the at least one server and at least one other streamlet is requested from a second server of the at least one server other than the first server."**

193. It is my opinion that Leaning in view of Leighton renders obvious this limitation.

194. As I explained above regarding claim 2[A], to the extent Leaning does not disclose more than one web server, a POSITA would have been motivated to

modify Leaning in view of Leighton to provide two or more servers, each of which having the same sets of requestable subfiles, in order to have redundancy in the system and allow for better geographic distribution of the subfiles based on location of the terminals making requests. *See* 2[A].

195. Therefore, Leaning, as modified by Leighton above, teaches at least one streamlet (subfile) may be requested from a first server of the at least one server and at least one other streamlet (subfile) may be requested from a second server of the at least one server other than the first server because each server has the same set of requestable subfiles.

196. Further, a POSITA would have understood that in certain instances after a client has requested a streamlet from a first server, the network connection between the first server and the client may be congested, or the first server may fail or otherwise become unavailable, such that the next streamlet would be requested from the second server.

197. And as I explained above regarding claim 2[A], a POSITA would have had a reasonable expectation of success with such a combination because (1) both Leaning and Leighton are drawn to similar systems of client-server communication of content via HTTP requests sent, via the internet, to a web server, (2) doing so would have been a simple matter of storing the same files on multiple servers, and (3) because it would have been a known process (*e.g.*, storing copies of the same

sub-files on multiple web servers, each at different locations) with predictable and known results (*e.g.*, more reliable, and efficient streaming service).

### 14. Claim 15: "The end user station of claim 11, wherein each of the streamlets is requestable by the processor without regard to whether the processor has previously requested other streamlets of the digital content."

198. In my opinion, Leaning discloses this limitation.

199. Leaning discloses the ability to view digital content as a live event, where an end user may begin watching after the live event starts and thus begin requesting subfiles that are not the initial subfiles of the video presentation without first or ever requesting those initial subfiles. EX1004, 6:46-47 ("'Mode' indicates 'recorded' (as here) or '***live***' (to be discussed below)."), 14:65-15:22 ("The files to be delivered have been referred to as 'recordings'. However, it is ***not necessary that the entire audio or video sequence should have been encoded - or even exist - before delivery is commenced***. Thus a computer could be provided to receive a ***live feed***, to code it using the chosen coding scheme, and generate the sub-files 'on the fly' and upload them to the server, so that, once a few sub-files are present on the server, delivery may commence…The same system can be used for a ***live audio (or video) feed***. It is in a sense still 'recorded' - ***the difference being primarily that delivery and replay commence before recording has finished***, although naturally there is an inherent delay in that one must wait until at least one sub-file has been

recorded and loaded onto the server 1."). Because Leaning discloses this ability is necessarily present within the context of watching a live-stream, a POSITA would have understood that each streamlet is requestable without regard to whether the processor has previously requested other streamlets.

**15. Claim 16: "The end user station of claim 11, wherein at least a plurality of streamlets are separate files stored by the at least one server."**

200. In my opinion, Leaning discloses this limitation.

201. Leaning discloses wherein at least a plurality of streamlets (subfiles) are separate files stored by the at least one server. *See* 1[A]; EX1004, 3:15-19 ("The expression 'sub-files' is used here to distinguish them from the original file containing the whole recording: it should however be emphasised [sic] that, as far as the server is concerned, ***each 'sub-file' is just a file like any other file***.").

**16. Claim 17:**

**a. 17[A]: "The end user station of claim 11, wherein the non- transitory machine-readable instructions further comprise instructions that cause the processor to:"**

202. In my opinion, Leaning discloses this limitation. *See* 11[B] and 12[A].

**b. 17[B]: "place a second streamlet request to the at least one server over the one or more network connections for a second streamlet of a different bit rate stream, wherein the different bit rate stream comprises a different stream than the selected stream;"**

203. In my opinion, Leaning discloses this limitation.

204. Leaning discloses placing a second streamlet (subfile) request to the at least one server over the one or more network connections for a second streamlet (subfile) of a different bit rate, wherein the different bit rate stream comprises a different stream than the selected stream. *See* 11[E] and 12[B]; EX1004, 14:43-57 ("Exactly the same process could be used ***for rate-switching***.... The request series would then look like: mpg_name/***096k_xl/000099.****bin*.mpg_ name/096/***128_xl/000100.bin.***mpg_ name/128k_xl/000101.bin").

**c. 17[C]: "receive the requested second streamlet from the at least one server via the one or more network connections;"**

205. In my opinion, Leaning discloses this limitation. *See* 11[F] and 12[C].

**d. 17[D]: "arrange the first streamlet and second streamlet in order of ascending presentation time for output of the digital content to the presentation device."**

206. In my opinion, Leaning discloses this limitation. *See* 12[D].

**17. Claim 18:**

**a. 18[A]: "The end user station of claim 16, wherein the non- transitory machine-readable instructions further comprise instructions that cause the processor to:"**

207. In my opinion, Leaning discloses this limitation. *See* 11[B] and 12[A].

**b. 18[B]: "determine an anticipated inability to receive the digital content at the second bit rate of the second bit rate stream at a rate sufficient for presenting the digital content as the digital content is received, and in**

> **response to the determining the anticipated inability, requesting a third streamlet of the first bit rate stream, the third streamlet immediately subsequently adjacent to the second streamlet of the digital content during presentation."**

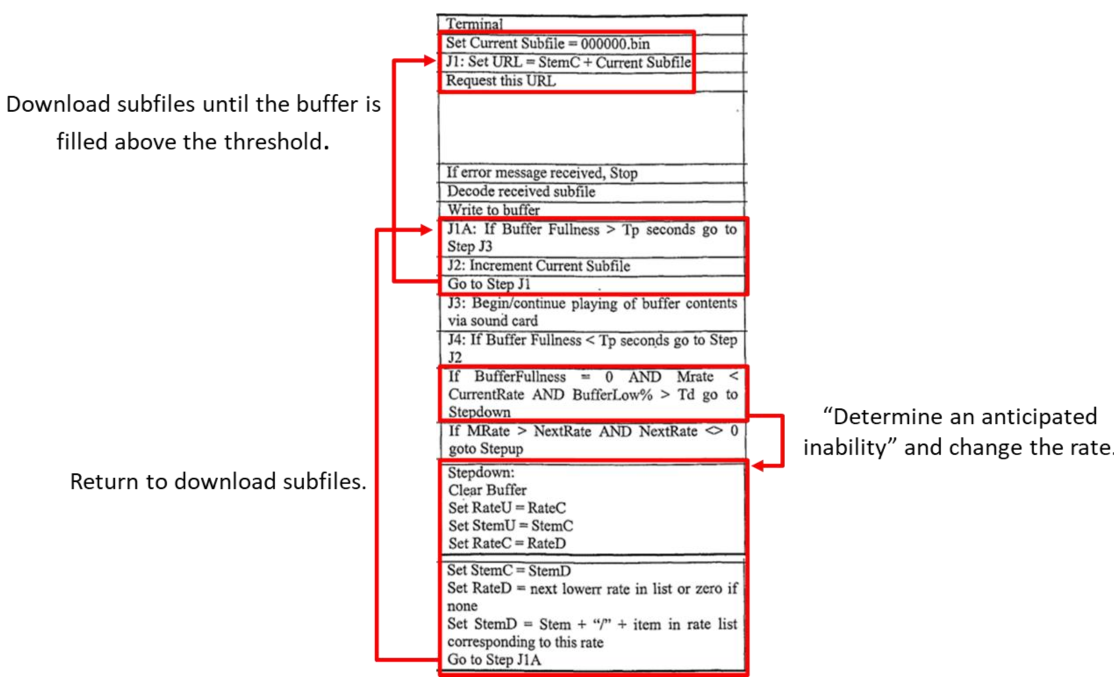
208. In my opinion, Leaning discloses this limitation.

209. Leaning discloses determining an anticipated inability to receive the digital content at the second bit rate of the second bit rate stream at a rate sufficient for presenting the digital content as the digital content is received, and in response to the determining the anticipated inability, requesting a third streamlet (subfile) of the first bit rate stream, the third streamlet immediately subsequently adjacent to the second streamlet of the digital content during presentation.

210. For example, Leaning discloses selecting a third streamlet (subfile) of the next immediately adjacent subfile upon switching to a lower (or first) bitrate due to a determination to "stepdown." *See* 11[D]; EX1004, 6:50-7:34 ("Initially the player program will begin by requesting, from the directory specified in the link file, the index file, and stores locally a list of available data rates for future reference….***player program measures the actual data rate*** being received from the server….***the next request*** to the server becomes a request for the higher (or ***lower***) rate, and the ***sub-file from the new directory is received***, decoded and entered into the buffer."); 9:65-10:1 ("highly desirable that the sub- file boundaries are the same for each rate, so that the ***first sub-file received for a new rate continues from the***

***same point in the recording that the last sub-file at the old rate ended***.”), 11:61-12:2 (“Recollecting that the criteria discussed earlier for automatic data rate switching downwards envisaged a rate reduction only in cases of buffer underflow (involving therefore interruptions in the output), we note that with this modification ***such interruption can be avoided and therefore it is preferable to employ a criterion which anticipates underflow*** and avoids it in the majority of cases. In this case ***the first of the three AND conditions mentioned above (namely, that the buffer is empty) would be omitted***.”).

211. The below flowchart (excerpt of flowchart reformatted for clarity, and annotated) shows an iterating subfile and stepping down rate for the next request. EX1004, 10-11.



212. The process begins at J1 where the terminal starts with subfile 000000.bin, and executes information (StemC which reflects the file directory name) to request its URL.

213. The process then moves to step J1A, which checks the file's buffer fullness. If the buffer fullness is less than the threshold, execute J2 where the process increments the current subfile to the next subfile (e.g., 000001.bin), and then back to J1 to repeat this process anew.

214. However, if the buffer fullness is greater than the threshold, execute J3 where the process plays the contents, before executing J4 to check the buffer fullness again. If the file passes the check, return to J2 to increment the current subfile to the next subfile and then back to J1 to repeat this process anew.

215. To reiterate, the above flowchart is just one example embodiment from Leaning among numerous possibilities which satisfies claim 18[A]. Even if this one example is not deemed to disclose claim 18[A], the above cited language from Leaning discloses this limitation.

### 18. Claim 19: "The end user station of claim 18, wherein the second streamlet of each of the groups of streamlets each has the same second duration and corresponds to the same second portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the second streamlet of the first bit rate stream having the same bit rate as the first streamlet of the first bit rate stream."

216. In my opinion, Leaning discloses this limitation. *See* claim 3.

### 19. Claim 20: "The end user station of claim 12, wherein the streamlets of the first bit rate stream, the second bit rate stream, and the third bit rate stream of the live event are available on a ten second delay."

217. In my opinion, Leaning discloses this limitation.

218. Leaning discloses that the subfiles of each bitrate stream of the live event are available on a ten second delay. *See* claim 15; EX1004, ("The same system can be used for a ***live*** audio (or video) feed. It is in a sense still 'recorded' - the difference being primarily that delivery and replay commence before recording has finished, although naturally ***there is an inherent delay*** in that one must wait until at least one sub-file has been recorded and loaded onto the server 1.").

219. Leaning discloses that the sub-files of each bitrate stream of the live event are available on a ten second delay. *See* EX1004, 3:60-63 ("Also shown is a region 39 of the memory 31 which is allocated as a buffer. This is a decoded audio buffer containing data waiting to be played (typically the playout time of the buffer might be 10 seconds"), 15:17-22 ("The same system can be used for a live audio (or video) feed. It is in a sense still 'recorded' –the difference being primarily that delivery and replay commence before recording has finished, ***although naturally there is an inherent delay*** in that one must wait until at least one sub-file has been recorded and loaded onto the server 1.") (emphasis added). It is my opinion that, at

the alleged time of invention, a POSITA would have had a reasonable expectation that the range of such an inherent delay includes a ten second delay—which is enough time to generate and load onto the server at least two sub-files.

220. It is also my opinion that a POSITA would have readily understood the length of the inherent delay disclosed in Leaning is determined by the particular hardware and software used to capture, encode, store, request, transmit, receive, and display each sub-file of a live event video that is streamed in near real time (*e.g.*, "on the fly"). For example, the '798 patent acknowledges that a 10 second delay is exemplary, and that use of a robust encoding module could results in no perceptible delay at all. *See* EX1001, 11:2-3 ("The encoding module 406 may take 10 seconds, for example, to generate the first set 306a of streamlets"); 11:20-25 ("The 10 second delay is given herein by way of example only. Multiple hosts 504 may be added to the encoding module 406 in order to increase the processing capacity of the encoding module 406. ***The delay may be shortened to an almost unperceivable level by the addition of high CPU powered systems, or alternatively multiple low powered systems***.") (emphasis added).

221. Thus, the '798 patent concedes that the claimed 10 second delay would only result from using a prior art encoding scheme. Indeed, the '798 patent, like Leaning, also does not purport to invent a new encoding scheme. Rather, it says "the content file 200 may be compressed using standard or proprietary encoding

schemes," and provides a list of prior art encoding schemes that are "capable of use with the present invention." Ex. 1001, 7:22-24.

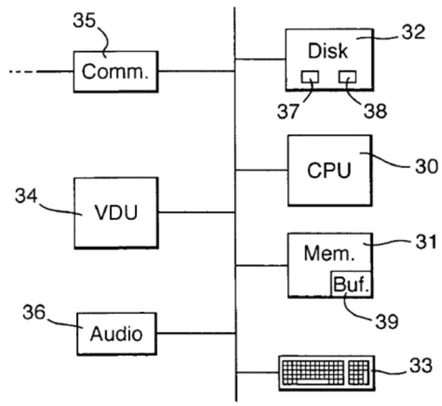
222. Accordingly, to the extent it is argued that Leaning's "inherent delay" does not include a ten second delay, it would have been obvious to a POSITA that the use of certain prior art encoding schemes would result in a ten second delay to provide enough time to generate and load onto the server one or more sub-files, for each set of sub-files, to ensure playback of live feeds. *Id.*

### 20. Claim 21: "The end user station of claim 12, wherein the processor providing the first received streamlet for playback comprises outputting the first streamlet to a presentation device connected to the end user station."

223. In my opinion, Leaning discloses this limitation.

224. Leaning discloses wherein the processor providing the first received streamlet for playback comprises outputting the first streamlet to a presentation device (video display 34) as a component of the end user station (terminal). EX1004, 3:47-49, FIG. 2.

Fig.2.




**21. Claim 22:**

**a. 22[Pre]: "A process executable by one or more servers to stream digital content for playback by one or more end user stations, the process comprising:"**

225. In my opinion, Leaning discloses this limitation. *See* 1[Pre].

**b. 22[A]: "storing, by the one or more servers, a plurality of streams including a first bit rate stream, a second bit rate stream, and a third bit rate stream,"**

226. In my opinion, Leaning discloses this limitation. *See* 1[A]-1[B].

**c. 22[B]: "wherein the first bit rate stream, the second bit rate stream, and the third bit rate stream each comprise a group of streamlets encoded at a respective one of a plurality of different bit rates, each group comprising at least first and second streamlets, each of the streamlets corresponding to a portion of the digital content;"**

227. In my opinion, Leaning discloses this limitation. *See* 1[C].

**d. 22[C]: "wherein at least one of the first bit rate stream, the second bit rate stream, and the third bit rate stream**

**is encoded at a bit rate of no less than 600 kbps; and"**

228. In my opinion, Leaning discloses this limitation. *See* 1[D].

**e. 22[D]: "wherein the first streamlet of each of the groups of streamlets has the same first duration and encodes the same first temporal portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the first streamlet of the first bit rate stream having a different one of the different bit rates than the first streamlet of the second bit rate stream and the first streamlet of the third bit rate stream;"**

229. In my opinion, Leaning discloses this limitation. *See* 1[E].

**f. 22[E]: "receiving at least one streamlet request over one or more network connections from the one or more end user stations to retrieve the first streamlet storing the first temporal portion of the digital content,"**

230. In my opinion, Leaning discloses this limitation. *See* 1[E]; 2[B].

**g. 22[F]: "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 first bit rate stream, the second bit rate stream, and the third bit rate stream based upon a determination by the end user station to select a higher or lower bit rate copy of the digital content;"**

231. In my opinion, Leaning discloses this limitation. *See* 2[B].

**h. 22[G]: "retrieving from the storage device the requested first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream; and"**

232. In my opinion, Leaning discloses this limitation. *See* 2[C].

**i. 22[H]: "sending the retrieved first streamlet from the currently selected one of the first bit rate stream, the second bit rate stream, and the third bit rate stream to the requesting one of the end user stations over the one or more network connections."**

233. In my opinion, Leaning discloses this limitation. *See* 2[D].

**22. Claim 23: "The method of claim 22, wherein a second streamlet of each of the groups of streamlets each has a same second duration and corresponds to a same second temporal portion of the digital content in the first bit rate stream, the second bit rate stream, and the third bit rate stream, the second streamlet of the first bit rate stream having the same bit rate as the first streamlet of the first bit rate stream."**

234. In my opinion, Leaning discloses this limitation. *See* 19.

**23. Claim 24: "The method of claim 23, wherein the first and second durations are different."**

235. In my opinion, Leaning discloses this limitation. *See* 4.

**24. Claim 25: "The method of claim 22, wherein the digital content is a live event, and wherein the first streamlets of the first bit rate stream, the second bit rate stream, and the third bit rate stream are available before the live event is complete."**

236. In my opinion, Leaning discloses this limitation. *See* 6.

**B. <u>Ground 2</u>: Claims 1-9 and 11-25 Are Obvious in View of Leaning, Leighton, and Reme**

237. The sections of Ground 1 (Section VII.A) are incorporated into this section by reference.

**1. Claim 1[D]**

238. To the extent that claim 1[D] is not disclosed by Leaning—it is, as I explained in Ground 1, *supra*—this claim is obvious over the combination of Leaning in view of Reme.

239. As I explained in Ground 1, Leaning teaches two or more streams encoded at different bitrates including one example with four streams encoded at 8, 16, 24, and 32 kbit/s, respectively. *See* 1[Pre]-1[C]. Leaning's example bitrates of 8, 16, 24, and 32 kbit/s, respectively are for audio encodings—which a POSITA would have understood generally have lower data requirements than video encodings and thus typically can be streamed using lower bitrates.

240. Leaning also teaches that the same principles may be applied to video encodings and a POSITA would have understood that a user streaming video encodings at the time of the alleged priority date would generally prefer higher bitrate encoding if supported by the user's network requirements to enjoy high quality viewing. EX1004, 13:42-14:64. (describing a video file ("mpg_name") that is encoded at 96 kbps and at 128 kbps and partitioned into two corresponding sets of subfiles (stored in directories "mpg_name/096k_x1/" and "mpg_name/0128k_x1/", respectively)).

241. To the extent Leaning does not explicitly teach a stream encoded at a bitrate of no less than 600 kbps, Reme teaches this limitation. Reme teaches that it was known to encode video content into at least three different quality levels (or

bitrates) for streaming, for example at 30 kbps, at 300 kbps, and at 5Mbps, in order to allow streaming to various clients with different network conditions. For example, Reme proposes "a plurality of pre-encoded versions of the [video] content, each version corresponding to a different encoding rate (and hence to a different quality)." EX1005, 3:15-17. Indeed, Reme explains that "Internet streaming applications should be quality adaptive" and that "streaming applications should adjust the quality of the delivered stream such that the bandwidth required for transmitting the stream ***matches*** the available bandwidth." EX1005, 3:11-14. To achieve this, Reme proposes that streaming clients "switch among [the] plurality of pre-encoded versions of the content" each with a different encoding rate (***bit rate***) or quality level." EX1005, 3:15-17.

| | | | |
|---|---|---|---|
| | Version $V_{i,1}$ (encoding rate 30kbps) | Version $V_{i,2}$ (encoding rate 300kbps) | Version $V_{i,3}$ (encoding rate 5Mbps) |

EX1004, 5:1-4 (annotated).

242. A POSITA would have been motivated to encode a video embodiment of Leaning (including the corresponding sets of subfiles) into each of a low quality, medium quality, and high quality level bitrate stream (low at 30 kbps, medium at 300 kbps, and high at 5 Mbps), as taught by Reme, because it would enable client

terminals with a wide variety of network bandwidth requirements to stream the video and would have allowed for those with user terminals with high bandwidth connections to stream at 5 Mbps and enjoy higher resolution viewing. A POSITA would have had a reasonable expectation of success with such a combination because both Leaning and Reme are drawn to similar systems of client-server based streaming of video encoded into multiple different bitrate copies and because simply encoding one of the video streams at a particular bitrate, such as the 5 Mbps taught by Reme, would have been a simple and straightforward modification for a POSITA.

### C. <u>Ground 3</u>: Claims 1-9 and 11-25 Are Obvious in view of Leaning, Leighton, and SMIL 2.0

243. The sections of Ground 1 (Section VII.A) are incorporated into this section by reference.

#### 1. Claim 8: The system of claim 7, wherein the first server is further configured to: receive at least one virtual timeline request over the one or more network connections from the one or more end user stations to retrieve a virtual timeline; and send the virtual timeline to the requesting one of the end user stations over the one or more network connections

244. To the extent that claim 8 is not disclosed by Leaning—it is, as I explained in Ground 1, *supra*—this claim is obvious over the combination of Leaning in view of Reme.

245. As I explained in Ground 1, Leaning teaches the limitation of claim 8. However, to the extent it is determined that Leaning does not teach a "virtual

timeline" in the form of "a playlist of entire content files" wherein each content file is played automatically one after the other, SMIL 2.0 teaches such limitations.

246. SMIL 2.0 contains several teachings that in my opinion would have been obvious for a POSITA to incorporate into the combination of Leaning and Leighton: the use of certain web elements (*e.g.*, the <seq> container) to "define[] a sequence of elements [(*e.g.*, videos)] in which elements play one after the other". EX1006, 158. SMIL 2.0's defined sequence of elements that successively play is a "virtual timeline," according to the plain and ordinary meaning of that term and how it is used in the '798 patent. *See* EX1001, 12:36-38 ("the virtual timeline (hereinafter 'VT') 600 may comprise a file that is configured to define a playlist for a user to view").

247. A POSITA would have been motivated to incorporate SMIL 2.0's teaching of a virtual timeline with the combination of Leaning's streaming system.

248. The system in Leaning is already in the streaming context and expressly discloses switching between different versions of streams based on the bitrate, or desired quality, and one or more network characteristics. EX1004, Abstract. A POSITA would have been motivated to further improve Leaning by applying SMIL 2.0's teachings regarding the use of a virtual timeline to control the playback of one or more media files.

249. SMIL 2.0 expressly teaches generating a playlist of entire content files – for example, the “vid2.mpg” file is followed by the “vid3.mpg” file using the “<seq>” element:

```
<seq>
   <img src="img1.jpg" />
   <video src="vid2.mpg" />
   <video src="vid3.mpg" />
</seq>
```

Playlist of entire content files

EX1006, 207, 158 (the seq container, shown by the <seq> and </seq> tags, “defines a sequence of elements in which **elements play one after the other**”) (emphasis added). A POSITA would have been motivated to create a virtual timeline playlist in Leaning of entire content files (*e.g.*, the .bin files streamed to the client in Leaning’s system) that play one after the other, as taught by SMIL 2.0 (*e.g.*, using the <seq> element, shown above), in order to set out a video schedule of similar videos for clients to view in succession. A POSITA would have had a reasonable expectation of success with such a combination because both Leaning and SMIL 2.0 are drawn to similar systems of client-server based streaming and generating a playlist of entire content files would have been a straightforward modification for a POSITA.

### D. <u>Ground 4</u>: Claims 1-25 Are Obvious in view of Leaning, Leighton,

**and Dalby**

250. The sections of Ground 1 (Section VII.A) are incorporated into this section by reference.

**1. Claim 10: "The system of claim 9, wherein the encoding module is configured to encode the streamlets of the multiple copies of the digital content in each of the different bit rates using a multi-pass encoding process."**

251. To the extent that claim 10 is not disclosed by Leaning —it is, as I explained in Ground 1, *supra*—in my opinion, this claim is obvious over the combination of Leaning in view of Dalby.

252. On its face, Leaning directs to teachings from Dalby regarding video encoding to teach that the encoding module is configured to encode the streamlets (subfiles) of the multiple copies of the digital content in each of the different bit rates. EX1004, 13:34-14:42 (pointing to "using the principle described in our [Dalby] patent" to solve problems with rate switching when video compression uses interframe techniques). Dalby teaches interframe encoding wherein "encoding of a video signal requires several passes through the encoder." EX1021, 4:43-49.

253. A POSITA would have been motivated to combine the teachings of multi-pass encoding from Dalby with the video encoding of streamlets in Leaning because Leaning explicitly directs a POSITA to Dalby to solve issues with rate-switching videos that have interframe encoding. A POSITA would have had a

reasonable expectation of success with such a modification because Leaning directs a POSITA to Dalby as a solution using video encoding techniques. *Id*.

## IV. SECONDARY CONSIDERATIONS DO NOT SUPPORT A CONCLUSION OF NONOBVIOUSNESS

254. I understand that the ALJ in the ITC Investigation, while discussing secondary considerations or "objective indicia of non-obviousness," accepted Patent Owner's argument that there was a presumption of a nexus between the claims that were asserted in the ITC Investigation and the Move Media Player (which was acquired by DISH). EX1009, 212-213. The ALJ found that DISH's expert demonstrated that Move's success was tied to the supposedly unique features of the claimed invention, namely "offering 'a smooth end user experience as the Move Media Player up-shifts and down-shifts in response to network and client CPU availability" and streaming using "simple HTTP protocol transfer of media files from standard Web servers rather than deployment of expensive media servers." EX1009, 213.

255. However, given the strong reasons that the challenged claims are obvious in light, including the motivations to combine the references set forth above, I do not believe such secondary considerations would rise to the level of overcoming the invalidity opinions I have expressed. Additionally, as discussed throughout, the claimed features reflect predictable results of combining known elements according

to their known functions, and thus, there are no unexpected and superior results from the claimed invention.

256. I am not aware of any other secondary considerations for the challenged claims.

## V. CITED PRINTED PUBLICATIONS

257. In Section IV.A above, I cite a number of printed publications that corroborate my opinions on the background of the technology. . I have personal knowledge that EX1014, dated 2004, is a true and correct copy of John G. Apostolopoulos et al, *Video Streaming: Concepts, Algorithms, and Systems*. Further, I also note that a book containing this printed publication is also available for purchase in hardcover form from well-known resources, such as Amazon, with an ISBN of 084937006X, Library of Congress Card No. 2003060762, and a publication date of Sept. 20, 2003. See https://www.amazon.com/Handbook-Video-Databases-Applications-Communications/dp/084937006X. Additionally, I have personal knowledge that EX1015, dated December, 1999 is a true and correct copy of Reza Rejaie, *An End-to-End Architecture for Quality Adaptive Streaming Applications in the Internet*, my dissertation that was published by 2001. I am an author of EX1015. Further, I have personal knowledge that EX1015 was publicly available to a POSITA at least before the presumed priority date. I can attest to the availability of EX1015 before the presumed priority date of the '798 Patent based on my own

experience as the author of EX1015. Additionally, I have personal knowledge that EX1017, dated 2001, is a true and correct copy of Reza Rejaie et al, *Design Issues for Layered Quality-Adaptive Internet Video Playback*, a paper that was published in 2001 in *Evolutionary Trends of the Internet,* a book that constitutes the proceedings of the Thyrrhenian International Workshop on Digital Communication held in Taormina, Italy in September 2001. I am an author of EX1017. Further, I have personal knowledge that EX1017 was publicly available to a POSITA at least before the presumed priority date. I can attest to the availability of EX1017 before the presumed priority date of the '798 Patent based on my own experience as an author of EX1017. Additionally, I have personal knowledge that EX1018, dated 1999, is a true and correct copy of Reza Rejaie et al, *Quality Adaptation for Congestion Controlled Video Playback over the Internet* that was published on August 30, 1999 in *ACM SIGCOMM Computer Communication Review,* Volume 29, Issue 4. I am an author of EX1018. Further, I have personal knowledge that EX1018 was publicly available to a POSITA at least before the presumed priority date. I can attest to the availability of EX1018 before the presumed priority date of the '798 Patent based on my own experience as an author of EX1018. Additionally, I have personal knowledge that EX1019, dated June 3, 2003, is a true and correct copy of Reza Rejaie et al, *PALS: Peer-to-Peer Adaptive Layered Streaming* that was published on June 1, 2003 in the proceedings of NOSSDAV '03. I am an author of

EX1019. Further, I have personal knowledge that EX1019 was publicly available to a POSITA at least before the presumed priority date. I can attest to the availability of EX1019 before the presumed priority date of the ’798 Patent based on my own experience as an author of EX1019. Each of the exhibits that I authored were also made publicly available on my personal website before the presumed priority date.

## VI. CONCLUSION

258. For the reasons set forth above, I believe claims 1-14 and 16-30 of the ’798 Patent are unpatentable in view of the prior art. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

259. I declare that all statements made herein of my knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: January 17, 2025

By: S. Reza Rejaie S.

*Reza Rejaie*

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## Curriculum Vitae

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## Education

1996 – 1999 **Ph.D. in Computer Science**, *University of Southern California (USC)*, Los Angeles, CA.
Thesis: An End-to-End Architecture for Quality Adaptive Streaming Applications in the Internet.
Co-Advisors: Prof. Deborah Estrin, Prof. Mark Handley

1994 – 1996 **M.S. in Computer Science**, *University of Southern California (USC)*, Los Angeles, CA.

1986 – 1991 **B.S. in Electrical Engineering**, *Sharif University of Technology*, Tehran, Iran.

## Professional Appointments

2023 – present **Associate Director**, *Oregon Cybersecurity Center of Excellence*, University of Oregon.

2020 – present **Department Head**, *Department of Computer Science*, University of Oregon.

Summer 2018 **Visiting Professor**, *The LINCS Research Center*, Sorbonne University, Paris, France.

2017 – present **Founding Member**, *The Center for Digital Mental Health*, University of Oregon.

Summer 2016 **Visiting Professor**, *Electronics & Telecom. Department*, Politecnico di Torino, Italy.

2015 – present **Professor**, *Department of Computer & Information Science*, University of Oregon.

2009 – 2010 **Visiting Professor**, *IMDEA Networks Institute*, Madrid, Spain.

2008 – 2015 **Associate Professor**, *Department of Computer & Information Science*, University of Oregon.

2002 – 2008 **Assistant Professor**, *Department of Computer & Information Science*, University of Oregon.

2002 – present **Founder & Co-Director**, *Oregon Network Research Group (ONRG)*, Department of Computer & Information Science, University of Oregon.

1999 – 2002 **Senior Technical Staff Member**, *AT&T Labs - Research*, Menlo Park, CA.

1996 – 1999 **Graduate Research Assistant**, *Information Sciences Institute (ISI)*, Los Angeles, CA.

1994 – 1996 **Graduate Research Assistant**, *Integrated Multimedia Service Center (IMSC)*, University of Southern California (USC), Los Angeles, CA.

## Awards & Recognition

2022 **Distinguished Member of ACM**.

2021 **Ripple Faculty Fellowship**.

2017 **IEEE Fellow**.

2009 **European Union Marie Curie Fellowship**.

2005 **National Science Foundation (NSF) CAREER Award**.

1999 **Academic Achievement Award**, *University of Southern California (USC)*.

1998 **Academic Achievement Award**, *University of Southern California (USC)*.

1997 **International Leadership Award**, *University of Southern California (USC)*.

1996 **International Leadership Award**, *University of Southern California (USC)*.

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[23] R. Rejaie, M. Handley, D. Estrin, "Layered Quality Adaptation for Internet Video Streaming", IEEE Journal on Selected Areas of Communications (JSAC), Volume 18, Number 12, Pages 2530 - 2543, Special issue on Internet QoS, Winter 2000 [acceptance rate 11%].

[24] S. Bajaj, L. Breslau, D. Estrin, K. Fall, S. Floyd, P. Haldar, M. Handley, A. Helmy, J. Heidemann, P. Huang, S. Kumar, S. McCanne, R. Rejaie, P. Sharma, K. Varadhan, Y. Xu, H. Yu, D. Zapalla, "Improving Simulation for Network Research", IEEE Computer, Volume 33, Pages 59 - 67, May 2000.

[25] S. Ghandeharizadeh, R. Zimmermann, W. Shi, R. Rejaie, D. Ierardi, and T. Li, "MITRA: A Continuous Media Server", Multimedia Tools and Applications Journal (Kluwer Academic Publishers), Volume 5, Number 1, Pages 79 - 108, July 1997.

**Non-Refereed Journal Papers**

[26] C. Misa, D. Guse, O. Hohlfeld, R. Durairajan, A. Sperotto, A. Dainotti, R. Rejaie, "Lessons Learned Organizing the PAM Virtual Conference", Computer Communication Review (CCR), Volume 50, Number 3, Pages 46 – 54, July 2020.

[27] N. Magharei, R. Rejaie, "ISP-Friendly P2P Streaming", IEEE Multimedia Communications Technical Committee E-Letter, Invited Article, October 2009.

**Book Chapters**

[28] D. Stutzbach, R. Rejaie, "Characterization of Peer-to-Peer Systems", book chapter, Handbook of Peer-to-Peer Networking, Editors Xuemin (Sherman) Shen, Heather Yu, John Buford, Mursalin Akon, Spriner Publishing, March 2009, ISBN: 978-0-387-09750-3.

[29] S. Ghandeharizadeh, R. Zimmermann, W. Shi, R. Rejaie, D. Ierardi, and T. Li, "MITRA: A Continuous Media Server", Multimedia Technologies and Applications for the 21st Century, (Editor Borko Furht), Kluwer Academic Publishers, Boston, December 1997, ISBN: 0-7923-8074-6.

**Refereed Conference Papers**

[30] Chris Misa, Ramakrishnan Durairajan, Arpit Gupta, Reza Rejaie and Walter Willinger, "Leveraging Prefix Structure to Detect Volumetric DDoS Attack Signatures with Programmable Switches", IEEE Symposium on Security and Privacy (S&P'24), San Franscisco, CA, May 2024.

[31] Bahador Yeganeh, Ramakrishnan Durairajan, Reza Rejaie and Walter Willinger, "A Case for Performance- and Cost-aware Multi-cloud Overlays", IEEE International Conference on Cloud Computing, Chicago, IL, July 2023.

[32] Chris Misa, Walt O' Connor, Ramakrishnan Durairajan, Reza Rejaie and Walter Willinger, "Dynamic Scheduling of Approximate Telemetry Queries", USENIX Symposium on Networked Systems Design and Implementation (NSDI), Renton, WA, April 2022.

[33] S. Jamshidi, Z. Hammoudeh, D. Lowd, R. Durairajan, R. Rejaie and W. Willinger, "On the Practicality of Learning Models for Network Telemetry", The Network Traffic Measurement and Analysis Conference (TMA), Berlin, Germany, June 2020.

[34] B. Yeganeh, R. Durairajan, R. Rejaie and W. Willinger, "A First Comparative Characterization of Multi-cloud Connectivity in Today's Internet", Passive and Active Measurement Conference (PAM), Eugene, Oregon, March 2020.

[35] K. Vermeulen, B. Ljuma, V. Krishna, M. Gouel, O. Fourmaux, T. Friedman and R. Rejaie, "Alias Resolution based on ICMP Rate Limiting", Passive and Active Measurement Conference (PAM), Eugene, Oregon, March 2020.

[36] B. Yeganeh, R. Durairajan, R. Rejaie, W. Willinger, "How Cloud Traffic Goes Hiding: A Study of Amazon's Peering Fabric", ACM Internet Measurement Conference (IMC), Amsterdam, Netherlands, October 2019.

[37] R. Motamedi, S. Rezayi, R. Rejaie, W. Willinger, "Unveiling Social Characteristics of Twitter Elite Network", IEEE/ACM International Conference on Advances in Social Network Analysis and Mining (ASONAM), Barcelona, Spain, August 2018 [acceptance rate 15%].

[38] S. Jamshidi, R. Rejaie, J. Li, "Trojan Horses in Amazon's Castle: Understanding the Incentivized Online Reviews", IEEE/ACM International Conference on Advances in Social Network Analysis and Mining (ASONAM), Barcelona, Spain, August 2018 [acceptance rate 15%].

[39] B. Yeganeh, R. Rejaie, W. Willinger, "A View From the Edge: A Stub-AS Perspective of Traffic Localization and Its Implications", IEEE/IFIP Network Traffic Measurement & Analysis Conference (TMA), Dublin, Ireland, June 2017 [acceptance rate 35%] (One of the selected three papers for the best paper award).

[40] Ali Safari Khatouni, Marco Ajmone Marsan, Marco Mellia, Reza Rejaie, "Adaptive Schedulers for Deadline-Constrained Content Upload from Mobile Multihomed Vehicles", IEEE International Symposium on Local and Metropolitan Area Networks (LANMAN), Osaka, Japan, June 2017 [acceptance rate 34%].

[41] R. Motamedi, R. Rejaie, W. Willinger, D. Lowd, R. Gonzalez, "Inferring Coarse Views of Connectivity in Very Large Graphs", ACM Conference on Online Social Networks (COSN), Dublin, Ireland, October 2014 [acceptance rate 16%].

[42] R. Farahbaksh, A. Cuevas, R. Cuevas, R. Rejaie, M. Kryczka, R. Gonzalez, N. Crespi, "Investigating the Reaction of BitTorrent Content Publishers to Antipiracy Actions", IEEE P2P, Trento, Italy, September 2013 [acceptance rate 20%].

[43] R. Gonzalez, R. Cuevas, R. Motamedi, R. Rejaie, A. Cuevas, "Google+ or Google-? Dissecting the Evolution of the New OSN in its First Year", World Wide Web (WWW) Conference, Rio de Janeiro, Brazil, May 2013 [acceptance rate 15%].

[44] A. Rasti, N. Magharei, R. Rejaie. W. Willinger, "Eyeball ASes: From Geography to Connectivity", ACM SIGCOMM Internet Measurement Conference (IMC), Pages 192-198, Melbourne, Australia, November 2011 [acceptance rate 22%].

[45] R. Cuevas, M. Kryczka, A. Cuevas, S. Kaune, C. Guerrero, R. Rejaie, "Is Content Publishing in BitTorrent Altruistic or Profit-Driven?", ACM SIGCOMM CoNEXT, Philadelphia, December 2010 [acceptance rate 19%](One of the top 3 papers that were selected for fast-track submission to the IEEE/ACM Transactions on Networking).

[46] A. Rasti, R. Rejaie. W. Willinger, "Characterizing the Global Impact of P2P Overlays on the AS-Level Underlay", Passive and Active Measurement Conference (PAM), Zurich, Switzerland, April 2010 [acceptance rate 29%].

[47] A. H. Rasti, M. Torkjazi, R. Rejaie, N. Duffield, W. Willinger, D. Stutzbach, "Respondent-driven Sampling for Characterizing Unstructured Overlays", IEEE INFOCOM Mini-Conference, Rio de Janeiro, Brazil, April 2009 [acceptance rate (including INFOCOM) 26.6%].

[48] N. Magharei, R. Rejaie, Y. Guo, "Mesh or Multiple-Tree: A Comparative Study on Live Peer-to-Peer Streaming Approaches", IEEE INFOCOM, Pages 1424 - 1432, Anchorage, Alaska, May 2007 [acceptance rate 17%].

[49] N. Magharei, R. Rejaie, "PRIME: Peer-to-Peer Receiver-driven Mesh-based Streaming", IEEE INFOCOM, Pages 1415 - 1423, Anchorage, Alaska, May 2007 [acceptance rate 17%].

[50] C. Xie, S. Guo, R. Rejaie, Y. Pan, "Examining Graph Properties of Unstructured Peer-to-Peer Overlay Topology", IEEE Global Internet Symposium, Anchorage, Alaska, May 2007 [acceptance rate 35%].

[51] A. Rasti, R. Rejaie, "Understanding Peer-Level Performance in BitTorrent: A Measurement Study", IEEE International Conference on Computer Communications and Networks (Chairs Recommended paper), Honolulu, Hawaii, August 2007 [acceptance rate 29%].

[52] N. Magharei, Y. Gou, R. Rejaie, "Issues in Offering Live P2P Streaming Service to Residential Users", IEEE Consumer Communications and Networking Conference, Pages 757 - 762, Las Vegas, January 2007.

[53] D. Stutzbach, R. Rejaie, N. Duffield, S. Sen, W. Willinger, "On Unbiased Sampling for Unstructured Peer-to-Peer Networks", ACM SIGCOMM Internet Measurement Conference (IMC), Pages 27 - 40, Rio de Janeiro, Brazil, October 2006 [acceptance rate 22%] (one of the three papers nominated for the best-paper award).

[54] D. Stutzbach, R. Rejaie, "Understanding Churn in Peer-to-Peer Networks", ACM SIGCOMM Internet Measurement Conference (IMC), Pages 189 - 202, Rio de Janeiro, Brazil, October 2006 [acceptance rate 22%].

[55] D. Stutzbach, R. Rejaie, N. Duffield, S. Sen, W. Willinger, "Sampling Techniques for Large, Dynamics Graphs", IEEE Global Internet Symposium, Barcelona, Spain, April 2006 [acceptance rate 36% of 63].

[56] A. Rasti, D. Stutzbach, R. Rejaie, "On the Long-term Evolution of the Two-tier Gnutella Overlay", IEEE Global Internet Symposium, Pages 1 - 6, Barcelona, Spain, April 2006 [acceptance rate 36% of 63].

[57] D. Stutzbach, R. Rejaie, "Improving Lookup Performance over a Widely-Deployed DHT", IEEE INFOCOM, Pages 1 - 12, Barcelona, Spain, April 2006 [acceptance rate 18% of 252].

[58] S. Zhao, D. Stutzbach, R. Rejaie, "Characterizing Files in the Modern Gnutella Network: A Measurement Study", ACM/SPIE-IS&T Multimedia Computing and Networking, Volume 6071, Pages 1 - 13, San Jose, January 2006 [acceptance rate 25%].

[59] D. Stutzbach, R. Rejaie, S. Sen, "Characterizing Unstructured Overlay Topologies in Modern P2P File-Sharing Systems", ACM SIGCOMM Internet Measurement Conference (IMC), Pages 49 - 62, Berkeley, USA, October 2005 [acceptance rate 27% of 82].

[60] D. Stutzbach, D. Zappala, R. Rejaie, "The Scalability of Swarming Peer-to-Peer Content Delivery", Networking, Pages 15 - 26, Waterloo, Canada, May 2005 [acceptance rate 25% of 430].

[61] D. Stutzbach, R. Rejaie, "Capturing Accurate Snapshots of the Gnutella Network", IEEE Global Internet Symposium, Pages 127 - 132, Miami, USA, March 2005 [acceptance rate 32% of 67].

[62] V. Agarwal, R. Rejaie, "Adaptive Multi-Source Streaming in Heterogeneous Peer-to-Peer Systems", SPIE/ACM Multimedia Computing & Networking, Pages 13 - 25, San Jose, January 2005 [acceptance rate 16% of 100].

[63] R. Rejaie, "On Design of Internet Multimedia Streaming Applications: An Architectural Perspective", IEEE International Conference on Multimedia and Expo (ICME), Pages 327-330, New York, USA, August 2000.

[64] R. Rejaie, M. Handley, D. Estrin, "Architectural Considerations for Playback of Quality Adaptive Video over the Internet", IEEE International Conference on Networks (ICON), Pages 204 - 209, Singapore, September 2000.

[65] R. Rejaie, H. Yu, M. Handley, D. Estrin, "Multimedia Proxy Caching Mechanism for Quality Adaptive Streaming Applications in the Internet", IEEE INFOCOM, Pages 980 - 989, Tel-Aviv, Israel, March 2000 [acceptance rate 26% of 735].

[66] R. Rejaie, M. Handley, D. Estrin, "Quality Adaptation for Congestion Controlled Video Playback over the Internet", ACM SIGCOMM, Pages 189 - 200, Cambridge, USA, September 1999 [acceptance rate 12% of 190].

[67] R. Rejaie, M. Handley, D. Estrin, "RAP: An End-to-end Rate-based Congestion Control Mechanism for Realtime Streams in the Internet", IEEE INFOCOM, Pages 1337 - 1345, New York, USA, March 1999 [acceptance rate 30% of 600].

**Refereed Workshop Papers**

[68] Y. Lavinia, R. Durairajan, R. Rejaie and W. Willinger, "Challenges in Using ML for Networking Research: How to Label If You Must", Workshop on Network Meets AI & ML (NetAI) co-located with ACM SIGCOMM, New York, USA, August 2020.

[69] R. Tian, R. Rejaie, "Re-examining the Complexity of Popular Websites", IEEE Workshop on Hot Topics in Web Systems and Technologies (HotWeb), Washington, D.C., November 2015; (Received Best Student Paper Award).

[70] W. Willinger, R. Rejaie, M. Torkjazi, M. Valafar, M. Moggioni, “Research on Online Social Networks: Time to Face the Real Challenges”, ACM SIGMETRICS Workshop on Hot Topics in Measurement and Modeling of Computer Systems (HotMetrics), Seattle, Washington, June 2009.

[71] M. Torkjazi, R. Rejaie, W. Willinger , “Hot Today, Gone Tomorrow: On the Migration of MySpace Users”, ACM SIGCOMM Workshop on Online Social Networks (WOSN), Barcelona, Spain, August 2009.

[72] M. Valafar, R. Rejaie, W. Willinger , “Beyond Friendship Graphs: A Study of User Interactions in Flickr”, ACM SIGCOMM Workshop on Online Social Networks (WOSN), Barcelona, Spain, August 2009.

[73] N. Magharei, R. Rejaie, “Overlay Monitoring and Repair in Swarm-based Peer-to-Peer Streaming”, International Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV), Williamsburg, Virginia, June 2009 [acceptance rate 31%].

[74] G. Memon, R. Rejaie, Y. Guo, D, Stutzbach, “Large-Scale Monitoring of DHT Traffic”, International Workshop on Peer-to-Peer Systems (IPTPS), Boston, MA, April 2009 [acceptance rate 20%].

[75] N. Magharei, R. Rejaie, “Understanding Mesh-based Peer-to-Peer Streaming”, International Workshop on Network and Operating Systems Support for Digital Audio and Video(NOSSDAV), Pages 56 - 61, Newport, Rhode Island, May 2006 [acceptance rate 31% of 74].

[76] R. Rejaie, S. Stafford, “A Framework for Architecting Peer-to-Peer Receiver-driven Overlays”, International Workshop in Network and Operating Systems Support for Digital Audio and Video (NOSSDAV), Pages 42 - 47, Kinsale, Ireland, June 2004 [acceptance rate 25% of 95].

[77] R. Rejaie, A. Ortega, “PALS: Peer-to-Peer Adaptive Layered Streaming”, International Workshop in Network and Operating Systems Support for Digital Audio and Video (NOSSDAV), Pages 153 - 161, Monterey, USA, June 2003 [acceptance rate 30% of 60].

[78] R. Rejaie, A. R. Reibman, “Design Issues for Layered Quality-Adaptive Internet Video Playback”, International Workshop on Digital Communications, Pages 433-451, Taormina, Italy, September 2001.

[79] R. Rejaie, Jussi Kangasharju, “Mocha: A Quality Adaptive Multimedia Proxy Cache for Internet Streaming”, International Workshop in Network and Operating Systems Support for Digital Audio and Video (NOSSDAV), Pages 3 - 10, Port Jefferson, New York, June 2001. [acceptance rate 33% of 60].

[80] R. Rejaie, M. Handley, H. Yu, D. Estrin, “Proxy Caching Mechanism for Multimedia Playback Streams in the Internet”, 4th International Web Caching Workshop, Pages 100 - 111, San Diego, USA, March 1999 [acceptance rate 50% of 38].

**U.S. Patent**

[81] C. Misa, R. Durairajan, R. Rejaie, and W. Willinger, “A Method for Dynamic Resource Scheduling of Programmable Dataplanes for Network Telemetry," patent pending, 2021. (Status: provisional patent filed.)

## Research Grants

NSF **CNS Core: Medium: Distributed Runtime Dataplane Telemetry as an Adaptive Query Scheduling Problem: Algorithms and Applications**, *Reza Rejaie (PI), Ram Durairajan (co-PI), Walter Willinger*, National Science Foundation (10/2022 – 9/2026), $1,056K.

NSF **CC* Integration-Large: Bringing Code to Data: A Collaborative Approach to Democratizing Internet Data Science**, *Ram Durairajan (PI), Reza Rejaie (co-PI), David Teach (co-PI), Arpit Gupta (co-PI), Walter Willinger*, National Science Foundation (10/2021 – 9/2023), $989K.

Ripple **Ripple Faculty Fellowship**, *Reza Rejaie (PI)*, (9/2021 – 8/2022), $50K.

Broadcom **Programmable Switches**, *Reza Rejaie (PI)*, Broadcom Inc., Equipment Donation (2018), $40K.

NSF **NeTS: Small: Collaborative Research: Studying Internet Interconnections in the Era of Cloud Computing**, *Reza Rejaie (PI), Bruce Maggs (co-PI), Walter Willinger*, National Science Foundation (8/2017 – 7/2020), $412K ($412K).

NSF **Personality Reputation Formation and Network Structure on Computer Technologies**, *Sanjay Srivastava (PI), Reza Rejaie (co-PI)*, National Science Foundation (9/2016 – 8/2019), $740K ($740K).

NIH **A Common Framework for Big Data Mental Health Research on Twitter**, *Sanjay Srivastava (PI), Reza Rejaie (co-PI)*, National Science Foundation (9/2015 – 8/2017), $375K ($375K).

NSF **NeTS: Small: Towards an Accurate, Geo-Aware, PoP-Level Perspective of the Internet's Inter-AS Connectivity**, *Reza Rejaie (PI), Bruce Maggs (co-PI), Walter Willinger, Bruce Maggs (co-PI)*, National Science Foundation (10/2013 – 9/2016), $532K ($532K).

NSF **CC-NIE: Network Infrastructure: Bridging Open Networks for Scientific Applications and Innovation (BONSAI)**, *Reza Rejaie (PI), Jose Dominguez (co-PI), Kimberly Espy (co-PI), Gregory Bothun (co-PI), Allen Malony (co-PI)*, National Science Foundation (7/2013 – 6/2014), $508K ($508K).

Dell **SDN Switch**, *Reza Rejaie*, Dell Inc., Equipment Donation (2013), $32K.

NSF **Multi-Resolution Analysis and Measurement of Large-Scale, Dynamic Networked Systems with Applications to Online Social Networks**, *Reza Rejaie (PI), Walter Willinger*, National Science Foundation (9/2009 – 8/2012), $355K.

NSF **Nets-NBD: Characterizing Large-Scale, Dynamics Peer-to-Peer Networks: New Sampling and Modeling Approach**, *Reza Rejaie (Sole PI)*, National Science Foundation (9/2006 – 8/2009), $300K.

Cisco **Characterizing and Modeling the Dynamics of Peer-to-Peer Networks**, *Reza Rejaie (Sole PI)*, Cisco Systems - Unrestricted Gift (8/2006 – 7/2007), $78K.

Thomson Lab **Contribution-Aware Peer-to-Peer Streaming**, *Reza Rejaie (Sole PI)*, Thomson Corporate Research at Princeton, NJ - Unrestricted Gift (2006), $20.3K.

NSF **CAREER: A Receiver-Driven Framework for Scalable and Adaptive Peer-to-Peer Streaming**, *Reza Rejaie (Sole PI)*, National Science Foundation (2/2005 – 1/2010), $410K.

## Advising

### Current Doctoral Students

2023– **Emad Taghiye**, (Co-advised with Ramakrishnan Durairajan).

2023– **Nima Nikkhah**, (Co-advised with Ramakrishnan Durairajan).

## Current M.S. Students

2023– **Mana Atarod**, (Co-advised with Ramakrishnan Durairajan).

## Ph.D. Dissertations Supervised

2019–2024 **Chris Misa** (Co-advised with Ramakrishnan Durairajan), *Thesis: Traffic Structure-Aware Network Telemetry Systems: Foundations, Designs, and Applications*, Award: Ripple Graduate Fellowships (2021, 2022), Pall Scholarship.

2014–2020 **Soheil Jamshidi**, *Thesis: The applications of Machine Learning Techniques in Networked Systems*, Award: Seeley Scholarship. First Employment: Amazon.

2013–2019 **Bahador Yeganeh** (Co-advised with Ramakrishnan Durairajan), *Thesis: Measuring the Evolving Internet in the Cloud Computing Era: Infrastructure, Connectivity, and Performance*, Award: Seeley Scholarship, Hubbard Scholarship, Pall Scholarship. First Employment: Snapchat Inc.

2010–2016 **Reza Motamedi**, *Thesis: Measurement-based Characterization of Large-Scale Networked Systems*, Award: Pall Scholarship, Julifs Scholarship, Dixon Graduate Innovation Award, First Employment: Twitter.

2005–2012 **Amir H. Rasti**, *Thesis: Investigating the Mutual Impact of the P2P Overlay and the AS-Level Underlay*, Award: Julifs Scholarship.

2005–2010 **Nazanin Magharei**, *Thesis: Peer-to-Peer Streaming: Design and Challenges*, Award: Julifs Scholarship, Smith Memorial Science Fellowship, First Employment: Cisco.

2004–2006 **Daniel Stutzbach**, *Thesis: Measuring and Characterizing Peer-to-Peer Systems*, Award: CIS Nomination for the ACM Dissertation Award, Dunbar Scholarship, First Employment: Google.

## M.S. Thesis Supervised

2020–2023 **Walt O'Connor**, *Thesis: On the Multi-Fractal Nature of Observed IP Addresses in Measured Internet Traffic*.

2017–2018 **Hooman Mostafavi**, *Thesis: A Longitudinal Assessment of Website Complexity*, First Employment: Amobee.

2013–2017 **Saed Rezayi**, *Thesis: Content Propagation in Google+: A Study of Ripples*.

2013–2017 **Ran Tian**, *Thesis: Re-examining the Complexity of Popular Web Sites*.

2013–2014 **Abhijit Alur**, *Thesis: Gathering Information about Network Infrastructure from DNS Names and Its Applications*, First Employment: JP Morgan Chase & Co.

2007–2010 **Mojtaba Torkjazi**, *Thesis: On the Migration of MySpace Users*, Award: Howe Scholarship, First Employment: Google.

2007–2010 **Masoud Valafar**, *Thesis: Beyond Friendship Graphs: A Study of User Interactions in Flickr*, First Employment: Twitter.

2006–2010 **Ghulam Memon**, *Thesis: Large-Scale Monitoring of DHT Traffic*, Award: Julifs Scholarship, Dunbar Scholarship, First Employment: Amazon.

2004–2005 **Shanyu Zhao**, *Thesis: Characterizing Files in the Modern Gnutella Network - A Measurement Study*, First Employment: Microsoft.

2003–2005 **Vikash Agarwal**, *Thesis: Adaptive Multi-Source Streaming in Heterogeneous Peer-to-Peer Systems*, First Employment: Cisco.

2003–2004 **Shad Stafford**, *Thesis: A Framework for Architecting Peer-to-Peer Receiver-driven Overlays*, First Employment: Palo Alto Software.

## Other M.S. Students Supervised

2022–2023 **Joseph Colton**, (Co-advised with Ramakrishnan Durairajan).

2019–2021 **Yukhe Lavinia**, (Co-advised with Ramakrishnan Durairajan).

2016–2017 **Sara Saleem**.

2011–2013 **Amir Farzad**.

2010–2011 **Kaveh Kazemi**.

2010–2011 **Shahab Yasami**.

2006–2007 **Sudheer Mogilappagari**.

2006–2007 **John Capehart**.

2006–2007 **Ryan Kersh**.

2004–2005 **Aroon Nataraj**.

2003–2004 **Chan (Thomas) Yu-Hao**.

## B.S. Honors Thesis Supervised

2023–2024 **Nathan Koga** (REU), *Thesis: Multi-level Application-centric Profiling of UO Internet Traffic*, Award: Hubbard Scholarship.

2021–2022 **Eugene Tan** (REU), *Thesis: Visualizing the Structure of Network Traffic Features Across the IP Address Space*, Award: Seeley Scholarship.

2021–2022 **Megan Walters** (REU), *Thesis: On the Multifractal Structure of Observed Internet Addresses*, Award: Juilfs Scholarship.

2020–2021 **Donna Hooshmand** (REU), *Thesis: Longitudinal Analysis of Major Video Streaming Services*, Award: Seeley Scholarship.

2016–2017 **Andrew Hill** (REU), *Thesis: Characterizing the Divergence of Intra-Country Internet Routes.*

2015–2016 **Phillip Kriegel** (REU), *Thesis: Determining the Location of Interconnects between the Top-Tier Autonomous Systems in the USA*, Award: Phi Beta Kappa Member, Phi Beta Kappa Oregon Six, Magna Cum Laude, Aaron Novick Award, CHC Thesis Award; First Employment: Google.

2013–2014 **Zhuojun (Morgan) Zhang**, *Thesis: Examining AS Relationships and Path Diversity with Looking Glass Servers*, Award: Juilfs Scholarship.

2008–2009 **Jimmy Hastings** (REU), *Thesis: Implementation and Evaluation of PRIME: A Peer-to-Peer Streaming Mechanism for Live Video.*

## Other B.S. Students Supervised

2019–2020 **Walt O'Conner** (REU).

2019 **Stefan Fields** (REU).

2019 **Pallavi Webb** (REU).

2017 **Sierra Battan** (REU).

2017 **Anisha Malynur** (REU).

2016–2018 **Trace Andreason** (REU).

2016 **Allen Roush** (REU).

2014–2015 **Miles Nerenberg** (REU).

2013–2015 **Rickie Kerndt**(REU).

2013 **Hannah Pruse**.

2013 **Zeyu Feng**.

2010–2011 **Eric M Berglund**.

2006 **Ross McClure**.

2005 **Daniel Ellsworth**.

2004 **Minho Kim**.

### Ph.D. Dissertation Committees

2022 **Zachary Kiefer**, *ECON*, Advisor: Woan Foong Wong.
2022 **Lumin Shi**, *CIS*, Advisor: Jun Li.
2019 **Mingwei Zhang**, *CIS*, Advisor: Jun Li.
2018 **Javid Ebrahimi**, *CIS*, Advisor: Dejing Dou.
2017 **Keegan Boyle**, *MATH*, Advisor: Robert Lipshitz.
2016 **Daniel Elsworth**, *CIS*, Advisor: Allen Malony.
2015 **Shangpu Jiang**, *CIS*, Advisor: Dejing Dou.
2014 **Steven Simpson**, *COE*, Advisor: Gerald Tindal.
2013 **Ghulam Memon**, *CIS*, Advisor: Jun Li.
2011 **Aaron Montgomery**, *MATH*, Advisor: David Levin.
2010 **Toby Ehrenkranz**, *CIS*, Advisor: Jun Li.
2005 **Nathan Dunn**, *CIS*, Advisor: John Conery.

### Visiting Scholars Hosted at UO

Summer 2023 **Prof. Ruben Cuevas**, *Universidad Carlos III de Madrid*.
Summer 2016 **Prof. Víctor M. López Millán**, *Universidad CEU-San Pablo, Madrid*.
Summer 2014 **Roberto Gonzalez**, *Ph.D. Student, Universidad Carlos III de Madrid*.
2012–2013 **Prof. Ruben Cuevas**, *Universidad Carlos III de Madrid*.

## Professional Services

### Organization Committee

2020 General Co-Chair, The Passive and Active Measurement (PAM) Conference
2020–2022 Advisory Board Member, Technology Association of Oregon (TAO-SWV)
2013–2014 Advisory Board Member, Enhanced Content Distribution with Social Information Consortium
2009 Technical Program Co-Chair, Multimedia Computing and Networking
2008 Technical Program Co-Chair, Multimedia Computing and Networking
2007 Technical Program Chair, ACM NOSSDAV
2006 Chair, Doctoral Symposium, ACM Multimedia
2004 Chair, Travel Grant Committee, IEEE INFOCOM
2007 Technical Program Co-chair, IEEE Global Internet Symposium
2001–present Member, the Council of Communications and Technology Advisors (www.thecouncils.com)

### Journal Editorial Boards

2017–2018 IEEE Transactions on Mobile Computing
2008–2018 ACM/Springer Multimedia Systems Journal
2007–2015 Springer Journal in P2P Networking and Applications
2006–2009 Journal of Advances in Multimedia
2009–2011 Computer Networks
2002–2008 IEEE Communications Surveys & Tutorials (Multimedia Networking)

### Technical Program Committees

2024 IEEE/ACM ASONAM
2023 Web Conference
2022 IEEE/ACM ASONAM
2021 Web Conference

IEEE/ACM ASONAM
2020 Web Conference
IEEE/ACM ASONAM
2019 SIGCOMM
Web Conference
IEEE/ACM ASONAM
ACM Multimedia Systems Conference
2018 ACM Multimedia Systems Conference.
2017 IEEE INFOCOM
2016 IEEE INFOCOM (Distinguished Member of the Technical Program Committee)
HotWeb
2015 IEEE INFOCOM
World Wide Web Conference
HotWeb
ACM NOSSDAV
2014 IEEE INFOCOM
IEEE ICDCS
Global Internet
2013 IEEE INFOCOM
IEEE ICDCS
ACM NOSSDAV
2012 IEEE INFOCOM
ACM SIGCOMM Workshop on Online Social Networks (WOSN)
ACM NOSSDAV
COMSNETS
2011 SIGCOMM Internet Measurement Conference (IMC)
IEEE INFOCOM
ACM Multimedia Systems
ACM NOSSDAV
COMSNETS
2010 ACM Multimedia
IEEE INFOCOM
ACM Multimedia Systems
IEEE Conference on Peer-to-Peer Computing
ACM NOSSDAV
ACM SIGCOMM Workshop on Online Social Networks (WOSN)
COMSNETS
2009 IEEE INFOCOM
IEEE Conference on Peer-to-Peer Computing
ACM NOSSDAV
COMSNETS
2008 SIGCOMM Internet Measurement Conference (IMC)
ACM Multimedia
IEEE INFOCOM

HotWeb
ACM NOSSDAV
IFIP Networking
2007 ACM Multimedia
SIGCOMM Peer-to-Peer Streaming and IP-TV Workshop
Globecom (Peer-to-Peer Networking Track)
ACM/SPIE Conference on Multimedia Computing and Networking
IEEE Workshop on End-to-End Monitoring Techniques & Services
IFIP Networking
IEEE Conference on Management of Multimedia and Mobile Networks and Services
2006 ACM Multimedia
IEEE INFOCOM
IEEE/IARIA International Conference on Internet Surveillance and Protection
IEEE Global Internet Symposium
IEEE/IFIP Workshop on End-to-End Monitoring Techniques and Services
ACM NOSSDAV
IFIP Networking
Packet Video Workshop
2005 IEEE INFOCOM
International Web Caching and Content Delivery Workshop (WCW)
ACM NOSSDAV
IFIP Networking
IEEE International Conference on Multimedia
2004 International Conference on Network Protocols(ICNP)
IEEE INFOCOM
ACM Multimedia
IEEE ICDCS
ACM NOSSDAV
ACM/SPIE Conference on Multimedia Computing and Networking
IEEE International Conference on Distributed Computing Systems
IEEE Globecom
Packet Video Workshop
2003 ACM NOSSDAV
IEEE International Conference on Multimedia
Packet Video Workshop
2002 ACM Mulrimedia
ACM NOSSDAV
IEEE International Conference on Multimedia
IEEE Global Internet, Packet Video Workshop
2001 IEEE Global Internet
International Web Caching and Content Delivery Workshop (WCW)

## Grant Review Panelist

2012 National Science Foundation (NSF)

2011 Qatar National Research Fund (QNRF)
2009 National Science Foundation (NSF)
2004 National Science Foundation (NSF)

## University & Department Services

### University Committees

2023-2023 Member, Implementation Team, School of Computer and Data Science
2022-2022 Member, Strategic Planning Committee, School of Computer and Data Science
2021-2022 Member, Dean's Heads Council, College of Arts and Sciences
2017-2018 Chair, Dean's Advisory Committee, College of Arts and Sciences
2016-2018 Member, IT Governance Executive Committee, UO
2016-2017 Member, Dean's Advisory Committee, College of Arts and Sciences
2016-2017 Member, CIO Recruiting Committee, UO
2012-2016 Senator, UO Faculty Senate
2010-2011 Senator, UO Faculty Senate
2008-2009 Senator, UO Faculty Senate

### Departmental Committees

2019-2020 Chair, Computing Resource Committee
2016-2019 Member, Recruiting Committee
2013-2016 Chair, Graduate Education Committee
2012-2013 Chair, Strategic Planning Committee
2012-2013 Member, Personnel Committee
2011-2012 Member, Graduate Education Committee
2010-2011 Chair, Computing Resource Committee
2007-2009 Member, Graduate Education Committee
2006-2007 Chair, Colloquium Committee
2003-2006 Member, Graduate Education Committee

## Selected Talks

2023 *"Overbuilding? or Futureproofing?"*, Panelist, Oregon Connections Conference, Ashland, Oregon.

2023 *"Enhancing Cybersecurity in Oregon Through Closer Partnership Among Stakeholder"*, Invited Talk, FBI Cyber Summit, Portland, Oregon.

2018 *"How Cloud Traffic Goes Hiding? A Study of Amazon Interconnection Fabric"*, Invited Talk, Telecom Paris Tech University, Paris, France.

*"On Mapping the Interconnections of Today's Internet"*, Invited Talk, LINCS Research Center, Paris, France.

2016 *"On the Geography of X-Connect"*, Invited Talk, Politecnico di Torino, Italy.

2014 *"Inferring Coarse Views of Connectivity in Very Large Graphs"*, Invited Talk, IMDEA Networks Institute, Madrid, Spain.

2011 "*Characterizing the Impact of P2P Overlay on AS-level Underlay*", Invited Feature Speaker, Reunion Workshop on "Multiscale Representation, Analysis and Modeling of Internet Data and Measurements", UCLA's Institute for Pure & Applied Mathematics (IPAM), Lake Arrowhead, USA.

2009 "*ISP-friendly Swarm-based P2P Streaming*", Invited Talk, Carlos III University of Madrid, Spain.

"*ISP-friendly Swarm-based P2P Streaming*", Invited Talk, Telefonica Research Lab, Barcelona, Spain.

2008 "*Empirical Characterizations of P2P Systems*", Invited Talk, Workshop on "Multiscale Representation, Analysis and Modeling of Internet Data and Measurements", Institute for Pure & Applied Mathematics (IPAM), UCLA.

"*Empirical Characterizations of P2P Systems*", Invited Talk, SIAM Symposium on The Many Faces of Internet Topology, San Diego, USA.

"*P2P and Online Networking Research at Mirage Group*", Invited Talk, Microsoft Research, Redmond, USA

2007 "*IonP2P: Measurement-based Characterization of P2P Networks*", Invited Talk, Microsoft Research, Redmond, USA.

"*Unbiased Sampling for Unstructured Peer-to-Peer Networks*", Distinguished Lecture Series, Cisco Systems, San Jose, USA.

"*IonP2P: Measurement-based Characterization of P2P Networks*", Invited Talk, UIUC, USA

2006 "*Understanding Mesh-based Peer-to-Peer Streaming*", Invited Talk, Multimedia Workshop, Microsoft Research, Redmond, USA.

"*Research Projects at the MIRAGE Group*", Invited Talk, Cisco Systems, San Jose, USA.

2005 "*Characterizing Overlay Topologies and Dynamics in Peer-to-Peer Networks*", Invited Talk, IEEE Computer Communications Workshop, Huntington Beach, USA.

"*Measurement-based Characterization of Unstructured Peer-to-Peer Networks*", Invited Talk, Sharif University of Technology, Tehran, Iran.

"*Measurement-based Characterization of Gnutella*", Invited Talk, Intel Research Lab, UC Berkeley, USA.

"*Measurement-based Characterization of Gnutella*", Computer Science Colloquium, HP Labs, Palo Alto, USA.

"*Peer-to-Peer Network Research at Mirage Group*", Invited Talk, Intel Corporation, Hillsboro, USA.

2004 "*Adaptive Multimedia Streaming over Peer-to-Peer Receiver-driven Overlays*", Invited Talk, Multimedia Workshop, Columbia University, USA.

2003 "*PALS: Peer-to-Peer Adaptive Layered Streaming*", Computer Science Colloquium, HP Labs, Palo Alto, USA.

## Training

Spring 2021 **Trauma Informed Leadership Seminar Series**, *University of Oregon*.

2020 - 2021 **Completed UO Leadership Academy**, *University of Oregon*.

## Teaching

**Note: * denotes courses that I developed.**.

CIS432/532 **Introduction to Computer Networks**∗, *[Fall 2003] [Fall 2004] [Fall 2005] [Fall 2007] [Fall 2010] [Fall 2012] [Fall 2014] [Fall 2015] [Fall 2017] [Fall 2019]*.

CIS630 **Distributed Systems**∗, *[Spring 2014] [Spring 2015] [Spring 2016] [Spring 2017] [Winter 2018] [Spring 2019]*.

CIS632 **Computer Networks**∗, *[Spring 2014] [Spring 2015] [Spring 2016] [Spring 2017] [Winter 2018] [Spring 2019]*.

CIS410/510 **System and Network Administration Lab**∗, *[Spring 2015] [Winter 2019] [Winter 2020]*.

CIS610 **Network Measurement**∗, *[Spring 2004] [Spring 2005]*.

CIS415 **Operating Systems**, *[Spring 2003] [Spring 2008] [Fall 2013]*.

CIS314 **Computer Organization**, *[Fall 2006] [Fall 2008] [Fall 2011]*.

CIS610 **Software-Defined Networking**∗, *[Spring 2013]*.

CIS410/510 **Wireless & Mobile Networks**∗, *[Fall 2016]*.

CIS410/510 **Internet Multimedia**∗, *[Winter2003]*.

CIS410/510 **P2P Networking**∗, *[Spring 2006]*.

CIS410/510 **Online Social Networking**∗, *[Winter 2009]*.

CIT383 **Enterprise Networking**, *[Spring 2009]*.

*last update, short version: 05/10/2024*