UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

WEBGROUP CZECH REPUBLIC A.S.,

NKL ASSOCIATES, S.R.O.,

Petitioners,

v.

DISH TECHNOLOGIES L.L.C.,

Patent Owner.

IPR2025-00468

PATENT NO. 10,951,680

DECLARATION OF DR. KEVIN JEFFAY IN SUPPORT OF PATENT OWNER PRELIMINARY RESPONSE

PATENT OWNER'S EXHIBIT LIST

Ex. No.	Description of Documents
2001	U.S. Patent App. Pub. No. 2004/0030547 by Leaning et al. ("Leaning US App 2004")
2002	Redline Comparison of Leaning US 2008 and Leaning US App 2004
2003	International P.C.T. Publication WO 200249343 to Leaning et al. ("Leaning PCT 2002")
2004	337-TA-1265 ITC Investigation Commission Opinion ("Comm'n Op.")
2005	337-TA-1265 ITC Investigation Final Determination and Limited Exclusion Order (EDIS Doc No. 1961623)
2006	Email Refusal to Waive Service
2007	"Peloton Will Pay Dish $75M To Avoid Import Ban" – Dani Kass, Law360 (May 5, 2023)
2008	Request for Ex Parte Reexamination of U.S. Patent No. 10,469,555
2009	Declaration of Dr. Kevin Jeffay including Curriculum Vitae ("Jeffay")
2010	Second Sub-file of Akiyo Video
2011	Akiyo Video
2012	Amendment dated April 25, 2008 to U.S. Application No. 10/433,259

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I. Introduction

1. I, Dr. Kevin Jeffay, hereby declare as follows:

A. Engagement

2. I am an independent consultant with over 40 years of experience in technologies related to media streaming. I have been retained on behalf of DISH Technologies L.L.C. ("Patent Owner" or "DISH"), as an expert consultant on telecommunications technology related to streaming media content over networks including the Internet.

3. As part of this work, I was requested by counsel for DISH to review the Petitions for *Inter Partes* Review and accompanying Declarations of Dr. Reza Rejaie submitted by Petitioners Webgroup Czech Republic, A.S. and NKL Associates, S.R.O. in IPR2025-00467 regarding U.S. Patent No. 10,469,554 ("the '554 Patent"), IPR2025-00468 regarding U.S. Patent No. 10,951,680 ("the '680 Patent"), IPR2025-00469 regarding U.S. Patent No. 11,470,138 ("the '138 Patent"), and IPR2025-00470 regarding U.S. Patent No. 11,677,798 ("the '798 Patent") (collectively, the "Challenged Patents" or "ABR Patents"). I understand that all of the Challenged Patents claim priority to a provisional application filed on April 30, 2004. I provide my opinion regarding validity of the Challenged Patents below.

4. I have been asked by counsel for DISH to provide technical opinions in connection with the *inter partes* reviews of the Challenged Patents. I submit this

combined declaration in support of Patent Owner's Preliminary Response in each of the above-listed IPRs. I reserve the right to supplement my opinions, should I be requested to provide additional analysis.

5. The specifications of the Challenged Patents are the same. I also understand that Dr. Rejaie provided substantially similar analysis across each of his declarations in these proceedings. Accordingly, in addressing certain claim elements and limitations recited across each Challenged Patent, I will cite to the '554 Patent and the Petition and Exhibits in IPR2025-00467, and my opinions expressed apply equally across all other cases unless otherwise noted.

6. I am being compensated at $800 per hour for my services in this matter. My compensation is not dependent upon the outcome of this matter. If called upon to do so, I am prepared to testify as an expert witness in this regard.

B. Background and Qualifications

7. I am qualified by education and experience to testify as an expert in the field of computer networking and video streaming. Attached, as Exhibit A, is a copy of my resume detailing my experience and education. Additionally, I provide the following overview of my background as it pertains to my qualifications for providing expert testimony in this matter.

8. I am a full professor in the Department of Computer Science at the University of North Carolina at Chapel Hill where I currently hold the position of

Gillian T. Cell Distinguished Professor of Computer Science. I have been a faculty member at UNC since 1989. From 2014-2022, and again in 2024, I also served as the Chairman of the Department.

9. I received a Ph.D. in computer science from the University of Washington in 1989. Before that I received a M.Sc. degree in computer science from the University of Toronto in 1984, and a B.S. degree with Highest Distinction in mathematics from the University of Illinois at Urbana-Champaign in 1982.

10. I have been involved in the research and development of computing systems for over 40 years. I have been a faculty member at the University of North Carolina since 1989 where I perform research and I teach in the areas of multimedia networking, computer networks, distributed systems, real-time systems, and operating systems, among others. A major theme of my research has been the development of technology to improve the performance of data transfers on the Internet generally and for real-time applications specifically. My research has examined problems ranging from network and operating system support for real-time multimedia applications such as audio and video streaming, voice-over-Internet protocol (VoIP) and Internet videoconferencing, to the design of congestion control mechanisms in network routers, to measurements and analysis of network traffic to passively assess the performance of servers on the Internet.

11. For example, starting in the late 1980s, the focus of my research was the development of network and operating system technology to enable the real-time transfer of streams of audio and video data across the Internet. This involved, among other things, the development of media encoders, media players, and network communication protocols for adaptive transmission of live audio and video data on the Internet. This work culminated in my research group developing some of the first videoconferencing systems for the Internet. Several of the papers authored by myself and members of my research group on this project won awards for their technical contributions.

12. The videoconferencing and adaptive streaming research attracted the attention of industry groups such as IBM, Intel, Digital Equipment Corporation, Cabletron, and AT&T Bell Laboratories. For example, starting in 1991 IBM supported aspects of my research at UNC and these efforts resulted in U.S. Patent No. 5,892,754 on adaptive media streaming being issued to IBM and UNC.

13. During this time, I was also collaborating with researchers at the Intel Architecture Labs in Hillsboro, OR, to modify an Intel product, the ProShare videoconferencing system, to use technology developed in my research lab at UNC for adaptive media transmission. By the late 1990s, the ProShare product included the ability to also transfer desktop information of a PC to a remote PC.

14. My research group also developed other "data conferencing" systems, also known as "shared window systems," that were capable of transferring the desktop information on a PC to a remote PC in real-time. One system that we built, called "XTV," was operational by 1991. The source code for XTV was made freely available and, by 1993, had been downloaded by over 600 users and institutions. The system was functionally and visually equivalent to today's Cisco's WebEx and Zoom's screen sharing products and services. It provided a sophisticated means of transferring the desktop information of a PC to a remote site. In the XTV system, individual windows displayed on the desktop, or the entire desktop itself, could be selected for sharing with remote users. The XTV system also allowed remote users to remotely control and manipulate the desktop whose information was being distributed, as well as remotely control the applications that were generating the desktop information that was being shared.

15. In much of my research, I regularly build and use clusters of computers interconnected by network switches, bridges, and routers to form and evaluate experimental and production networks. For example, in the late 1990s and early 2000s, my research evolved to consider router-based mechanisms for controlling the performance of network traffic. In much of this research, my students and I built and instrumented network routers and performed large scale experiments with this equipment. The instrumentation included, for example, the development of network

monitors that would receive copies of packets flowing on a network link and analyze and store packets or the results of analyses on these packets, all in real-time. Based on these experiments, in 2003, my group at UNC won the most prestigious research award for original research in computer networking. UNC applied for, and received, U.S. Patent No. 7,447,209 for aspects of this research.

16. This project, and others, took place in a networking lab my students and I constructed at UNC over a number of years. The lab consists of several hundred computers and networking devices. Managing this lab required establishing and configuring VLANs, firewalls, and other security appliances to isolate the lab from the campus network (and vice versa).

17. More recently, my research group has considered the design and operation of next generation aerial networks. UNC applied for, and received, U.S. Patent No. 9,832,705 for aspects of this research.

18. I have authored or co-authored over 100 articles in peer-reviewed journals, conference proceedings, texts, and monographs in the aforementioned areas of computer science and others. In addition, I have edited and co-edited numerous published proceedings of technical conferences and have edited a book of readings in multimedia computing and networking (with Hong-Jiang Zhang) published by Morgan Kaufman. I am a co-author (with Long Le and F. Donelson Smith) of a monograph related to computer network protocols, and a co-author (with

Jay Aikat and F. Donelson Smith) of a second monograph related to experimental computer networking.

19. My research extends to leadership positions in several journals, conferences, and committees. I have previously served as Editor-in-Chief for the journal Multimedia Systems and Associate Editor for the journal Real-Time Systems. In addition, I have been an active participant in the Association for Computing Machinery ("ACM") and the Institute of Electrical and Electronics Engineers ("IEEE"). Specifically, I have been a member of the steering committees for the ACM Special Interest Group on Multimedia, and the ACM Special Interest Group on Data Communications ("SIGCOMM") and its subgroup on Internet Measurement. I have also served as a member of the IEEE Technical Committee on Real-Time Systems. As a result of this involvement, I have served as a program chair or member of the technical program committee for over 100 professional, international, and technical conferences, workshops, and symposia. I was previously on the steering committee for the ACM technical committee on Internet measurement, where we worked on community standards for measurement-based research. I have also served on numerous proposal review panels for the National Science Foundation and other international funding agencies in the aforementioned areas of computer science.

20. In addition to the U.S. patents referenced above, I am a named inventor on a fourth patent. Each of these patents is generally related to computer networking and the delivery of services over networks including audio and video transmission.

21. I have developed and taught undergraduate and graduate level courses on operating systems, computer networking, computer security, and multimedia computing. These courses have been developed for, and delivered to, students at UNC as well as for industry professionals.

22. I have served as an expert witness and technical consultant in litigation and *inter partes* review matters concerning videoconferencing, data conferencing and screen sharing, cellular and wireline telephony, voice over IP (VoIP) telephony, multimedia networking, distributed systems, operating systems, computer networks, datacenter networking, embedded systems and embedded software, and real-time systems, among others. I have testified in several trials, arbitrations, and claim construction hearings as an expert witness.

II. Relevant Legal Principles

23. I have applied the following legal principles provided to me by counsel in arriving at the opinions set forth in this report.

24. I understand that the Petitioner in an IPR proceeding bears the burden of demonstrating invalidity of the Challenged Claims by a preponderance of the evidence.

A. Prior Art

25. I understand that a person shall not be entitled to a patent if the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention. I understand that disclosures made one year or less before the effective filing date of the claimed invention shall not be prior art if the disclosures were made by an inventor, joint inventor, or by another who obtained the subject matter directly or indirectly from the inventor or a joint inventor; or the disclosures were made by another after an initial disclosure by an inventor, joint inventor, or by another who obtained the subject matter directly or indirectly from the inventor.

26. I understand that prior art also includes issued patents or published applications in which the patent or application names another inventor and was effectively filed before the effective filing date of the claimed invention. I understand that such disclosures shall not be prior art if (1) the subject matter disclosed was obtained directly or indirectly from the inventor or a joint inventor; (2) the subject matter disclosed had been publicly disclosed by the inventor before the effective filing date; or (3) the disclosed subject matter and the claimed invention were owned by the same entity no later than the effective filing date.

B. Anticipation

27. It is my understanding that invalidation by "anticipation" only exists if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. I understand that the references must be viewed from the perspective of a person of ordinary skill in the art (a "POSITA"). I understand that two or more items of prior art cannot be combined to find anticipation. I also understand that the single prior art reference must include all elements arranged as required by the claim. I further understand that to be considered anticipatory, the prior art reference must be enabling and must describe the patentee's claimed invention sufficiently to have placed it in the possession of a person of ordinary skill in the field of invention. I understand that the disclosure in the particular item of prior art does not have to be in the same words as the claim, but all of the requirements of the claim must be there, either expressly or inherently, so that a person of ordinary skill in the art looking at that particular item of prior art would be able to make and use at least one embodiment of the claimed invention.

28. I understand that a reference that does not expressly anticipate a claim or claim element can be found to inherently anticipate, but only if the reference necessarily includes the unstated limitation or necessarily functions in accordance with the claim or claim element. I understand that inherency cannot be established

by probabilities or possibilities. And I further understand that a reference must enable someone to practice the invention in order to anticipate under § 102.

C. Obviousness

29. I understand that a patent claim is invalid if the claimed invention would have been obvious to a person of ordinary skill in the art at the time the invention was made. I understand a claimed invention is obvious when, even if all the requirements of the claim cannot be found in a single item of prior art that would otherwise anticipate the claim, it would have been obvious to a person of ordinary skill in the art, having knowledge of all of the analogous prior art, to have come up with the claimed invention.

30. I understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was independently known in the prior art. Most, if not all, inventions rely upon building blocks of prior art, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known. Accordingly, to determine whether an invention is obvious, I understand it can be important to determine whether there is a reason that would have prompted a person of ordinary skill in the art to combine the elements in the way the claimed new invention does. I understand that such teachings, suggestions, and motivations may be found in the prior art, the knowledge of a

person of ordinary skill in the art, or the nature of the problem solved by the claimed invention.

31. In evaluating whether the Challenged Claims would have been obvious, I have also considered the following factors:

- Whether Petitioner has identified a reason that would have prompted a person of ordinary skill in the art to combine elements or concepts from the prior art in the same way as in the claimed invention;
- Whether the claimed invention applies a known technique that had been used to improve a similar device or method in a similar way; and
- Whether the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art.

32. I understand that it is important to be careful not to determine obviousness using hindsight, because many true inventions can seem obvious after the fact. Obviousness is determined from the position of a person of ordinary skill in the art at the time the claimed invention was made, and I understand it is improper to consider what is known today or what is learned from the teaching of the patent.

For example, I understand it is improper to use the challenged patent as a road map for selecting and combining prior art.

33. I understand that the ultimate conclusion of whether a claim is obvious should be based on a determination of the following factual issues:

- The level of ordinary skill in the art that someone would have had at the time the claimed invention was made;
- The scope and content of the prior art;
- The differences, if any, that existed between the claimed invention and the prior art; and
- Secondary considerations or objective evidence of non-obviousness.

34. I understand that objective evidence or secondary considerations of non-obviousness include the following:

- Commercial success of a product due to the merits of the claimed invention;
- A long-felt, but unsolved, need for the solution provided by the claimed invention;
- Unsuccessful attempts by others to find the solution provided by the claimed invention;
- Copying of the claimed invention by others;

- Unexpected and superior results from the claimed invention;
- Acceptance by others of the claimed invention as shown by praise from others in the field of the invention; and
- Disclosures in the prior art that criticize, discredit, or otherwise discourage the claimed invention and would therefore tend to show that the invention was not obvious.

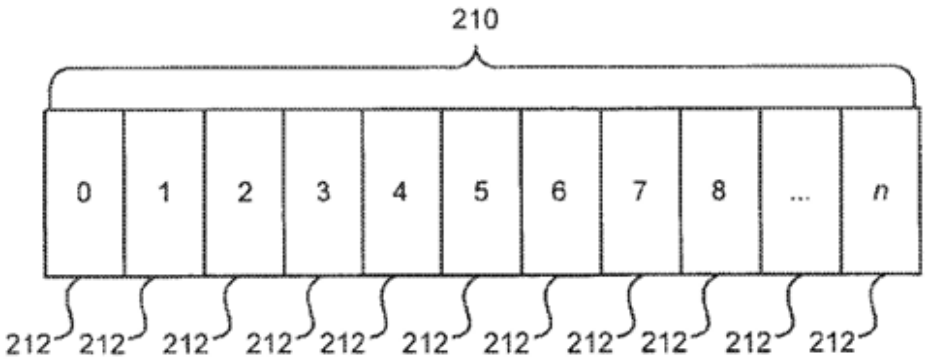
35. I have been informed that a patentee is entitled to a rebuttable presumption of nexus between the asserted evidence of objective indicia and a patent claim if the patentee shows that the asserted objective evidence is tied to a specific product and that the product is the invention disclosed and claimed. In other words, presuming nexus is appropriate when the patentee shows that the asserted objective evidence is tied to a specific product and that product embodies the claimed features, and is coextensive with them. If on the other hand, the patented invention is only a component of a commercially successful machine or process, the patentee is not entitled to a presumption of nexus.

III. The Challenged Patents

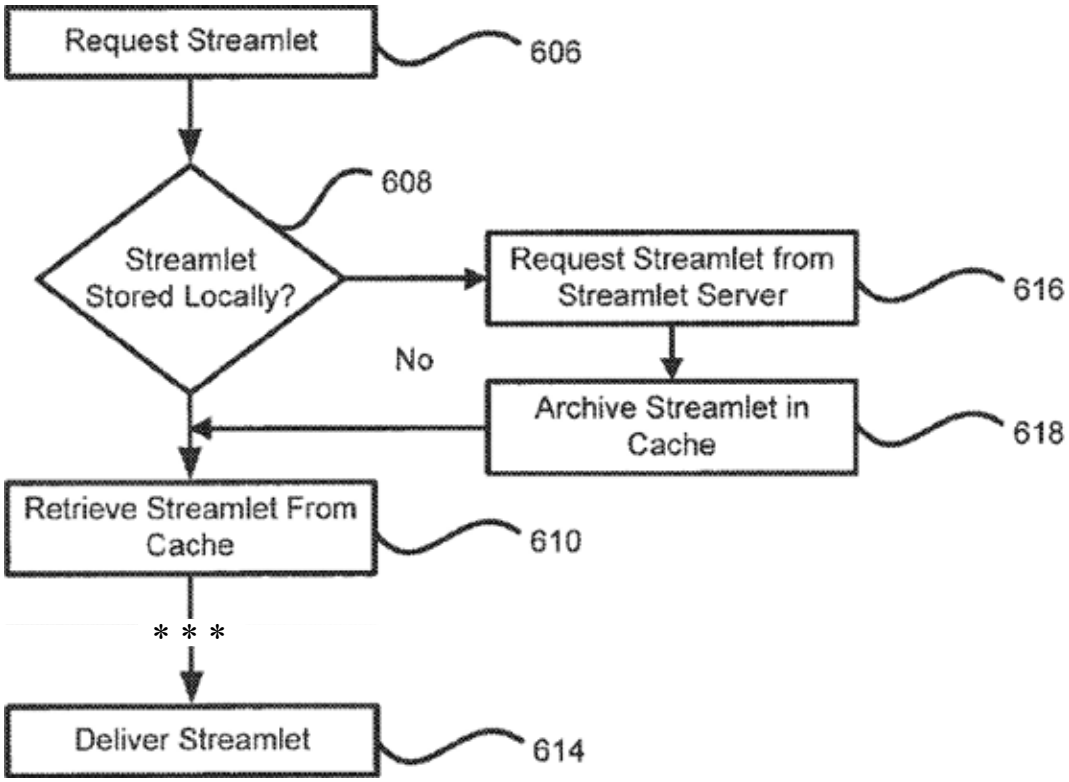
36. The Challenged Patents are directed to "alleviat[ing] the problems of reliability, efficiency, and latency" when "video streaming over packet switched networks such as the Internet." EX1001, 1:31-32, 2:58-60. The Challenged Patents' primary focus in this regard is "the viewing or listening experience of the user." *Id.*,

2:37-39; *see also id.*, 2:45-47. As the Challenged Patents explain, "[u]sers generally … tend to want to see or hear … media file[s] instantaneously," and without any "break" or "slowdown" in playback. *Id.*, 1:66-67, 2:30-32, 2:37-38.

37. The Challenged Patents disclose time-dividing media files into smaller portions, or "streamlets," thus allowing playback to begin as soon as a single streamlet is downloaded, rather than waiting for the entire media file to download. Exemplary streamlets 212 are depicted below and described by the Challenged Patents as "independent media object[s]" that correspond to 2-second portions of a larger stream 210.

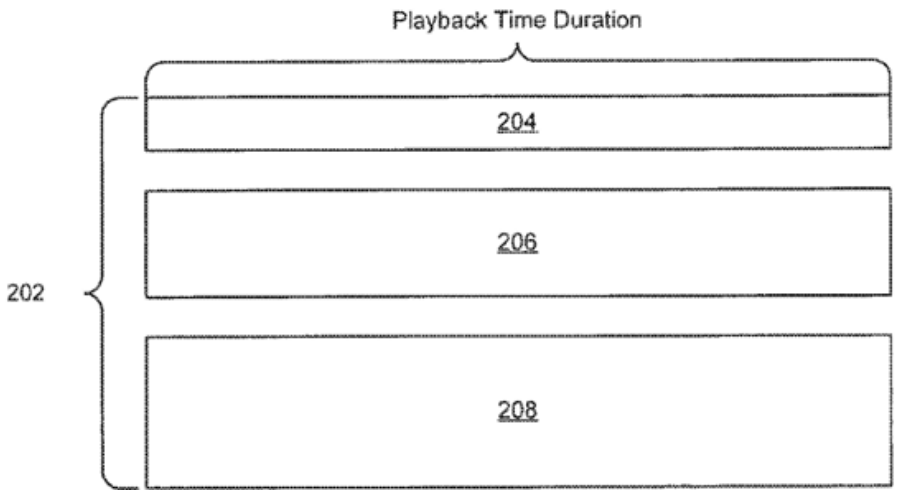


Id., 6:58-63, Fig. 2c. The Challenged Patents' exemplary process for requesting (Step 606), downloading (Step 618), and playing back (Steps 610 & 614) a single streamlet is depicted below.

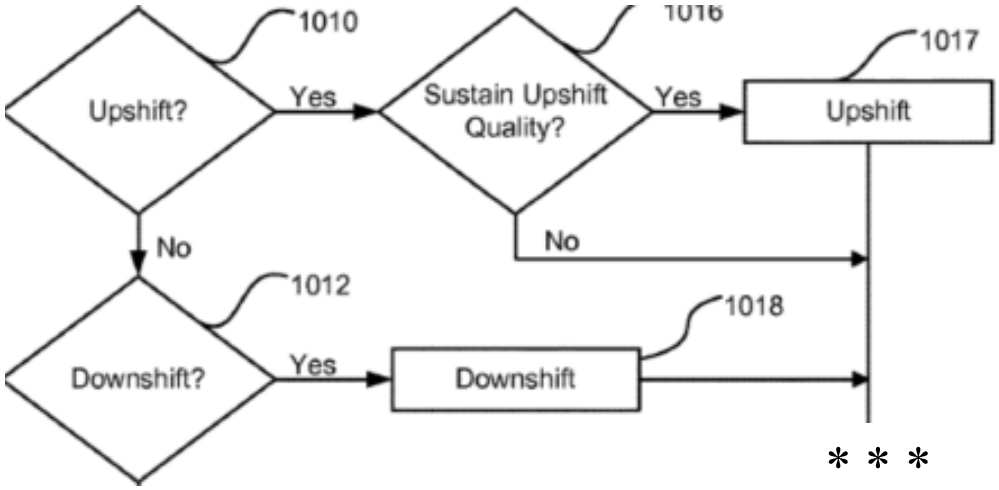


Id., 16:33-67, Fig. 9.

38. The Challenged Patents acknowledge that conventional streaming approaches are "vulnerable to network failures or congestion" that can result in "delays or losses" during playback. EX1001, 1:47-49, 2:9-10, 2:30-36 (emphasis added). The Challenged Patents address this problem by creating different copies of its streamlets at different bit rates and inserting a step into the process depicted above—specifically, Step 910—that responds to changes in network conditions. An example of these different copies 202 of the Challenged Patents' streamlets 212 are depicted below and described by the Challenged Patents as corresponding to "a low quality stream 204, a medium quality stream 206, and a high quality stream 208."



Id., 7:27-32, Fig. 2b. An exemplary process for determining whether to perform a rate shift is depicted below.



Id., Fig. 10. As depicted, the invention of the Challenged Patents responds to network conditions by "upshift[ing to a] higher quality stream[]" when a user's network connection improves or "downshift[ing] the stream quality" when a user's network connection degrades. *Id.*, 17:55-15, 18:6-8.

IV. Level of Ordinary Skill in the Art

39. Dr. Rejaie contends that a POSITA at the time of invention of each of the ABR Patents "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." EX1003, ¶ 79.

40. I disagree. Instead, it is my opinion that a POSITA at the time of the invention would have been someone with at least a bachelor's degree in electrical engineering or computer science, or an equivalent degree or experience in a related field, with at least two years of practical experience or coursework in the design or development of distributed multimedia delivery systems.

41. Dr. Rejaie's proposed definition of a POSITA is improper because it does not require any experience with "multimedia delivery systems" or "streaming media," and instead may be satisfied by someone with simply a bachelor's degree in a relevant field and networking experience. Accordingly, the definition of a POSITA I propose above is more suitable. However, for purposes of my analysis presented below, Dr. Rejaie's proposed definition may be accepted as sufficient.

V. Claim Construction

42. In general, I understand that claim terms are to be given their plain and ordinary meaning according to a POSITA at the time of the invention. Here I understand that the International Trade Commission "ITC") in Investigation No.

337-TA-1265 (the "1265 Investigation") previously construed the term "streamlet(s)" as recited in two of the ABR Patents as "any sized portion of a content file each of which is stored separately." However, this construction is not required for purposes of rendering the opinions I express here.

43. I have not identified any other terms of the Challenged Claims of the Challenged Patents that require construction for purposes of rendering the opinions I express here.

VI. The Petition and Dr. Rejaie Fail to Demonstrate that Any Claims of the Challenged Patents are Invalid

44. Petitioner and Dr. Rejaie rely on Leaning US 2008 (EX1004)[1] combined with the knowledge of a POSITA as allegedly disclosing or suggesting the vast majority of limitations of the Challenged Patents. But Petitioner and Dr. Rejaie's proposal to modify Leaning US 2008's audio embodiments to use H.261 video coding is inoperable, as confirmed by Leaning US 2008 itself, which says the technique would result in "mistracking." EX1004, 13:19-20, 13:30-33. For at least the reasons discussed below, it is my opinion that Petitioner and Dr. Rejaie fail to show that any Challenged Claim is invalid.

[1] I refer to Petitioner's primary reference as "Leaning US 2008" to maintain consistency with the naming convention used in Patent Owner's Preliminary Response.

45. Each Challenged Claim is directed to adaptive rate video/content streaming using streamlets of varying quality levels:

Challenged Claim	Element
'554 Patent Claim 1[Pre]	A system for ***adaptive-rate content streaming of live event video*** playable on one or more end user stations over the Internet, the system comprising:
'554 Patent Claim 16[F]	select a specific one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to ***select a higher or lower bitrate version of the streams***;
'554 Patent Claim 26[D]	receiving at least one streamlet request over one or more internet connections from the one or more end user stations to retrieve the first streamlet storing the first portion of the live event video, wherein the at least one streamlet request from the one or more end user stations includes a request for a currently selected first streamlet from one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to ***select a higher or lower bitrate version of the live event video***;
'554 Patent Claim 30[D]	selecting, by the content player device, a currently selected one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to ***select a higher or lower bitrate version of the live event video***;
'680 Patent Claim 1[Pre]	A system for ***adaptive-rate content streaming of video*** playable on one or more end user stations over the Internet, the system comprising:
'680 Patent Claim 14[D]	select a specific one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to ***select a higher or lower bitrate version of the streams***;
'680 Patent Claim 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 low quality stream, the medium quality stream, and the high quality stream

	based upon a determination by the end user station to ***select a higher or lower bitrate version of the video***;
’680 Patent Claim 28[F]	selecting, by the content player device, a currently selected one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to ***select a higher or lower bitrate version of the video***;
’138 Patent Claim 1[Pre]	A system for ***adaptive-rate content streaming of a video*** that is playable on one or more end user stations over the internet, the system comprising:
’138 Patent Claim 14[D]	select a specific one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the end user station to ***select a higher or lower bitrate version of the streams***;
’138 Patent Claim 23[F]	wherein the at least one streamlet request from the respective one of the one or more end user stations includes a request for a currently selected first streamlet from one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the respective one of the one or more end user stations to ***select a higher or lower bitrate version of the video***;
’138 Patent Claim 28[F]	selecting, by the content player device, a currently selected one of the low quality stream, the medium quality stream, and the high quality stream based upon a determination by the content player device to ***select a higher or lower bitrate version of the video***;
’798 Patent Claim 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:
’798 Patent Claim 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;
’798 Patent Claim 22[D]	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***;

46. Petitioner and Dr. Rejaie primarily cite to Leaning US 2008's discussion of rate shifting ***audio*** in their arguments. *See* EX1003, ¶¶ 95-125 (citing almost exclusively to Leaning US 2008's audio embodiment to meet elements of Claim 1), ¶¶ 126-240 (cross-citing Claim 1 analysis for video elements of other claims). Nevertheless, Petitioner and Dr. Rejaie's invalidity theories exclusively rely on modifying Leaning US 2008's audio embodiment to use H.261 encoded video. Attempting to bridge the gap between the audio-based disclosures of Leaning US 2008 and the H.261 encoded video he relies upon for the proposed modification, Dr. Rejaie cites to a portion of Leaning which vaguely states that "[t]he same [unstated] principle may be applied to the delivery of video recordings."[2] EX1004, 12:48-50 (cited at EX1003, ¶¶ 96, 104, 113).

47. Petitioner and Dr. Rejaie are wrong. A POSITA would understand that Leaning US 2008's statement discussed above (*i.e.*, "same principle" disclosed for

[2] Petitioner and Dr. Rejaie also cite to another portion of Leaning US 2008 discussing video, but that section is directed to "fast forward" and "fast rewind" functionality, which differs from rate shifting insofar as users would be more willing to accept serious visual errors and distortions when fast forwarding or rewinding, as compared to rate shifting during playout of a recorded or live streaming video. *See* EX1003, ¶ 114 (citing EX1004, 13:42-14:64). Similarly, Dr. Rejaie also cites to other portions of Leaning US 2008 that disclose that the "same [unstated] system can be used for a live audio (or video) feed," but these portions do not relate to rate shifting of video. *See, e.g.*, EX1003, ¶¶ 97, 98. These portions of Leaning US 2008 are therefore largely irrelevant to the argument below, which focuses primarily on the claimed rate shifting functionality.

audio "may be applied to the delivery of video recordings" (EX1004, 12:48-57)) was, at best, aspirational, and that applying Leaning US 2008's teachings would not result in a commercially-acceptable solution. Indeed, in the very next paragraph, Leaning US 2008 explains that "further implications" arise for "delivery of video recordings." EX1004, 12:65-67. And those "further implications" are particularly problematic for the particular configuration on which Petitioner and Dr. Rejaie's obviousness theory is exclusively premised.

48. Specifically, Petitioner and Dr. Rejaie's obviousness theories for each Challenged Claim expressly and exclusively rely on the "H.261" video codec to encode video for streaming and to decode it for playback. EX1003, ¶¶ 53, 104, 113, 115, 127. For example, Dr. Rejaie states the following:

> Further based on my personal knowledge and experience, it is my opinion that 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***.

EX1003, ¶ 115. Petitioner and Dr. Rejaie cite this same analysis for meeting elements of other claims as well. *See* EX1003, ¶¶ 126-240.

49. But Leaning US 2008 expressly states that such a modification "***is not possible***." EX1004, 13:9-11. Indeed, Leaning US 2008 explains that use of "H.261," as relied on by Dr. Rejaie, results in "***serious mistracking***" after rate-shifting. EX1004, 13:9-33. In view of this, a POSITA would have understood that Leaning US 2008 not only teaches away from the modification that Petitioner and Dr. Rejaie propose, it also expressly states that such proposed modification would result in a system that is inoperable for video streaming.

50. The audio-based content partitioning technique of Leaning US 2008 relied on by Dr. Rejaie involve two steps, which are expressly described in Leaning US 2008 as being performed in an order that precludes the ability to achieve streaming when applied to ***video***. First, the same source content is encoded at several bitrates. Second, the encoded content is "partitioned" into sub-files.

> 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 ….

EX1004, 5:40-45 (emphasis added). Thus, Dr. Rejaie relies on Leaning US 2008's disclosed approach to ***audio*** segmentation that involves "encoding … ***then*** partition[ing]" to arrive at the claimed "files" or "streamlets." *See, e.g.*, EX1003, ¶¶ 103, 106, 107, 118, 123 (emphasis added) (each citing figures and portions of Leaning US 2008 discussing partitioning or partitioned audio files).

51. But Dr. Rejaie overlooks that partitioning ***video*** files in this manner would prevent the decoder from properly decoding partitioned files received after a rate switch, yielding discontinuities and undesirable artifacts in playback, as confirmed by the explicit teachings of Leaning US 2008 itself. Leaning US 2008 refers to this problem as "mistracking." EX1004, 13:19-20. The results of "mistracking" are dramatic, as demonstrated empirically by the images below, where the left image shows a properly decoded frame taken from a complete media file and the right image shows the same frame taken from a portion of that same media file:

Properly Decoded Frame	Same Frame With "Mistracking"
	

52. The left image was decoded sequentially from the beginning of the media file, while the right frame was decoded sequentially from the beginning of the portion of the media file, rather than the media file itself. "Mistracking" arises under these circumstances for video, but not audio, because each frame of an audio file is independently decodable without any dependencies between frames. By contrast, video is encoded using a mixture of independently decodable frames (I-frames), and dependently decodable frames (P- or B-frames), the latter of which can only be decoded if the decoder has access to other preceding frames. As Leaning US 2008 explains, problems arise when the player has to decode a dependently decodable frame for which the decoder does not have the preceding frame from which it depends. EX1004, 16:26-31. Leaning US 2008 expressly discloses that "mistracking" will occur if the system were to attempt to perform rate switching between videos compressed with the H.261 "inter-frame" coding techniques because

"of course the terminal does not have at its disposal" the preceding frames required to decode the P-Frames of the new stream. EX1004, 13:18-20.

53. Returning to the images above, the difference between these two frames is that the left frame was decoded when the decoder had access to the I-Frame at the beginning of the original video file, while the right frame was decoded when the decoder did not have access to the I-Frame at the beginning of the original video file, simulating a "rate switch" operation in Leaning US 2008. The result is that the right image was decoded without the benefit of the preceding intra-frame, or "I-frame," needed to decode it, which results in a significant loss in image data.

54. The images above were generated from a video file called "akiyo." The "akiyo" video is a well-known video for demonstrating and testing video codecs. I downloaded the uncompressed YUV4MPEG format of the akiyo video at CIF resolution (352x288) from https://media.xiph.org/video/derf/. I have included a copy of the akiyo video as EX2011.[3] I opened the uncompressed akiyo video in the freely available VLC media player and played it on my computer. The video played back at the expected CIF resolution without any playback issues.

[3] I was told by counsel that the PTAB's PTACTS filing system only accepts MPEG4-encoded videos. Accordingly, the uncompressed akiyo video is encoded in MPEG4 format in order to facilitate filing. I reviewed the MPEG4 compressed version of the video and confirmed it plays as expected at the CIF resolution.

55. The uncompressed akiyo video was then compressed in H.261 format specifying a 128 kbit/second bitrate using the ffmpeg tool, which is a widely-used open source video codec. https://www.ffmpeg.org/. The command for encoding the uncompressed akiyo video follows:

> ffmpeg -i akiyo_cif.y4m -b:v 128k -g 99999 -c:v h261 akiyo_cif.h261.

56. Next, the following command was run to segment the h.261 encoded version into four second sub-files:

> ffmpeg -i akiyo_cif.h261 -c copy -f segment -segment_time 4 segment_cif_%03d.h261

57. Executing this command created three sub-files of the akiyo video. While the first sub-file plays at CIF resolution as expected, the second and third sub-files do not. Those sub-files demonstrate the concept of "mistracking" discussed by Leaning US 2008. The image on the right side above was generated by taking a screenshot during playback of the second subfile. I have included a copy of the second sub-file at EX2010.[4]

58. Critically, Dr. Rejaie failed to address this "serious mistracking" problem as expressly disclosed by Leaning US 2008 and failed to explain how or

[4] I transcoded the second H.261 sub-file from the segmented akiyo video in MPEG4 format in order to comport with the PTACTS filing system. I reviewed the MPEG4 compressed version to confirm it displays the same mistracking effect I experienced when playing the H.261 encoded version.

why a POSITA would modify Leaning US 2008's teaching to resolve "mistracking" in video.

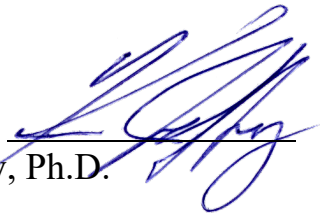
VII. Conclusion

59. I reserve the right to add to or modify this expert declaration in the event that inaccuracies or omissions are discovered or if new or additional information is provided to me. I also reserve the right to make any such other changes as may be deemed necessary or appropriate.

60. I have not yet developed all demonstratives or illustrations to illustrate my opinions and the bases for those opinions; however, I reserve the right to present any and all such demonstratives or illustrations at trial or a hearing.

61. I reserve the right to supplement and/or amend my analyses and opinions expressed herein in response to any new positions taken by Petitioner's experts or witnesses in reports, declarations, affidavits, or testimonies whether in response to my report herein or in amendment to their previous reports and testimonies to the extent such positions are relevant to the subject matter I have addressed in my report herein.

62. I declare under I declare under penalty of perjury that the foregoing is true and correct.

Signature: 
Kevin Jeffay, Ph.D.

Executed On June 16, 2025 at San Jose, CA

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Education

Ph.D. Computer Science, University of Washington.
Honors: IBM Graduate Fellowship.

M.Sc. Computer Science, University of Toronto.
Honors: University of Toronto Open Fellowship.

B.S. Mathematics with Highest Distinction, University of Illinois at Urbana-Champaign.
Honors: Phi Beta Kappa, James Scholar.

Academic Experience

Gillian T. Cell Distinguished Professor in Computer Science, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 2008–present.

Chairman, Department of Computer Science, University of North Carolina at Chapel Hill, Chapel Hill, NC, 2014–2022, 2024.

S. S. Jones Distinguished Professor in Computer Science, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 2001–2008.

S. S. Jones Distinguished Term Associate Professor of Computer Science, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 2000.

Associate Professor, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 1996–2000.

Visiting Professor, Carnegie Mellon University, School of Computer Science, Pittsburgh, PA, 1994.

Assistant Professor, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 1989–1995.

Honors and Awards

Alumni Achievement Award, University of Washington, Department of Computer Science and Engineering, June 2015.

Excellence in Teaching Award, Computer Science Student Association, University of North Carolina at Chapel Hill, Department of Computer Science, May 2011.

Favorite Faculty Award, an award given by the Computer Science majors of the 2010 graduating class, May 2010.

Carolina Women's Center Women's Advocacy Award, University of North Carolina at Chapel Hill, Chapel Hill, NC, March 2010.

Gillian T. Cell Distinguished Professor in Computer Science, University of North Carolina at Chapel Hill, College of Arts and Sciences, Chapel Hill, NC, June 2008.

Outstanding Teaching Award, an award given by the Computer Science majors of the 2008 graduating class, May 2008.

Favorite Faculty Award, an award given by the Computer Science majors of the 2004 graduating class, May 2004.

Edward Kidder Graham Outstanding Faculty Award, an award given by the Class of 2004 and the General Alumni Association, April 2004.

Edward Kidder Graham Advisor of the Year Award, an award given by the Class of 2004 and the General Alumni Association, April 2004.

IEEE Service Award, Service to the IEEE Technical Committee on Real-Time Systems, December 2001.

Outstanding Teaching Award, Computer Science Student Association, University of North Carolina at Chapel Hill, Department of Computer Science, May 2000.

S. Shepard Jones Distinguished Term Professorship, University of North Carolina at Chapel Hill, College of Arts and Sciences, Chapel Hill, NC, March 1999.

Award Papers:

ACM SIGCOMM 2000, 2003.

IEEE International Symposium on High Assurance Systems Engineering 1999, 2000.

IEEE Real-Time Technology and Applications Symposium, 1995.

ACM International Conference on Multimedia, 1994.

Computer Networks and ISDN Systems, 1994.

International Workshop on Network and Operating System Support for Digital Audio and Video, 1991, 1992, 1993, 1997.

Testifying Experience (Within Last Four Years)

CosmoKey Solutions GMBH & Co. KG v. Duo Security, Inc. n/k/a Duo Security LLC and Cisco Systems, Inc., United States District Court for the District of Delaware, Case No. 18-1477-CFC.

Provided deposition and trial testimony on behalf of defendants Duo Security LLC and Cisco Systems, Inc.

In re: Inter Partes review of U.S. Patent Nos. 8,868,772, 9,407,564, 10,757,156, 11,991,234.

Provided deposition testimony on behalf of Patent Owner DISH Technologies LLC.

Headwater Research LLC, v. Cellco Partnership, d/b/a Verizon Wireless and Verizon Corporate Services Group Inc., and *Headwater Research LLC v. T-Mobile USA, Inc. et al,* United States District Court for the Eastern District of Texas, Marshall Division, Case Nos. 2:23-cv-00352-JRG-RSP, 2:23-cv-00379-JRG-RSP, and 2:23-cv-00377-JRG-RSP.

Provided deposition testimony on behalf of defendants Verizon Wireless *et al*. and T-Mobile *et al.*

Joseph Taylor, Edward Mlakar, Mick Cleary, Eugene Alvis, and Jennifer Nelson, individual and on behalf of all others similarly situated, v. Google LLC, United States District Court for the Northern District of California, San Jose Division, Case No. 5:20-cv-07956-VKD.

Provided deposition testimony on behalf of defendant Google LLC.

Touchstream Technologies Inc., *v. Comcast Cable Communications, LLC, d/b/a XFINITY, et al.,* United States District Court for the Eastern District of Texas, Marshall Division, Case No. 2:23-cv-00062-JRG.

Provided deposition and trial testimony on behalf of defendant Comcast Cable Communications LLC.

Corrigent Corporation, *v. Cisco Systems, Inc.,* United States District Court for the Western District of Texas, Waco Division, Case No. 6:22-cv-369-ADA-DTG.

Provided deposition and trial testimony on behalf of defendant Cisco Systems.

Koninklijke KPN N.V. v. Cisco Systems, Inc., Arbitration Pursuant to the Rules of Arbitration of the International Chamber of Commerce, ICC Case No. 28424/PDP.

Provided deposition testimony on behalf of respondent Cisco Systems, Inc.

In re: Inter Partes review of U.S. Patent Nos. 9,407,564, 10,469,554, 10,951,680, 11,470,138, 11,677,798.

Provided deposition testimony on behalf of Patent Owner DISH Technologies LLC.

IBM Corporation, *v. Zynga, Inc.,* United States District Court for the District of Delaware, Case No. 1:22-cv-00590-GBW.

Provided deposition and trial testimony on behalf of plaintiff IBM Corp.

Netsocket Inc., *v. Cisco Systems, Inc.,* United States District Court for the Eastern District of Texas, Marshall Division, Case No. 2:22-00172-JRG.

Provided deposition testimony on behalf of defendant Cisco Systems, Inc.

DataCore Software Corporation, *v. Scale Computing, Inc.,* United States District Court for the District of Delaware, Case No. 22-535-GBW.

Provided deposition and trial testimony on behalf of defendant Scale Computing Systems.

Koninklijke Philips N.V. and Philips North America LLC, v. Hewlett Packard, Inc., United States District Court for the District of Delaware, Case No. 2:20-cv-1241-CFC.

Provided deposition and hearing testimony on behalf of defendant Hewlett Packard, Inc.

Smart Path Connections, LLC, *v. Nokia Corporation, et al.,* United States District Court for the Eastern District of Texas, Marshall Division, Case No. 2:22-cv-00296-JRG-RSP.

Provided deposition and trial testimony on behalf of defendant Nokia Corporation.

Lionra Technologies Ltd., *v. Cisco Systems, Inc.,* United States District Court for the Eastern District of Texas, Marshall Division, Case No. 2:22-cv-00305-JRG-RSP.

Provided deposition testimony on behalf of defendant Cisco Systems.

In re: Inter Partes review of U.S. Patent No. 7,895,641.

Provided deposition testimony on behalf of Petitioner Palo Alto Networks, Inc.

Correct Transmission, LLC, *v. Nokia Corporation, et al.,* United States District Court for the Eastern District of Texas, Marshall Division, Case No. 2:22-cv-0343-JRG-RSP.

Provided deposition testimony on behalf of defendant Nokia Corporation.

WSOU Investment, LLC d/b/a Brazos Licensing and Development v. Salesforce.com, Inc., United States District Court for the Western District of Texas, Waco Division, Case No. 6:20-cv-01167-ADA.

Provided deposition testimony on behalf of defendant Salesforce.com, Inc.

3G Licensing, S.A., Koninklijke KPN N.V., and Orange, S.A., v. HTC Corporation, United States District Court for the District of Delaware, Case Nos. 17-cv-83-GBW.

Provided trial testimony on behalf of defendant HTC Corporation.

In re: Inter Partes review of U.S. Patent No. 9,878,243.

Provided deposition testimony on behalf of Petitioner DraftKings Inc.

Attila Csupo, et al., v. Google LLC, Superior Court of the State of California for the County of Santa Clara, Case No. 1:19CV352557.

Provided deposition testimony on behalf of defendant Google LLC.

WSOU Investment, LLC d/b/a Brazos Licensing and Development v. Dell Technologies Inc., Dell Inc., EMC Corporation, and Vmware Inc., United States District Court for the Western District of Texas, Waco Division, Case Nos. 6:20-cv-00481 & -00486-ADA-DTG.

Provided deposition testimony on behalf of defendant Vmware, Inc.

Voxer, Inc. and Voxer IP LLC v. Facebook, Inc. and Instagram LLC, United States District Court for the Western District of Texas, Austin Division, Case No. 1:20-cv-00655 [ADA].

Provided deposition and trial testimony on behalf of defendants Facebook, Inc., and Instagram LLC.

Koninklijke KPN N.V., v. Telefonaktiebolaget LM Ericsson and Ericsson, Inc., United States District

Court for the Eastern District of Texas, Marshall Division, Case No. 2:21-cv-113.

Provided trial testimony on behalf of defendants Telefonaktiebolaget LM Ericsson and Ericsson, Inc.

In re: Inter Partes review of U.S. Patent No. 7,783,788.

Provided deposition testimony on behalf of Petitioner Hewlett Packard Enterprise Company.

Egenera, Inc., v. Cisco Systems, Inc., United States District Court for the District of Massachusetts, Case No. 1-16-cv-11613-RGS.

Provided deposition and trial testimony on behalf of defendant Cisco Systems, Inc.

In re: Inter Partes review of U.S. Patent No. US 8,243,593.

Provided deposition testimony on behalf of Petitioner Cloudflare, Inc. and Sonicwall, Inc.

Flexiworld Technologies, Inc., v. Roku, Inc., United States District Court for the Western District of Texas, Waco Division, Case No. 6:20-cv-00819-ADA.

Provided deposition testimony on behalf of defendant Roku, Inc.

Longhorn HD, LLC v. Netscout Systems, Inc., United States District Court for the Eastern District of Texas, Marshall Division, Case No. 2:20-cv-00349.

Provided deposition and trial testimony on behalf of defendant Netscout Systems, Inc.

ClearDoc, Inc. v. Riverside, Inc., United States District Court for the District of Delaware, Case No. 21-1422-RGA.

Provided deposition testimony on behalf of defendant RiversideFM, Inc.

AlterWAN, Inc. v. Amazon.com, Inc. and Amazon Web Services, Inc., United States District Court for the District of Delaware, Case No. 1:19-cv-01544-MN.

Provided deposition testimony on behalf of defendants Amazon.com, Inc. and Amazon Web Services, Inc.

Industry Experience

Consultant, Mälardalen University, Vásteras, Sweden, 2001.

Member, Technical Advisory Board, Ganymede Software Inc., Research Triangle Park, NC, 1996–1999.

Consultant and Author, INTEROP Graduate Institute, SOFTBANK Inc., Foster City, CA, 1996–1997.

Consultant, National Science Foundation, Arlington, VA, 1995–2014.

Consultant, Monterey Technologies Inc., Cary, NC, 1994–1996.

Consultant, Hewlett-Packard Inc., Ink Jet Components Division, Corvallis, OR, 1993–1994.

Visiting Researcher, IBM T.J. Watson Research Center, Computer Systems Principles Group, Yorktown Heights, NY, 1986.

Consultant, Boeing Aerospace, Kent, WA, 1985–1986.

Software Engineer, R.R. Donnelley & Sons Company Inc., Technical Center, Chicago, IL, 1984.

Computer Programmer, US Army Corps of Engineers Construction Engineering Research Lab, Champaign, IL, 1981–1982.

Community Service

Consultant (unpaid), Children's Museum About the World (now called *Exploris*), Raleigh, NC, 1995–1996.

Professional Activities

Editor
Associate Editor, *Real-Time Systems*, Kluwer Academic Publishers, The Netherlands, 2003-2012.
Editor in Chief, *Multimedia Systems*, ACM/Springer-Verlag, Heidelberg, Germany, 2000–2001.

Editorial Board
Journal of Multimedia Tools and Applications, Kluwer Academic Publishers, 1994–1999.

Guest Editor
Computer Communications, special issue on system support for multimedia computing, Volume 18, Number 10, October 1995.

Executive Committees
ACM/SIGCOMM Internet Measurement Conference Steering Committee, 2005-2009.
College of Reviewers, Canada Research Chairs Program, 2004-2008.
Statistical and Applied Mathematical Sciences Institute (SAMSI) program on Network Modeling for the Internet, 2002-2004.
IEEE Technical Committee on Real-Time Systems, 2000-2007.
ACM Special Interest Group on Multimedia, 2000-2002.

Other Committees
IEEE Distinguished Visitors Program, 2004–2007.

Conference Program Chair
11th International Workshop on Quality-of-Service (Co-Chair), Monterey, CA, June 2003.
Sixth IEEE Symposium on Computers and Communications, Hammamet, Tunisia, July 2001.
21st IEEE Real-Time Systems Symposium, Orlando, FL, November 2000.
Tenth International Workshop on Network and Operating System Support for Digital Audio and Video, Chapel Hill, NC, June 2000.
Seventh ACM International Conference on Multimedia (Co-Chair), Orlando, FL, November 1999.
SPIE/ACM Multimedia Computing and Networking 1999 (Co-Chair), San Jose, CA, January 1999.
Sixth ACM International Conference on Multimedia (Associate Chair), Bristol, UK, September 1998.
IEEE International Conference on Multimedia Computing Systems (Associate Chair), Austin, TX, June 1998.
SPIE/ACM Multimedia Computing and Networking 1998 (Co-Chair), San Jose, CA, January 1998.
SPIE/ACM Multimedia Computing and Networking 1997 (Associate Chair), San Jose, CA, February 1997.
IEEE Workshop on Resource Allocation Problems in Multimedia Systems, Washington D.C., December 1996.
Second IEEE Real-Time Technology and Applications Symposium, Boston, MA, June 1996.

Conference General Chair
ACM SIGCOMM Internet Measurement Conference, San Diego, CA, October 2007.
22nd IEEE Real-Time Systems Symposium, London, UK, December 2001.
Tenth International Workshop on Network and Operating System Support for Digital Audio and Video, Chapel Hill, NC, June 2000.
Third IEEE Real-Time Technology and Applications Symposium, Montreal, Canada, June 1997.
IEEE Workshop on Resource Allocation Problems in Multimedia Systems, Washington D.C., December 1996.

Member of Conference Program
21st IEEE International Conference on Network Protocols, Goettingen, Germany, October 2013.
18th IEEE International Conference on Network Protocols, Kyoto, Japan, October 2010.

Committee

ACM SIGCOMM 2010, New Delhi, India, August 2010.

17th IEEE International Conference on Network Protocols, Princeton, NJ, October 2009.

9th Passive and Active Measurement Conference 2008, Cleveland, OH, April 2008.

ACM SIGMETRICS 2008, Annapolis, MA, June 2008.

IEEE INFOCOM 2008, Phoenix, AZ, April 2008.

6th ACM SIGCOMM Workshop on Hot Topics in Networks, Atlanta, GA, November 2007.

15th IEEE International Conference on Network Protocols, Beijing, China, October 2007.

5th IEEE Workshop on Embedded Systems for Real-Time Multimedia, Salzburg, Austria, October 2007.

Workshop on Experimental Computer Science, ACM FCRC, San Diego, CA, June 2007.

15th International Workshop on Quality-of-Service, Chicago, IL, June 2007.

17th International Workshop on Network and Operating System Support for Digital Audio and Video, Urbana-Champaign, IL, June 2007.

10th IEEE Global Internet Symposium 2007, Anchorage, AK, May 2007.

ACM SIGMETRICS 2007, San Diego, CA, June 2007.

14th IEEE International Conference on Network Protocols, Santa Barbara, CA, October 2006.

ACM Internet Measurement Conference 2006, Rio de Janeiro, Brazil, October 2006.

Second ACM SIGCOMM Conference on Future Networking Technologies, Lisbon, Portugal, December 2006.

16th International Workshop on Network and Operating System Support for Digital Audio and Video, Newport, RI, June 2006.

IEEE Workshop on Research Directions for Security and Networking in Critical Real-Time and Embedded Systems, San Jose, CA, April 2006.

IEEE INFOCOM 2006, Barcelona, Spain, April 2006.

13th IEEE International Conference on Network Protocols, Boston, MA, November 2005.

15th International Workshop on Network and Operating System Support for Digital Audio and Video, Skamania, WA, June 2005.

IEEE INFOCOM 2005, Miami, FL, March 2005.

SPIE/ACM Multimedia Computing and Networking 2005, San Jose, CA, January 2005.

ACM Multimedia 2004, New York, NY, October 2004.

ACM Internet Measurement Conference 2004, Taormina, Italy, October 2004.

16th EUROMICRO Conference on Real-Time Systems, Catania, Italy, June-July 2004.

14th International Workshop on Network and Operating System Support for Digital Audio and Video, Cork, Ireland, June 2004.

12th International Workshop on Quality-of-Service, Montreal, Canada, June 2004.

10th IEEE Real-time and Embedded Technology and Applications Symposium, Toronto, Canada, May 2004.

IEEE INFOCOM 2004, Hong Kong, March 2004.

24nd IEEE Real-Time Systems Symposium, Cancun, Mexico, December 2003.

19th ACM Symposium on Operating Systems Principles, Lake George, New York, October 2003.

15th EUROMICRO Conference on Real-Time Systems, Porto, Portugal, July 2003.

Ninth IEEE Real-Time and Embedded Technology and Applications Symposium, Toronto, CA, May

2003.

SPIE/ACM Multimedia Computing and Networking 2003, San Jose, CA, January 2003.

23nd IEEE Real-Time Systems Symposium, Austin, TX, November 2002.

10th International Conference on Network Protocols, Paris, France, November 2002.

Second Workshop on Embedded Software, Grenoble, France, October 2002.

22nd IFIP International Symposium on Computer Performance Modeling, Measurement and Evaluation (Performance 2002), Rome, Italy, September 2002.

Eighth IEEE Real-Time and Embedded Technology and Applications Symposium, San Jose, CA, September 2002.

10th International Workshop on Quality-of-Service, Miami, FL, June 2002.

Seventh Global Internet Symposium (held in conjunction with Globecom 2002), Taipei, Taiwan, November 2002.

14th EUROMICRO Conference on Real-Time Systems, Vienna, Austria, June 2002.

ACM SIGMETRICS 2002, Marina del Rey, CA, June 2002.

SPIE/ACM Multimedia Computing and Networking 2002, San Jose, CA, January 2002.

22nd IEEE Real-Time Systems Symposium, London, UK, December 2001.

Sixth Global Internet Symposium (held in conjunction with Globecom 2001), San Antonio, TX, November 2001.

27th EUROMICRO Conference, Warsaw, Poland, September 2001.

Sixth IEEE Symposium on Computers and Communications, Hammamet, Tunisia, July 2001.

Seventh IEEE Real-Time Technology and Applications Symposium, Taipei, Taiwan, June 2001.

Ninth IFIP International Workshop on Quality of Service, Karlsruhe, Germany, June 2001.

SPIE/ACM Multimedia Computing and Networking 2001, San Jose, CA, January 2001.

Fifth Global Internet Mini-Conference (held in conjunction with Globecom 2000), San Francisco, CA, November 2000.

21st IEEE Real-Time Systems Symposium, Orlando, FL, December 2000.

Tenth International Workshop on Network and Operating System Support for Digital Audio and Video, Chapel Hill, NC, June 2000.

Sixth IEEE Real-Time Technology and Applications Symposium, Washington, D.C., June 2000.

SPIE/ACM Multimedia Computing and Networking 2000, San Jose, CA, January 2000.

19th IEEE Real-Time Systems Symposium, Phoenix, AZ, December 1999.

Fourth Global Internet Mini-Conference (held in conjunction with Globecom '99), Rio de Janero, Brazil, November 1999.

Fifth International Workshop on Multimedia Information Systems, Palm Springs, CA, October 1999.

Ninth International Workshop on Network and Operating System Support for Digital Audio and Video, Basking Ridge, NJ, June 1999.

IEEE Workshop on QoS Support for Real-Time Internet Applications, Vancouver, Canada, June, 1999.

Second ACM Workshop on Internet Server Performance (held in conjunction with SIGMETRICS '99), Atlanta, GA, May 1999.

Seventh IEEE International Workshop on Parallel and Distributed Real-Time Systems, San Juan, Puerto Rico, April 1999.

SPIE/ACM Multimedia Computing and Networking 1998, San Jose, CA, January 1999.

19th IEEE Real-Time Systems Symposium, Madrid, Spain, December 1998.

Third Global Internet Mini-Conference (held in conjunction with Globecom '98), Sydney, Australia November 1998.

Sixth ACM International Conference on Multimedia, Bristol, UK, September 1998.

Third IEEE/ACM International Workshop on Multimedia Database Management Systems, Dayton, OH, August 1998.

Eighth International Workshop on Network and Operating System Support for Digital Audio and Video, Cambridge, UK, July 1998.

SPIE Interactive Multimedia Services and Equipment, Zurich, Switzerland, May 1998.

IEEE Workshop on Dependable and Real-Time E-Commerce Systems, Denver, CO, June 1998.

Fourth IEEE Real-Time Technology and Applications Symposium, Denver, CO, June 1998.

IEEE International Conference on Multimedia Computing Systems, Austin, TX, June 1998.

SPIE/ACM Multimedia Computing and Networking 1998, San Jose, CA, January 1998.

16th IEEE Symposium on Reliable Distributed Systems, Durham, NC, October 1997.

Third IEEE Real-Time Technology and Applications Symposium, Montreal, Canada, June 1997.

IEEE Real-Time Education Workshop, Montreal, Canada, June 1997.

Seventh International Workshop on Network and Operating System Support for Digital Audio and Video, St. Louis, MO, May 1997.

17th International Conference on Distributed Computing Systems, Distributed Real-Time Systems Track, Performance of Distributed Systems Track, Distributed Multimedia Track, Baltimore, MD, May 1997.

Fifth IFIP International Workshop on Quality of Service, New York, NY, May 1997.

Third International Conference on Computer Science & Informatics, Raleigh-Durham, NC, March 1997.

SPIE/ACM Multimedia Computing and Networking 1997, San Jose, CA, February 1997.

Fourth ACM International Conference on Multimedia, Boston, MA, November 1996.

Second USENIX Symposium on Operating Systems Design and Implementation, Seattle, WA, October/November 1996.

ACM SIGSOFT '96: Fourth Symposium on the Foundations of Software Engineering, San Francisco, CA, October 1996.

Second IEEE International Workshop on Multimedia Database Management Systems, Blue Mountain Lake, NY, August 1996.

Second IEEE Real-Time Technology and Applications Symposium, Boston, MA, June 1996.

Sixth International Workshop on Network and Operating System Support for Digital Audio and Video, Zushi, Japan, April 1996.

First International Workshop on Real-Time Databases: Issues and Applications, Newport Beach, CA, March 1996.

SPIE Multimedia Computing and Networking 1996, San Jose, CA, February 1996.

16th IEEE Real-Time Systems Symposium, Pisa, Italy, December 1995.

Third ACM International Conference on Multimedia, Technical Paper Program, San Francisco, CA, November 1995.

Third ACM International Conference on Multimedia, Video Program, San Francisco, CA, November 1995.

1995 ACM Conference on Organizational Computing Systems, Technical Track, Milpitas, CA, August 1995.

Fifth IEEE Workshop on Hot Topics in Operating Systems, Orcas Island, WA, May 1995.

15th International Conference on Distributed Computing Systems, Distributed Real-Time Systems Track and CSCW track, Vancouver, British Columbia, Canada, May 1995.

Fifth International Workshop on Network and Operating System Support for Digital Audio and Video, Durham, NH, April 1995.

IEEE Workshop on the Role of Real-Time in Multimedia, Research Triangle Park, NC, December 1993.

14th IEEE Real-Time Systems Symposium, Research Triangle Park, NC, December 1993.

13th International Conference on Distributed Computing Systems, Real-Time Issues Track, Pittsburgh, PA, May 1993.

12th IEEE Real-Time Systems Symposium, San Antonio, TX, December 1991.

IEEE Conference on Communication Software: Communications for Distributed Applications and Systems, Chapel Hill, NC, April 1991.

Conference Organizing Committees

Finance Chair, IEEE Real-Time Systems Symposium, Miami, FL, December 2005.

Finance Chair, IEEE Real-Time Systems Symposium, Lisbon, Portugal, December 2004.

Finance Chair, IEEE Real-Time Systems Symposium, Cancun, Mexico, December 2003.

Poster Session Chair, ACM Symposium on Operating System Principles, Bolton Landing, NY, October 2003.

Demonstrations Chair, ACM Conference on Computer-Supported Cooperative Work, Research Triangle Park, NC, November 1994.

Wine Steward, ACM Symposium on Operating System Principles, Asheville, NC, December 1993.

Local Arrangements Chair, 14th IEEE Symposium on Real-Time Systems, Durham, NC, December 1993.

Refereed Publications

Technical Papers

Explicit Topology Management for Continental-Scale Airborne Networks, B. Newton, J. Aikat, K. Jeffay, IEEE INFOCOM Workshop on Wireless Communications and Networking in Extreme Environments, Atlanta, GA, May 2017, pages 72-77.

Scientific Training in the Era of Big Data: A New Pedagogy for Graduate Education, J. Aikat, T. Carsey, K. Fecho, K. Jeffay, A. Krishnamurthy, P.J. Mucha, A. Rajasekar, S. Ahalt, Big Data, Volume 5, Number 1, 2017, pages 12-18.

Geographic Routing in Extreme-Scale Highly-Dynamic Mobile Ad hoc Networks, B. Newton, J. Aikat, K. Jeffay, Proceedings of the 24th IEEE/ACM International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS), London, UK, September 2016, pages 205-210.

Simulating Large-Scale Airborne Networks with ns-3, B. Newton, J. Aikat, K. Jeffay, Proceedings of the 2015 ACM Workshop on ns-3, Barcelona, Spain, May 2015, pages 32-39.

Explicit Topology Control for Airborne Networks, B. Newton, K. Jeffay, J. Aikat, Proceedings of the 22nd IEEE International Conference on Network Protocols, Research Triangle, NC, October 2014, pages 368-373.

The Continued Evolution of Web Traffic, B. Newton, K. Jeffay, J. Aikat, Proceedings of the 21st IEEE/ACM International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS), San Francisco, CA, August 2013, pages 80-89.

Gini in a Bottle: A Case Study of Pareto's Principle in the Wild, A. Blate, K. Jeffay, International Journal of Computer Networks and Communications Security, Vol. 1, No. 1, June 2013, pages 30-39.

Experiment Replication Using ProtoGENI Nodes, D. O'Neill, J. Aikat, K. Jeffay, Proceedings of the Second GENI Research and Educational Experiment Workshop, Salt Lake City, UT, March 2013, pages 9-15.

Towards Traffic Benchmarks for Empirical Networking Research: The Role of Connection Structure in Traffic Workload Modeling, J. Aikat, S. Hasan, K. Jeffay, F.D. Smith, Proceedings of the 20th IEEE/ACM International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS), Arlington, VA, August 2012, pages 78-86.

Generating Realistic Synthetic TCP Application Workloads, J. Aikat, K. Jeffay, F.D. Smith, Proceedings, GENI Infrastructure Workshop, Princeton, NJ, June 2010, 8 pages.

Correlations of Size, Rate, and Duration in TCP Connections: The Case Against, C. Park, F. Hernández-Campos, J.S. Marron, K. Jeffay, F.D. Smith, Annals of Applied Statistics, Volume 4, Number 1, May 2010, pages 26-52.

Passive, Streaming Inference of TCP Connection Structure for Network Server Management, J. Terrell, K. Jeffay, F.D. Smith, J. Gogan, J. Keller, IFIP International Workshop on Traffic Monitoring and Analysis, Aachen, Germany, May 2009, in, Lecture Notes in Computer Science, Volume 5537, Springer, Berlin, Germany, pages 42-53.

Exposing Server Performance to Network Managers Through Passive Network Measurements, J. Terrell, K. Jeffay, F.D. Smith, J. Gogan, J. Keller, IEEE Internet Network Management Workshop 2008, Orlando, FL, October 2008, pages 1-6.

Multi-Resolution Anomaly Detection for the Internet, L. Zhang, Z. Zhu, K. Jeffay, J.S. Marron, F.D. Smith, IEEE Workshop on Network Management, Phoenix, AZ, April 2008, 6 pages.

The Effects of Active Queue Management and Explicit Congestion Notification on Web Performance, L. Le, J. Aikat, K. Jeffay, F.D. Smith, IEEE/ACM Transactions on Networking, Volume 15, Number 6, December 2007, pages 1217-1230.

Co-Scheduling Variable Execution Time Requirement Real-time Tasks and Non-Real-Time Tasks, A. Singh, K. Jeffay, Proceedings of the 19th Euromicro Conference on Real-Time Systems, Pisa, Italy, July 2007, pages 191-200.

Quantifying the Effects of Recent Protocol Improvements to Standards-Track TCP: Impact on Web Performance, M.C. Weigle, K. Jeffay, F.D. Smith, Computer Communications, Volume 29, Number 15, September 2006, pages 2853-2866.

Tmix: A Tool for Generating Realistic TCP Application Workloads in ns-2, M.C. Weigle, P. Adurthi, F. Hernández-Campos, K. Jeffay, F.D. Smith, ACM Computer Communications Review, Volume 36, Number 3, July 2006, pages 67-76.

A Loss and Queuing-Delay Controller for Router Buffer Management, L. Le, K. Jeffay, F.D. Smith, Proceedings of the 26th IEEE International Conference on Distributed Computing Systems, Lisbon, Portugal, July 2006, 10 pages.

Understanding Patterns of TCP Connection Usage with Statistical Clustering, F. Hernández-Campos, A.B. Nobel, F.D. Smith, K. Jeffay, 13th IEEE/ACM International Symposium on Modeling, Analysis, and

Simulation of Computer and Telecommunication Systems (MASCOTS), Atlanta, GA, September 2005, pages 35-44.

Delay-Based Early Congestion Detection and Adaptation: Impact on Web Performance, M.C. Weigle, K. Jeffay, F.D. Smith, Computer Communications, Volume 8, Number 8, May 2005, pages 837-850.

Extremal Dependence: Internet Traffic Applications, F. Hernández-Campos, K. Jeffay, C. Park, J.S. Marron, S.I. Resnick, Stochastic Models, Volume 21, Number 1, 2005, pages 1-35.

Generating Realistic TCP Workloads, F. Hernández-Campos, F.D. Smith, K. Jeffay, Proceedings of the Computer Measurement Group's 2004 International Conference, Las Vegas, NV, December 2004, pages 273-284.

Differential Congestion Notification: Taming the Elephants, L. Le, J. Aikat, K. Jeffay, F.D. Smith, Proceedings of the 12th IEEE International Conference on Network Protocols, Berlin, Germany, October 2004, pages 118-128.

Stochastic Models for Generating Synthetic HTTP Source Traffic, J. Cao, W.S. Cleveland, Y. Gao, K. Jeffay, F.D. Smith M.C. Weigle, Proceedings of IEEE INFOCOM 2004, Hong Kong, March 2004, Volume 3, pages 1546-1557.

Variability in TCP Roundtrip Times, J. Aikat, J. Kaur, D. Smith, K. Jeffay, Proceedings of the 2003 ACM SIGCOMM Internet Measurement Conference, Miami Beach, FL, October 2003, pages 279-284.

Tracking the Evolution of Web Traffic: 1995-2003, F. Hernández-Campos, K. Jeffay, F.D. Smith, Proceedings of the 11th IEEE/ACM International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS), Orlando, FL, October 2003, pages 16-25.

The Effects of Active Queue Management on Web Performance, L. Le, J. Aikat, K. Jeffay, F.D. Smith, Proceedings of ACM SIGCOMM 2003, Karlsruhe, Germany, August 2003, pages 265-276.

Managing Latency and Buffer Requirements in Processing Graph Chains, S.M. Goddard, K. Jeffay, The Computer Journal, Volume 44, Number 6, 2001, (special issue on high-assurance systems), pages 486-503.

Rate-Based Resource Allocation Methods for Embedded Systems, K. Jeffay, S.M. Goddard, in, *Embedded Software*, Proceedings of the First International Workshop on Embedded Software (*EMSOFT 2001*), Tahoe City, CA, October 2001, Lecture Notes in Computer Science, Volume 2211, T. Henzinger, C. Kirsch, editors, Springer-Verlag, Berlin, Germany, 2001, pages 204-222.

Beyond Audio and Video: Multimedia Networking Support for Distributed, Immersive Virtual Environments, K. Jeffay, T. Hudson, M. Parris, Proceedings of the 27th EUROMICRO Conference, Warsaw, Poland, September 2001, pages 300-307.

Tuning RED for Web Traffic, M. Christiansen, K. Jeffay, D. Ott, F.D. Smith, IEEE/ACM Transactions on Networking, Volume 9, Number 3, (June 2001), pages 249-264.

What TCP/IP Protocol Headers Can Tell Us About the Web, F.D. Smith, F. Hernández Campos, K. Jeffay, D. Ott, Proceedings of ACM SIGMETRICS 2001/Performance 2001, Cambridge, MA, June 2001, pages 245-256.

Experiments in Best-Effort Multimedia Networking for a Distributed Virtual Environment, T. Hudson, M.C. Weigle, K. Jeffay, R.M. Taylor II, in *Multimedia Computing and Networking 2001*, Proceedings, SPIE Proceedings Series, Volume 4312, San Jose, CA, January 2001, pages 88-98.

Analyzing the Real-Time Properties of a U.S. Navy Signal Processing System, S.M. Goddard, K. Jeffay, International Journal of Reliability, Quality and Safety Engineering, Volume 8, Number 4, December

2001, (special issue of HASE '99 best papers) pages 301-322.

A Comparative Study of the Realization of Rate-Based Computing Services in General Purpose Operating Systems, K. Jeffay, G. Lamastra, Proceedings of the Seventh IEEE International Conference on Real-Time Computing Systems and Applications, Cheju Island, South Korea, December 2000, pages 81-90.

The Synthesis of Real–Time Systems from Processing Graphs, S.M. Goddard, K. Jeffay, Proceedings of the Fifth IEEE International Symposium on High Assurance Systems Engineering, Albuquerque, NM, November 2000, pages 177-186.

Tuning RED for Web Traffic, M. Christiansen, K. Jeffay, D. Ott, F.D. Smith, Proceedings of ACM SIGCOMM 2000, Stockholm, Sweden, August-September 2000, pages 139-150.

Towards a Better-Than-Best-Effort Forwarding Service for Multimedia Flows, K. Jeffay, IEEE Multimedia, Volume 6, Number 4, October-December 1999, pages 84-88.

A Theory of Rate-Based Execution, K. Jeffay, S.M. Goddard, Proceedings of the 20th IEEE Real-Time Systems Symposium, Phoenix, AZ, December 1999, pages 304-314.

Parallel Switching in Connection-Oriented Networks, S. Baruah, K. Jeffay, J. Anderson, Proceedings of the 20th IEEE Real-Time Systems Symposium, Phoenix, AZ, December 1999, pages 200-209.

Analyzing the Real-Time Properties of a U.S. Navy Signal Processing System, S.M. Goddard, K. Jeffay, Proceedings of the Fourth IEEE International Symposium on High Assurance Systems Engineering, Washington, DC, November 1999, pages 141-150.

Application-Level Measurements of Performance on the vBNS, M. Clark, K. Jeffay, Proceedings of the IEEE International Conference on Multimedia Computing and Systems, Volume 2, Florence, Italy, June 1999, pages 362-366.

Lightweight Active Router-Queue Management for Multimedia Networking, M. Parris, K. Jeffay, F.D. Smith, in *Multimedia Computing and Networking 1999*, Proceedings, SPIE Proceedings Series, Volume 3654, San Jose, CA, January 1999, pages 162-174.

Proportional Share Scheduling of Operating System Services for Real-Time Applications, K. Jeffay, F.D. Smith, A. Moorthy, J.H. Anderson, Proceedings of the 19th IEEE Real-Time Systems Symposium, Madrid, Spain, December 1998, pages 480-491.

Efficient Object Sharing in Quantum-Based Real-Time Systems, J.H. Anderson, R. Jain, K. Jeffay, Proceedings of the 19th IEEE Real-Time Systems Symposium, Madrid, Spain, December 1998, pages 346-355.

A Better-Than-Best-Effort Service for Continuous Media UDP Flows, M. Parris, K. Jeffay, F.D. Smith, J. Borgersen, Proceedings of the Eighth International Workshop on Network and Operating System Support for Digital Audio and Video, Cambridge, UK, July 1998, pages 193-197.

Managing Memory Requirements in the Synthesis of Real-Time Systems from Processing Graphs, S. Goddard, K. Jeffay, Proceedings of the Fourth IEEE Real-Time Technology and Applications Symposium, Denver, CO, June 1998, pages 59-70.

Fair On-Line Scheduling of a Dynamic Set of Tasks on a Single Resource, S.K. Baruah, J.E. Gehrke, C.G. Plaxton, I. Stoica, H. Abdel-Wahab, K. Jeffay, *Information Processing Letters*, Volume 64, Number 1, October 1997, pages 43-51.

A Two-Dimensional Audio Scaling Enhancement to an Internet Videoconferencing System, P. Nee, K. Jeffay, M. Clark, G. Danneels, Proceedings of the International Workshop on Audio-Visual Services over

Packet Networks, Aberdeen, Scotland, UK, September 1997, pages 201-206.

Feasibility Concerns in PGM Graphs With Bounded Buffers, S. Baruah, S. Goddard, K. Jeffay, Proceedings of the Third IEEE International Conference on Engineering of Complex Computer Systems, Como, Italy, September 1997, pages 130-139.

Analyzing the Real-Time Properties of a Dataflow Execution Paradigm Using a Synthetic Aperture Radar Application, S. Goddard, K. Jeffay, Proceedings of the Third IEEE Real-Time Technology and Applications Symposium, Montreal, Canada, June 1997, pages 60-71.

Real-Time Computing with Lock-Free Shared Objects, J.H. Anderson, S. Ramamurthy, K. Jeffay, ACM Transactions on Computing Systems, Volume 15, Number 2, May 1997, pages 134-165.

The Performance of Two-Dimensional Media Scaling for Internet Videoconferencing, P. Nee, K. Jeffay, G. Danneels, Proceedings of the Seventh International Workshop on Network and Operating System Support for Digital Audio and Video, St. Louis, MO, May 1997, pages 237-248. Republished in "Readings in Multimedia Computing," K. Jeffay, H.J. Zhang, editors, Morgan Kaufmann, 2002.

On the Duality between Resource Reservation and Proportional Share Resource Allocation, I. Stoica, H. Abdel-Wahab, K. Jeffay, in *Multimedia Computing and Networking 1997*, Proceedings, SPIE Proceedings Series, Volume 3020, San Jose, CA, February 1997, pages 207-214.

Strategic Directions in Real-Time and Embedded Systems, J.A. Stankovic, A. Burns, K. Jeffay, M. Jones, G. Koob, I. Lee, J. Lehoczky, J. Liu, A. Mok, K. Ramamritham, J. Ready, L. Sha, A. van Tilborg, *ACM Computing Surveys*, Volume 28, Number 4, December 1996, pages 751-763.

A Proportional Share Resource Allocation Algorithm For Real-Time, Time-Shared Systems, I. Stoica, H. Abdel-Wahab, K. Jeffay, S.K. Baruah, J.E. Gehrke, C.G. Plaxton, Proceedings of the 17th IEEE Real-Time Systems Symposium, Washington, DC, December 1996, pages 288-299.

A General Framework For Continuous Media Transmission Control, T.M. Talley, K. Jeffay, Proceedings of the 21st IEEE Conference on Local Computer Networks, Minneapolis, MN, October 1996, pages 374-383.

A Router-Based Congestion Control Scheme For Real-Time Continuous Media, K. Jeffay, M. Parris, T. Talley, F.D. Smith, Proceedings of the Sixth International Workshop on Network and Operating System Support for Digital Audio and Video, Zushi, Japan, April 1996, pages 79-86.

Lock-Free Transactions for Real-time Systems, J.H. Anderson, S. Ramamurthy, M. Moir, K. Jeffay, Proceedings of the First Workshop on Real-Time Databases: Issues and Applications, Newport Beach, CA, March 1996, pages 107-114.

Real-Time Computing with Lock-Free Shared Objects, J.H. Anderson, S. Ramamurthy, K. Jeffay, Proceedings of the 16th IEEE Real-Time Systems Symposium, Pisa, Italy, December 1995, pages 28-37.

Early Experience with the Repository for Patterned Injury Data, D. Stotts, J.B. Smith, K. Jeffay, P. Dewan, D.K. Smith, W. Oliver, Proceedings of the SPIE International Symposium on Investigative and Trial Image Processing, San Diego, CA, July 1995, SPIE Volume 2567, 1995, pages 249-260.

Early Prototypes of the Repository for Patterned Injury Data, P. Dewan, K. Jeffay, J. Smith, D. Stotts, W. Oliver, Proceedings of Digital Libraries '95, The Second Annual Conference on the Theory and Practice of Digital Libraries, Austin, TX, June 1995, pages 123-130.

Support For Real-Time Computing Within General Purpose Operating Systems: Supporting co-resident operating systems, G. Bollella, K. Jeffay, Proceedings of the IEEE Real-Time Technology and Applications Symposium, Chicago, IL, May 1995, pages 4-14.

A Rate-Based Execution Abstraction For Multimedia Computing, K. Jeffay, D. Bennett, Proceedings of the Fifth International Workshop on Network and Operating System Support for Digital Audio and Video, Durham, NH, April 1995, published in *Lecture Notes in Computer Science*, T.D.C. Little, R. Gusella, editors, Volume 1018, pages 64-75, Springer-Verlag, Heidelberg, Germany, 1995.

An Empirical Study of Delay Jitter Management Policies, D.L. Stone, K. Jeffay, *ACM Multimedia Systems*, Volume 2, Number 6, January 1995, pages 267-279. Republished in "Readings in Multimedia Computing," K. Jeffay, H.J. Zhang, editors, Morgan Kaufmann, 2002.

On the Partitioning of Function in Distributed Synchronous Collaboration Systems, J. Menges, K. Jeffay, ACM CSCW '94, Proceedings of the Workshop on Distributed Systems, Multimedia, and Infrastructure Support in CSCW, Research Triangle Park, NC, October 1994, SIGOIS Bulletin, Volume 15, Number 2, December 1994, pages 34-37.

Two-Dimensional Scaling Techniques For Adaptive, Rate-Based Transmission Control of Live Audio and Video Streams, T.M. Talley, K. Jeffay, Proceedings of the Second ACM International Conference on Multimedia, San Francisco, CA, October 1994, pages 247-254.

Transport and Display Mechanisms For Multimedia Conferencing Across Packet-Switched Networks, K. Jeffay, D.L. Stone, F.D. Smith, *Computer Networks and ISDN Systems*, Volume 26, Number 10, July 1994, pages 1281-1304. Republished in "A Guided Tour of Multimedia Systems and Applications," B. Furht, M. Milenkovic, editors, IEEE Computer Society Press, 1995.

A Patterned Injury Digital Library for Collaborative Forensic Medicine, D. Stotts, J.B. Smith, P. Dewan, K. Jeffay, F.D. Smith, D. Smith, S. Weiss, J. Coggins, W. Oliver, Proceedings of Digital Libraries '94, The First Annual Conference on the Theory and Practice of Digital Libraries, College Station, TX, June 1994, pages 25-33.

The Artifact-Based Collaboration System: An infrastructure for supporting and studying collaboration, K. Jeffay, J.B. Smith, F.D. Smith, D.E. Shackelford, J. Menges, Proceedings of the 15th Interdisciplinary Workshop on Informatics and Psychology, Schärding, Austria, May 1994, 27 pages.

On Latency Management in Time-Shared Operating Systems, K. Jeffay, Proceedings of the 11th IEEE Workshop on Real-Time Operating Systems and Software, Seattle, WA, May 1994, pages 86-90.

Inverting X: An Architecture for a Shared Distributed Window System, J. Menges, K. Jeffay, Proceedings of the Third Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises, Morgantown, WV, April 1994, IEEE Computer Society Press, pages 53-64.

Issues, Problems, and Solutions in Sharing X Clients on Multiple Displays, H. Abdel-Wahab, K. Jeffay, *Internetworking — Research and Practice*, Volume 5, Number 1, March 1994, pages 1-15.

Dynamic Participation in a Computer-based Conferencing System, G. Chung, K. Jeffay, H. Abdel-Wahab, *Computer Communications*, Volume 17, Number 1, January 1994, pages 7-16.

Accounting for Interrupt Handling Costs in Dynamic Priority Task Systems, K. Jeffay, D.L. Stone, Proceedings of the 14th IEEE Real-Time Systems Symposium, Raleigh-Durham, NC, December 1993, pages 212-221.

Queue Monitoring: A Delay Jitter Management Policy, D.L. Stone, K. Jeffay, Proceedings of the Fourth International Workshop on Network and Operating System Support for Digital Audio and Video, Lancaster, UK, November 1993, published in *Lecture Notes in Computer Science*, D. Shepherd, G. Blair, G. Coulson, N. Davies, F. Garcia, editors, Volume 846, pages 149-160, Springer-Verlag, Heidelberg, Germany, 1994.

The Real-Time Producer/Consumer Paradigm: A paradigm for the construction of efficient, predictable real-time systems, K. Jeffay, Proceedings of the 1993 ACM/SIGAPP Symposium on Applied Computing,

Indianapolis, IN, ACM Press, February 1993, pages 796-804.

Accommodating Late-Comers in Shared Window Systems, G. Chung, K. Jeffay, H. Abdel-Wahab, *IEEE Computer*, Volume 26, Number 1, January 1993, pages 72-74.

Scheduling Sporadic Tasks with Shared Resources in Hard-Real-Time Systems, K. Jeffay, Proceedings of the 13th IEEE Real-Time Systems Symposium, Phoenix, AZ, December 1992, pages 89-99.

Adaptive, Best-Effort, Delivery of Audio and Video Data Across Packet-Switched Networks, K. Jeffay, D.L. Stone, T. Talley, F.D. Smith, Proceedings of the Third International Workshop on Network and Operating System Support for Digital Audio and Video, La Jolla, CA, November 1992, published in *Lecture Notes in Computer Science*, V. Rangan, editor, Volume 712, pages 3-14, Springer-Verlag, Heidelberg, Germany, 1993.

Architecture of the Artifact-Based Collaboration System Matrix, K. Jeffay, J.K. Lin, J. Menges, F.D. Smith, J.B. Smith, ACM CSCW '92, Proceedings of the Conference on Computer-Supported Cooperative Work, Toronto, Canada, ACM Press, November 1992, pages 195-202.

Client/Server Protocol Filtering: An infrastructure for supporting group collaborations, K. Jeffay, J. Menges, J.-K. Lin, ACM CSCW '92, Proceedings of the Workshop on Tools and Technologies, Toronto, Canada, November 1992, pages 96-99.

Kernel Support for Live Digital Audio and Video, K. Jeffay, D.L. Stone, F.D. Smith, *Computer Communications*, Volume 15, Number 6, July/August 1992, pages 388-395.

On Kernel Support for Real-Time Multimedia Applications, K. Jeffay, Proceedings of the Third IEEE Workshop on Workstation Operating Systems, Key Biscayne, FL, April 1992, pages 39-46.

On Non-Preemptive Scheduling of Periodic and Sporadic Tasks, K. Jeffay, D.F. Stanat, C.U. Martel, Proceedings of the Twelfth IEEE Real-Time Systems Symposium, San Antonio, TX, December 1991, pages 129-139.

Kernel Support for Live Digital Audio and Video, K. Jeffay, D.L. Stone, F.D. Smith, Proceedings of the Second International Workshop on Network and Operating System Support for Digital Audio and Video, Heidelberg, Germany, November 1991, published in *Lecture Notes in Computer Science*, R.G. Herrtwich, editor, Volume 614, pages 10-21, Springer-Verlag, Heidelberg, Germany, 1992.

UNC Collaboratory Project Overview, J.B. Smith, F.D. Smith, P. Calingaert, J.R. Hayes, D. Holland, K. Jeffay, M. Lansman, Proceedings of the 1991 Symposium on Command and Control Research, National Defense University, Washington, D.C., June 1991, pages 341-391.

YARTOS: Kernel support for efficient, predictable real-time systems, K. Jeffay, D. Stone, D. Poirier, Proceedings of the Joint Eighth IEEE Workshop on Real-Time Operating Systems and Software and IFAC/IFIP Workshop on Real-Time Programming, Atlanta, GA, May 1991, in Real-Time Systems Newsletter, Volume 7, Number 4, Fall 1991, pages 8-13. Republished in "Real-Time Programming," W. Halang, K. Ramamritham, editors, 1992.

System Design for Workstation-Based Conferencing With Digital Audio and Video, K. Jeffay, F.D. Smith, Proceedings of the IEEE Conference on Communication Software: Communications for Distributed Applications and Systems, Chapel Hill, NC, April 1991, pages 169-180.

Designing a Workstation-Based Conferencing System Using the Real-Time Producer/Consumer Paradigm, K. Jeffay, F.D. Smith, Proceedings of the First International Workshop on Network and Operating System Support for Digital Audio and Video, International Computer Science Institute, Berkeley, CA, November 1990, pages 40-55.

Analysis of a Synchronization and Scheduling Discipline for Real-Time Tasks with Preemption

Constraints, K. Jeffay, Proceedings of the Tenth IEEE Real-Time Systems Symposium, Santa Monica, CA, December 1989, pages 295-305.

Corset & Lace: Adapting Ada Runtime Support to Real-Time Systems, T.P. Baker, K. Jeffay, Proceedings of the Eighth IEEE Real-Time Systems Symposium, San Jose, CA, December 1987, pages 158-167.

Research in Real-Time Systems, A.C. Shaw, C. Binding, W.L. Hu, K. Jeffay, Proceedings of the Third IEEE Workshop on Real-Time Operating Systems, Boston, MA, February 1986, pages 121-131.

Book Chapters

Rate-Based Resource Allocation Methods, K. Jeffay, in, "Handbook of Real-Time and Embedded Systems," I. Lee, J. Y-T. Leung, S.H. Son, editors, Chapman & Hall/CRC Press, Boca Raton, FL, 2008, pages 4-1 – 4-15.

Visualization and Natural Control Systems for Microscopy, R.M. Taylor II, D. Borland, F.P. Brooks Jr., M. Falvo, M. Guthold, T. Hudson, K. Jeffay, G. Jones, D. Marshburn, S.J. Papadakis, L.-C. Qin, A. Seeger, F.D. Smith, D.H. Sonnenwald, R. Superfine, S. Washburn, C. Weigle, M.C. Whitton, P. Williams, L. Vicci, W. Robinett, in "Visualization Handbook," C. Johnson, C. Hansen, editors, Harcourt Academic Press, 2005, pages 875-900.

An Empirical Study of Delay Jitter Management Policies, D.L. Stone, K. Jeffay, in "Readings in Multimedia Computing and Networking," K. Jeffay, H.J. Zhang, editors, Morgan Kaufmann, San Francisco, CA, 2002, pages 525-537.

The Performance of Two-Dimensional Media Scaling for Internet Videoconferencing, P. Nee, K. Jeffay, G. Danneels, in "Readings in Multimedia Computing and Networking," K. Jeffay, H.J. Zhang, editors, Morgan Kaufmann, San Francisco, CA, 2002, pages 581-592.

Lock-Free Transactions for Real-time Systems, J.H. Anderson, S. Ramamurthy, M. Moir, K. Jeffay, in "Real-Time Database Systems: Issues and Applications," A. Bestavros, K.J. Lin, S.H. Son, editors, Kluwer Academic Publishers, Norwell, MA, 1997, pages 215-234.

Transport and Display Mechanisms For Multimedia Conferencing Across Packet-Switched Networks, K. Jeffay, D.L. Stone, F.D. Smith, in "A Guided Tour of Multimedia Systems and Applications," B. Furht, M. Milenkovic, editors, IEEE Computer Society Press, Los Alamitos, CA, 1995, pages 439-461.

Contributor to: *R&D for the NII: Technical Challenges*, M.K. Vernon, E.D. Lazowska, S.D. Personick, editors, Interuniveristy Communications Council (EDUCOM), 1994.

YARTOS: Kernel support for efficient, predictable real-time systems, K. Jeffay, D. Stone, D. Poirier, in "Real-Time Programming," W. Halang, K. Ramamritham, editors, Pergamon Press, Oxford, UK, 1992, pages 7-12.

Videotapes

Adaptive, Best-Effort Delivery of Live Audio and Video Across Packet-Switched Networks, K. Jeffay, D.L. Stone, ACM Multimedia '94 Video Proceedings, San Francisco, CA, October 1994, 6 minutes. Excerpts also appear on the CD-ROM version of the conference proceedings.

Abstracts & Short Papers

Quantifying the Effects of Recent Protocol Improvements to Standards-Track TCP, M.C. Weigle, K. Jeffay, and F.D. Smith, Proceedings of the 11th IEEE/ACM International Symposium on Modeling, Analysis, and Simulation of Computer and Telecommunication Systems (MASCOTS), Orlando, FL, October 2003, pages 226-229.

Engineering of Rate Based Services for Real-Time Computing, G. Lamastra, K. Jeffay, 20th IEEE Real-Time Systems Symposium Work in Progress Proceedings, Phoenix, AZ, December 1999, pages 51-55.

Lightweight Active Router-Queue Management for Multimedia Networking, M. Parris, K. Jeffay, F.D. Smith, IS&T/SPIE International Symposium on Electronic Imaging: Science and Technology, San Jose,

CA, January 1999, pages 280-281.

Support For Real-Time Computing in Windows NT, K. Jeffay, Usage Abstracts, USENIX Windows NT Workshop, Seattle, WA, August 1997, page 84.

On the Duality between Resource Reservation and Proportional Share Resource Allocation, I. Stoica, H. Abdel-Wahab, K. Jeffay, IS&T/SPIE Ninth Symposium on Electronic Imaging: Science and Technology 1997, San Jose, CA, February 1997, pages 135-136.

Technical and Educational Challenges For Real-Time Computing, K. Jeffay, *ACM Computing Surveys*, Volume 28A, Number 4(es), December 1996, URL *http://www.acm.org/pubs/contents/journals/surveys/1996-28/#4es*, 3 pages.

Distributed Real-Time Dataflow: An Execution Paradigm for Image Processing and Anti-Submarine Warfare Applications, S. Goddard, K. Jeffay, 19th IEEE Real-Time Systems Symposium Work in Progress Proceedings, Washington, DC, December 1996, pages 55-58.

Why Using the Request Abstraction in Proportional Share Allocation Systems is Useful, I. Stoica, H. Zhang, K. Jeffay, Proceedings of the IEEE Real-Time Systems Symposium Workshop on Resource Allocation Problems in Multimedia Systems, Washington, DC, December 1996, 4 pages.

Future distributed embedded and real-time applications will be adaptive: Meanings, challenges, and research paradigms, A.K. Mok, C.L. Heitmeyer, K. Jeffay, M.B. Jones, C.D. Locke, R. Rajkumar, 15th Proceedings of the 15th IEEE International Conference on Distributed Computing Systems, Vancouver, British Columbia, Canada, May 1995, pages 182-184.

Adaptive, Best-Effort Delivery of Live Audio and Video Across Packet-Switched Networks, K. Jeffay, D.L. Stone, Proceedings of the Second ACM International Conference on Multimedia, San Francisco, CA, October 1994, pages 487-488.

Adaptive Rate-Based Flow and Latency Management of Audio and Video Streams, T.-M. Chen, T. Talley, K. Jeffay, Abstracts of the Fourth Workshop on Network and Operating System Support for Digital Audio and Video, Lancaster, UK, November 1993, pages 17-20.

Client/Server Protocol Filtering: An infrastructure for supporting group collaborations, K. Jeffay, J. Menges, J.-K. Lin, ACM CSCW '92, Proceedings of the Workshop on Tools and Technologies, Toronto, Canada, November 1992, pages 96-99.

Network and Operating Systems Support for Digital Audio and Video, K. Jeffay, in 13th ACM Symposium on Operating System Principles "Work in Progress" Abstracts, E.D. Lazowska, editor, Operating Systems Review, Volume 26, Number 2, April 1992, pages 7-31.

Posters

Education Modules for Networking, Cloud Computing, and Security in Systems Courses, J. Aikat, M.K. Reiter, K. Jeffay, ACM Special Interest Group on Computer Science Education Technical Symposium, Memphis, TN, March 2016.

Efficient Management of a High-Capacity Airborne Network of Commercial Aircraft, B. Newton, J. Aikat, K. Jeffay, NSF Cyber-physical Systems Young Professional Workshop, Washington, DC, March 2014.

Variability of TCP Round-trip Times (RTTs) Over the Years, W. Yau, J. Aikat, K. Jeffay, Grace Hopper Celebration of Women in Computing (GHC), Baltimore, MD, October 2012.

Characterizing Modern Web Traffic using TCP Headers, S. Zolayvar, J. Aikat, K. Jeffay, Grace Hopper Celebration of Women in Computing (GHC), Baltimore, MD, October 2012.

Multivariate SVD Analyses For Network Anomaly Detection, J. Terrell, L. Zhang, K. Jeffay, A. Nobel, H.

Shen, F.D. Smith, Z, Zhu, ACM SIGCOMM 2005 Poster Session, Philadelphia, PA, August 2005.

How Real Can Synthetic Traffic Be?, F. Hernández-Campos, K. Jeffay, F.D. Smith, ACM SIGCOMM 2004 Poster Session, Portland, OR, August 2004.

A Non-Parametric Approach to Generation and Validation of Synthetic Network Traffic, F. Hernández-Campos, A. Nobel, F.D. Smith, K. Jeffay, IMA Workshop on Measurement, Modeling, and Analysis of the Internet, Minneapolis, MN, January 2004.

Sync-TCP: Using GPS Synchronized Clocks for Early Congestion Detection in TCP, M.C. Weigle, K. Jeffay, F.D. Smith, ACM SIGCOMM 2000 Poster Session, Stockholm, Sweden, August 2000, page 6.

Reviews

Advance Reservation Systems, K. Jeffay, Proceedings of the Fifth International Workshop on Network and Operating System Support for Digital Audio and Video, Durham, NH, April 1995, published in *Lecture Notes in Computer Science*, T.D.C. Little, R. Gusella, editors, Volume 1018, pages 1-2, Springer-Verlag, Heidelberg, Germany, 1995.

Books and Proceedings

The Effects of Traffic Structure on Application and Network Performance, J. Aikat, K. Jeffay, and F. D. Smith, Springer Publishing, New York, NY, 2012, 289 pages.

The Effects of Active Queue Management on TCP Application Performance, An experimental performance evaluation, L. Le, K. Jeffay, F.D. Smith, Lambert Academic Publishing, Berlin, Saarbrücken, Germany, 2009, 222 pages.

Quality-of-Service — IWQoS 2003, K. Jeffay, I. Stoica, K. Wehrle, editors, Lecture Notes in Computer Science, Springer-Verlag, Berlin, Heidelberg, Germany, Volume 2707, 2003, ISBN 3-540-40281-0, 517 pages.

Readings in Multimedia Computing and Networking, K. Jeffay, H.J. Zhang, editors, Morgan Kaufman, San Francisco, CA, 2002, ISBN 1-55860-651-3, 863 pages.

Proceedings, The 22nd IEEE Real-Time Systems Symposium, K. Jeffay, G. Buttazzo, editors, IEEE Computer Society Press, Los Alamitos, CA, 2001, ISBN 0-7695-1420-0, 321 pages.

Proceedings, The Sixth IEEE International Symposium on Computers and Communications, K. Jeffay, R. Steinmetz, editors, IEEE Computer Society Press, Los Alamitos, CA, 2001, ISBN 0-7695-1177-5, 754 pages.

Proceedings, The 21st IEEE Real-Time Systems Symposium, K. Jeffay, W. Zhao, editors, IEEE Computer Society Press, Los Alamitos, CA, 2000, ISBN 0-7695-0900-2, 311 pages.

Proceedings, The 10th International Workshop on Network and Operating System Support for Digital Audio and Video, K. Jeffay and H. Vin, editors, Technical Report, Department of Computer Science, University of North Carolina at Chapel Hill, 2000, 320 pages. Proceedings also published on-line at *http://www.cs.unc.edu/nossdav2000*.

ACM Multimedia '99, D. Bulterman, K. Jeffay, H.J. Zhang, editors, ACM Press, Los Angeles, CA, 1999, ISBN 0-8194-3125-7, 500 pages.

Multimedia Computing and Networking 1999, D.D. Kandlur, K. Jeffay, T. Roscoe, editors, Proceedings of SPIE, Volume 3654, SPIE, Bellingham, WA, 1998, ISBN 0-8194-3125-7, 328 pages.

Multimedia Computing and Networking 1998, K. Jeffay, D.D. Kandlur, T. Roscoe, editors, Proceedings of SPIE, Volume 3310, SPIE, Bellingham, WA, 1997, ISBN 0-8194-250-0, 266 pages.

Proceedings, 1997 IEEE Real-Time Technology and Applications Symposium, R. Rajkumar, K. Jeffay,

editors, IEEE Computer Society Press, Los Alamitos, CA, 1997, ISBN 0-8186-8016-4, 269 pages.

Proceedings, IEEE Real-Time Systems Symposium Workshop on Resource Allocation Problems in Multimedia Systems, K. Jeffay, editor, *http://www.cs.unc.edu/~jeffay/meetings/mm-wrkshp96/prog. html,* 1996, 250 pages.

Proceedings, 1996 IEEE Real-Time Technology and Applications Symposium, K. Jeffay, W. Zhao, editors, IEEE Computer Society Press, Los Alamitos, CA, 1996, ISBN 0-8186-7448-2, 264 pages.

Unrefereed Publications

Invited Papers

Modeling and Generation of TCP Application Workloads, F. Hernández-Campos, K. Jeffay, F.D. Smith, Proceedings of the 4th IEEE International Conference on Broadband Communications, Networks, and Systems, Raleigh, NC, September 2007, 10 pages.

Statistical Clustering of Internet Communication Patterns, F. Hernández-Campos, A.B. Nobel, F.D. Smith, K. Jeffay, Proceedings of the 35th Symposium on the Interface of Computing Science and Statistics, Salt Lake City, UT, July 2003, Computing Science and Statistics, Volume 35, 2004.

Rate-Based Resource Allocation Methods for Embedded Systems, K. Jeffay, S.M. Goddard, in, *Embedded Software*, Proceedings of the First International Workshop on Embedded Software (*EMSOFT 2001*), Tahoe City, CA, October 2001, Lecture Notes in Computer Science, Volume 2211, T. Henzinger, C. Kirsch, editors, Springer Verlag, Berlin, Germany, 2001, pages 204-222.

Beyond Audio and Video: Multimedia Networking Support for Distributed, Immersive Virtual Environments, K. Jeffay, T. Hudson, M. Parris, Proceedings of the 27th EUROMICRO Conference, Workshop on Multimedia and Telecommunication, Warsaw, Poland, September 2001, pages 300-307.

Experiments in Best-Effort Multimedia Networking for a Distributed Virtual Environment, T. Hudson, M.C. Weigle, K. Jeffay, R.M. Taylor II, in *Multimedia Computing and Networking 2001*, Proceedings, SPIE Proceedings Series, Volume 4312, San Jose, CA, January 2001, pages 88-98.

Towards a Better-Than-Best-Effort Forwarding Service for Multimedia Flows, K. Jeffay, IEEE Multimedia, Volume 6, Number 4, October-December 1999, pages 84-88.

Network Support For Distributed, Immersive, Virtual Laboratories K. Jeffay, Proceedings of the NSF Workshop on Automated Control of Distributed Instrumentation, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, Urbana, IL, April 1999, pages 73-78.

Storage Requirements For Distributed Virtual Laboratories, K. Jeffay, Proceedings of the Internet2 Distributed Storage Infrastructure Application Workshop, University of North Carolina at Chapel Hill, Chapel Hill, NC, March 1999, pages 57-59.

Efficient Kernel Support for Continuous Time Media Systems, K. Jeffay, Proceedings of the ITC Workshop on Continuous Time Media, Carnegie Mellon University, Pittsburgh, PA, June 1991, 4 pages.

White Papers

Contributor to: *NSF Report on Network Research Testbeds*, B. Braden, M. Gerla, J. Kurose, J. Lepreau, R. Rao, J. Turner, editors, December 2002. A white paper commission by NSF that led to the creation of a $10 million funding program for network research testbeds.

Contributor to: *R&D for the National Information Infrastructure: Technical Challenges*, M.K. Vernon, E.D. Lazowska, S.D. Personick, editors, Interuniveristy Communications Council (EDUCOM), 1994.

Technical Reports

Beyond Window Sharing Hacks: Support for First-Class Window Sharing, J. Menges, K. Jeffay, Report TR97-021, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill,

NC, April 1997.

A Proportional Share Resource Allocation Algorithm For Real-Time, Time-Shared Systems, I. Stoica, H. Abdel-Wahab, K. Jeffay, S.K. Baruah, J.E. Gehrke, C.G. Plaxton, Report TR96-038, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, September 1996.

Predicting Worst Case Execution Times on a Pipelined RISC Processor, S.J. Bharrat, K. Jeffay, Report TR94-072, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, April 1994.

The Design, Implementation, and Use of a Sporadic Tasking Model, K. Jeffay, D. Becker, D. Bennett, S. Bharrat, T. Gramling, M. Housel, Report TR94-073, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, April, 1994.

UNC Collaboratory Project Overview, J.B. Smith, F.D. Smith, P. Calingaert, J.R. Hayes, D. Holland, K. Jeffay, M. Lansman, Report 90-042, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, November 1990.

An Implementation and Application of the Real-Time Producer/Consumer Paradigm, D. Poirier, K. Jeffay, Report 90-038, University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, October 1990.

The Real-Time Producer/Consumer Paradigm: Towards Verifiable Real-Time Computations, K. Jeffay, Report 89-09-15, University of Washington, Department of Computer Science, Seattle, WA, September 1989, (Ph.D. Dissertation).

On Optimal, Non-Preemptive Scheduling of Periodic and Sporadic Tasks, K. Jeffay, R. Anderson, Report 88-11-06, University of Washington, Department of Computer Science, Seattle, WA, November 1988.

On Optimal, Non-Preemptive Scheduling of Periodic Tasks, K. Jeffay, Report 88-10-03, University of Washington Department of Computer Science, Seattle, WA, October 1988.

Software Engineering of Real-Time Operating Systems, A.C. Shaw, K. Jeffay, Report 88-01-01, University of Washington Department of Computer Science, Seattle, WA, January 1988.

Concurrent Programming with Time, A thesis proposal, K. Jeffay, Report 87-10-03, University of Washington Department of Computer Science, Seattle, WA, October 1987.

A Lace for Ada's Corset, T.P. Baker, K. Jeffay, Report 86-09-06, University of Washington Department of Computer Science, Seattle, WA, September 1986.

Software Distributions

GENI tmix — A synthetic TCP workload generator for GENI, J. Aikat, D. O'Neil, B. Newton, K. Jeffay, June 2012.

Distributed to the GENI networking research community.

tmix — A synthetic TCP workload generator, F. Hernández Campos, K. Jeffay, F.D. Smith, June 2005.

Distributed to other academic and industry networking research groups via the Web.

UNC VNC — A version of the public domain workspace sharing system VNC to support secure sharing of workspace regions and windows of individual applications. J. Branscomb, L. Fowler, K. Jeffay, August 2004.

Distributed to other research groups and the public via the Web and SourceForge.

thttp 2003 — An HTTP/v1.0 and v1.1 traffic generation program used to simulate the traffic generated by a collection of geographically distributed web browsers and servers. L. Le, A. Van Osdol, F.D.

Smith, K. Jeffay, January 2004.

Distributed to other academic and industry networking research groups via the Web.

thttp 2001 — An HTTP/v1.0 and v1.1 traffic generation program used to simulate the traffic generated by a collection of geographically distributed web browsers and servers. F. Hernández Campos, F.D. Smith, K. Jeffay, August 2002.

Distributed to other academic and industry networking research groups via the Web.

Packmime Implementation in ns — An implementation of the Lucent Bell Labs (Bill Cleaveland) HTTP traffic model in ns. M.C. Weigle, K. Jeffay, F.D. Smith, September 2001.

Distributed as part of the Network Simulator (**ns-2**) distribution.

UNC Campus Network Trace Data and Empirical Distributions — A collection of network traces and empirical distributions illustrating the nature of web browsing and the structure of web pages. F. Hernández Campos, K. Jeffay, F.D. Smith, June 2001.

Distributed to other academic and industry networking research groups via the Web.

HTTP Analysis Tools— A set of tools for analyzing http connections. F. Hernández Campos, K. Jeffay, F.D. Smith, June 2001.

Distributed as part of the Network Simulator (**ns-2**) distribution.

thttp — An HTTP traffic generation program used to simulate the traffic generated by a collection of geographically distributed web browsers and servers. M. Christiansen, F.D. Smith, K. Jeffay, January 2000.

Distributed to other academic and industry networking research groups via the Web.

FlowGen — A general purpose, programmable network flow generator. M. Clark, K. Jeffay, F.D. Smith, December 1999.

Distributed to Advanced Networking Systems Inc. for use in performance evaluation studies of Internet 2 and Abilene. Also available via anonymous *ftp* from *http://www.cs.unc.edu/Research/Dirt*.

TruTime Device Drivers for FreeBSD — A set of FreeBSD device drivers for the TruTime GPS boards, A. Moorthy, K. Jeffay, and F.D. Smith, December 1998.

Distributed to Advanced Networking Systems Inc. for use in the IETF Internet Performance Measurement Initiative (IPMI) Surveyor network.

YARTOS (*Yet Another Real-Time Operating System*) — A real-time operating system kernel for Intel x86 platforms that uses a novel task implementation based on a single, shared run-time stack, an earliest-deadline-first processor scheduling algorithm developed at UNC, and integrates processor scheduling and inter-process communication. K. Jeffay and D. Stone, January 1996.

Distributed to several universities for use in operating system research and teaching. Also adopted by researchers at IBM's Networking Software Division, RTP, NC, for use in constructing a network protocol evaluation testbed.

XPEL (*The X Protocol Engine Library*) — A C^{++} library for constructing modular X Window System pseudo-servers, J. Menges and K. Jeffay, November 1993.

Distributed on the Internet via anonymous *ftp* from *ftp.cs.unc.edu*.

XTV (*X Terminal View*) — An X Window System pseudo-server that supports window sharing and conferencing across the Internet, H. Abdel-Wahab (Old Dominion University) and K. Jeffay, August 1991.

Distributed by MIT as part of the contributed software portion of the X Window System distribution (release 11, version 5). Last revised January 1993.

Also adopted by the NEC Corporation of Japan as the basis for their *Xprotodist* (X protocol

distributor) product.

Patents

Methods, Systems, and Computer Readable Media For Topology Management and Geographic Routing in Mobile Ad-Hoc Networks, U.S. Patent Number 9,832,705, B. Newton, K. Jeffay, J. Aikat, November 2017.

High-Performance Virtualized Applications Platform, U.S. Patent Application No. 421-343. A. Blate, K. Jeffay, May 2014.

Methods, Systems, and Computer Program Products For Network Server Performance Anomaly Detection, U.S. Patent No. 8,938,532, J.S. Terrell. K. Jeffay, F.D. Smith, R. Broadhurst, January 2015.

Method for Understanding the Use of TCP/IP Networks by Users, and Non-Parametric Generation of Synthetic Internet Traffic, U.S. Patent Number 7,447,209, F. Hernández-Campos, K. Jeffay, F.D. Smith, A. Nobel, November 2008.

User Controlled Adaptive Flow Control for Packet Networks, U.S. Patent Number 5,892,754, V. Kompella, F.D. Smith, J.P. Gray, and K. Jeffay, April 1999.

Public Demonstrations

Education Modules for Networking, Cloud Computing and Security in Systems Courses, J. Aikat, K. Jeffay, Demo session at the ACM SIGCSE, Special Interest Group for Computer Science Education, Memphis, TN, March 2016.

Exploring the Internet's Future with GENI (Global Environment for Network Innovations), J. Aikat, K. Jeffay, NSF Higher Education Technology Conference 2013, Morgantown, WV, October 2013.

Your first experiment on GENI: a Hands-on Tutorial, J. Aikat, K. Jeffay, NSF Higher Education Technology Conference 2013, Morgantown, WV, October 2013.

NSF Workshop on GENI in Education (one day), J. Aikat, K. Jeffay, New York University - Polytechnic, NY, October 2013.

Using the GENI Networking Testbed, J. Aikat, K. Jeffay, ACM SIGCSE, Special Interest Group for Computer Science Education, Denver, Colorado, March 2013.

Run your Systems/Networking Experiments using (free) GENI Resources, Lunchtime Table Topics, S. Zolayvar, W. Yau, J. Aikat, K. Jeffay, Grace Hopper Celebration of Women in Computing, Baltimore, Maryland, October 2012.

NSF Workshop on Designing Tools and Curricula for Undergraduate Courses in Distributed Systems, J. Aikat, K. Jeffay, Boston, MA, July 2012.

Introduction to Network Experiments using the GENI CyberInfrastructure, J. Aikat, K. Jeffay, ACM SIGMETRICS/Performance Joint International Conference on Measurement and Modeling of Computer Systems, London, UK, June 2012.

The nanoManipulator "reverse field trip" to Orange County High-School, G. Jones, R. Superfine, R.M. Taylor, M. Whitton, T. Lovelace, R. Parameswaran, K. Jeffay, F.D. Smith, Orange County High School, Hillsboro, NC, November 1999.

The Distributed NanoManipulator Project, R.M. Taylor, K. Jeffay, T. Hudson, M. Clark, an invited demonstration for the Internet 2 Spring 1999 Members Meeting, Washington, DC, April 1999.

A Demonstration of Internet Access to UNC-CH Advanced Microscopy Facilities for Science Education Outreach, K. Jeffay, F.D. Smith, R. Superfine, G. Jones, R.M. Taylor, T. Hudson, M. Clark, Orange County High School, Hillsboro, NC, June 1998.

The Artifact-Based Collaboration (ABC) System, J.B. Smith, K. Jeffay, D. Shackelford, J. Menges, J. Hilgedic, B. Ladd, M. Parris, E. Kupstas, T. Ellis, and T. Hudson, CSCW '94, ACM Conference on Computer-Supported Cooperative Work, RTP, NC, October 1994.

CONCUR: A Window System Supporting Window Sharing, J. Menges and K. Jeffay, CSCW '94, ACM Conference on Computer-Supported Cooperative Work, RTP, NC, October 1994.

Adaptive, Best-Effort Delivery of Live Audio and Video Across Packet-Switched Networks, K. Jeffay, Second MCNC/NSF Packet Video Workshop, Research Triangle Park, NC, December 1992.

Grants and Awards

GENI in the classroom: Course Modules for Teaching Networking Concepts, J. Aikat, K. Jeffay, National Science Foundation (GENI Project: Raytheon Corporation), October 2013, 3 years, $178,978.

II-New: Seeing the Future: Ubiquitous Computing in EyeGlasses, J.-M. Frahm, *et al.*, National Science Foundation, November 2013, 3 years, $613,623.

GENI Tutorial at ACM SIGCSE, J. Aikat, K, Jeffay, National Science Foundation, grant number CNS 13-32340, March 2013, 1 year, $13,388.

Development of Education and Training Resources for GENI Experimenters, K, Jeffay, J. Aikat, Global Environment for Network Innovations/National Science Foundation, December 2011, 3 years, $388,590.

Exploring Privacy Breaches in Encrypted VoIP Communications, F. Monrose, K, Jeffay, National Science Foundation, grant number CNS 10-17318, August 2010, 3 years, $496,492.

Synthetic Traffic Generation Tools and Resource: A Community Resource for Experimental Networking Research, K, Jeffay, F.D. Smith, UNC, M. Weigle, Old Dominion University, A. Vahdat, University of California San Diego, P. Barford, University of Wisconsin, National Science Foundation, grant number CRI 07-09081, August 2007, 3 years, $799,745.

Modeling and Testing of Application Workloads on Corporate Enterprise Networks, K, Jeffay, F.D. Smith, IBM Global Services Faculty Award, September 2006, 2 years, $70,000 (exempt from indirect costs).

Tera-pixels: Using High-resolution Pervasive Displays to Transform Collaboration and Teaching, K, Jeffay, A. Lastra, K. Mayer-Patel, L. McMillan, F.D. Smith, National Science Foundation (CISE RI Program), grant number EIA 03-03590, August 2003, 5 years, $962,902.

Extracting and Using Semantic Information in Network Workloads, K, Jeffay, F.D. Smith, IBM Global Services Faculty Award, September 2006, 1 year, $40,000 (exempt from indirect costs).

Modeling and Testing of Application Workloads on Corporate Enterprise Networks, K, Jeffay, F.D. Smith, IBM Global Services Faculty Award, September 2006, 1 year, $40,000 (exempt from indirect costs).

Generation and Validation of Synthetic Internet Traffic, K, Jeffay, F.D. Smith, A.B. Noble, National Science Foundation, grant number ANI 03-23648, September 2003, 3 years, $470,000.

Rate-Based Resource Allocation Methods for Real-Time Embedded Systems, K, Jeffay, F.D. Smith,

National Science Foundation, grant number CCR 02-08924, August 2002, 3 years, $179,990.

Empirical Workload Characterizations for Advanced Networks, K. Jeffay, F.D. Smith, Cisco Systems, November 2000, 3 years, $212,500.

Support for Active Queue Management, Distributed XP Programming, and a Teaching Laboratory for Web Services, F.D. Smith, K. Jeffay, J.B. Smith, P.D. Stotts, IBM Shared University Research Grant, August 2002, 1 year, $83,000.

Internet Traffic Measurement and Analysis and A Teaching Laboratory for Enterprise Java Computing, F.D. Smith, K. Jeffay, J.B. Smith, P.D. Stotts, IBM Shared University Research Grant, April 2001, 1 year, $83,000.

An NS Implementation of the HTTP Connection Model, F.D. Smith, K. Jeffay, M. Clark Weigle, Lucent Technologies, April 2001, $10,000.

Multimedia Networking Research in Support of Virtual Field Trips, K. Jeffay, F.D. Smith, R.M. Taylor II, Dell Computer Corporation Strategic Technology and Research (STAR) program, December 2000, 1 year, $25,000.

Rate-based Scheduling Technology for Latency-Sensitive Graphics Applications, J. Anderson, S. Baruah, K. Jeffay, R. Taylor, National Science Foundation, grant number ITR 00-82866, September 2000, 3.5 years, $350,000.

Active Router Queue Management for Congestion Control and Quality-of-Service, K. Jeffay, F.D. Smith, National Science Foundation, grant number ITR 00-82870, September 2000, 3 years, $451,903.

Internet Measurements and Analysis to Support the nanoManipulator and Tele-Immersion, F.D. Smith, K. Jeffay, P. Jones, IBM Shared University Research Grant, September 2000, 1 year, $250,000.

The Performance of Differentiated Services Implementations for Supporting Distributed Virtual Environment Applications, K. Jeffay, North Carolina Network Initiative, September 2000, 1 year, $25,000.

Empirical Application-Workload Characterizations for Advanced Networks, K. Jeffay, F.D. Smith, Sun Microsystems, September 2000, $79,000.

Empirical Application-Workload Characterizations for Advanced Networks, F.D. Smith, K. Jeffay, MCNC, September 2000, 1 year, $50,000.

A Quality-of-Service Network for the nanoManipulator, K. Jeffay, Cabletron Inc. and the North Carolina Network Initiative, September 1999, $25,000.

Interactive Graphics for Molecular Studies and Microscopy — Supplement for Collaborative Science, F.P. Brooks, D. Erie (Chemistry), K. Jeffay, J. Samulski (Gene Therapy), F.D. Smith, D. Sonnenwald (Information and Library Science), R. Superfine (Physics and Astronomy), R. Taylor, National Institute of Health, October 1998, 4 years, $1,902,544.

Computing Power for Collaborative Science, S.R. Aylward, G. Bishop, D.W. Brenner, E. Bullitt, E.L. Chaney, V.L. Chi, B.J. Dempsey, N. England, A.G. Gash, D. Fritsch, H. Fuchs, B. Hemminger, J. Hermans, K. Jeffay, K. Keller, A. Lastra, M. Lin, D. Manocha, L.S. Nyland, S.M. Pizer, J.W. Poulton, J.F. Prins, J. Rosenman, F.D. Smith, R. Superfine, R.M. Taylor, S. Tell, G. Tracton, A. Tropsha, S. Washburn, G. Welch, Intel Corporation, August 1998, 3 years, $2,858,747. PI on *Multimedia Networking* and *A Distributed Teaching Laboratory for Networking and Internet Technologies* sections (F.D. Smith, B.J. Dempsey, Co-PIs), $557,669.

Empirical Application-Workload Characterizations for Advanced Networks, F.D. Smith, K. Jeffay, North

Carolina Network Initiative, September 1998, $40,000.

Congestion control for high-speed networks, F.D. Smith, K. Jeffay, IBM Corporation, 1998, $20,000.

A Communications Middleware For Immersive Distributed Virtual Environments, K. Jeffay, North Carolina Network Initiative, 1998, $15,000.

Technology for Real-Time Services in Protocol Stack Implementations, K. Jeffay, IBM Corporation, 1997, $80,000.

Internet Access to UNC-CH Advanced Microscopy Facilities for Science Education Outreach, K. Jeffay, R. Superfine (Physics and Astronomy), G. Jones (Education), University of North Carolina at Chapel Hill Instructional Technology Award, 1997, $29,750.

Support for the Real-Time Technology and Applications Symposium, K. Jeffay, Office of Naval Research, 1997, $7,000.

Research Experience For Undergraduates supplement to *Object Sharing Technology For Real-Time Systems*, J. Anderson, K. Jeffay, National Science Foundation, 1996, $10,000.

Infrastructure for Research in Collaborative Systems, S.F. Weiss, J.B. Smith, K. Jeffay, P. Dewan, P. D. Stotts, D.K. Smith, F.D. Smith, W. Oliver (U.S. Armed Forces Institute of Pathology), National Science Foundation, grant number CDA-9624662, August 1996, 5 years, $1,260,830.

Collaboration Bus: An Infrastructure for Supporting Interoperating Collaborative Systems, P. Dewan, K. Jeffay, H. Abdel-Wahab (Old Dominion University), P. D. Stotts, L. Nyland, J.B. Smith, J. Mchugh (Portland State University), J. Menges (Hewlett Packard), Advanced Research Projects Agency, grant number 96-06580 (High Performance Distributed Services Technology), 1996, $973,334.

Object Sharing Technology For Real-Time Systems, J. Anderson, K. Jeffay, National Science Foundation, grant number CCR 95-10156, 1996, $209,442.

Flexible Shared Windows, P. Dewan, K. Jeffay, National Science Foundation, grant number IRIS 95-08514, 1995, $343,811.

An ATM Testbed For Multimedia Networking and Computer-Supported Cooperative Work, K. Jeffay, IBM Corporation, 1995, $400,000.

An Examination of Flow and Congestion Control Mechanisms for Media Transmission in Collaborative Systems, K. Jeffay, IBM Corporation, 1995, $125,242.

Software Infrastructure for the Rapid Development of Interactive and Collaborative Educational Simulations, J.F. Prins, K. Jeffay, P.D. Stotts, L.S. Nyland, Advanced Research Projects Agency, grant number 95-36871 (Computer Aided Education and Training Initiative), 1995, $200,000.

A Proposal For Network Routers, K. Jeffay, IBM Corporation, Research Triangle Park, NC, 1994, $40,000.

System Support For Video Teleconferencing Across Local Area Networks, K. Jeffay, Intel Corporation, 1993, $253,385.

The Integration and Use of Digital Audio and Video in Desktop Computing Environments, K. Jeffay, IBM Corporation, 1993, $100,000.

Construction of a UNC-Tektronix MBONE Link, K. Jeffay, Tektronix Corporation, 1993, $10,000.

An Empirical Determination of the Limits of Human Perception of Properties of Digital Audio and Video

Streams, K. Jeffay, University of North Carolina Research Council, 1993, $2,000.

Processor and Resource Allocation Problems in Hard-Real-Time Systems: Theory and Practice, K. Jeffay, National Science Foundation, RIA Award, 1991, $59,400.

Accommodating Continuous Media in a Local Area Network: An exercise in distributed real-time computing, K. Jeffay, University of North Carolina Junior Faculty Development Award, 1990, $3,000.

Building and Using a Collaboratory: A Foundation for Supporting and Studying Group Collaborations, J.B. Smith, F.D. Smith, P. Calingaert, K. Jeffay, J.R. Hayes, D. Holland, M. Lansman, National Science Foundation, grant number ICI-9015443, 1990, $946,000.

Enhanced program of research and teaching in communications software and distributed systems, K. Jeffay, IBM Corporation, 1989, $429,000.

The Design and Construction of Predictable Real-Time Systems, K. Jeffay, Digital Faculty Program Award, Digital Equipment Corporation, 1989, $180,000.

Invited Presentations

Keynote Addresses

Network Neutrality Considered Harmful,

PearlHacks, University of North Carolina at Chapel Hill, Chapel Hill, NC, March 2014.

Carolina Science Café, University of North Carolina at Chapel Hill, Chapel Hill, NC, May 2015.

Network Neutrality Considered Harmful, Revisiting the Quality-of-Service Morass

ACM International Workshop on Network and Operating System Support for Digital Audio and Video, Newport, RI, May 2006.

Rate-Based Resource Allocation Methods for Multimedia Computing

SPIE Multimedia Computing and Networking 2003, Santa Clara, CA, January 2003.

Network Support For Distributed Virtual Environments: The Tele-nanoManipulator

NCNI Advanced Networking Symposium, Research Triangle Park, NC, May 1999.

The Internet 2 Spring Members Meeting (presented jointly with R.M. Taylor), Washington, DC, April 1999.

Network Support For Distributed, Immersive, Virtual Environments

Workshop on Automated Control of Distributed Instrumentation, Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, Urbana, IL, April 1999.

The Future of Networking: The Networking Revolution Has Yet to Begin

North Carolina Governor's Board of Science and Technology Retreat, Banner Elk, NC, September 1998.

Distinguished Lectures

The Synthetic Traffic Generation Problem: The least sexy problem in computer networking

University of Minnesota, Minneapolis, MN, January 2008.

The Effect of Active Queue Management on Web Performance: The Good, the Bad, and the Ugly

University of Nebraska, Lincoln, NE, November 2003.
University of Pennsylvania, April 2004.

The Evolution of Quality-of-Service on the Internet

Mälardalen University, Sweden, February 2001.

Colloquia

Efficient Topology Management and Geographic Routing in High-Capacity Continental- Scale Airborne Networks

University of Virginia, November 2017.

The Evolution of Quality-of-Service on the Internet

IEEE Computer Society Seattle Chapter, Seattle, WA, September 2005.

Modeling and Generating TCP Application Workloads

Georgia Institute of Technology, Atlanta, GA, September 2005.
Microsoft Research, Redmond, WA, September 2005.
Worcester Polytechnic Institute, Worcester, MA, July 2005.
Cisco Systems, RTP, NC, May 2005 (presently jointly with F. Hernandez-Campos and F.D. Smith).

A Rate-Based Execution Abstraction For Embedded Real-Time Systems

University of Pennsylvania, April 2004.

How "Real" Can Synthetic Network Traffic Be?

University of Virginia, March 2004.

Non-Parametric Approach to Generation and Validation of Synthetic Network Traffic

Columbia University, New York, NY, January 2004.

Is Explicit Congestion Notification (ECN) Worthwhile?

Cisco Systems, San Jose, CA, October 2003.
Intel Architecture Labs, Hillsboro, OR, October 2003.

Tuning RED for Web Traffic: RED Considered Harmful?

Sprint Advanced Technology Research Laboratories, San Francisco, CA, March 2000.
University of Illinois at Urbana-Champaign, Urbana, IL, March 2000.

Internet Traffic: Measurement & Generation

Ganymede Software, Research Triangle Park, NC, June 1999. (Presented jointly with F.D. Smith.)

Lightweight Active Router-Queue Management for Multimedia Networking

University of Toronto, October 2000.
HP Laboratories, Palo Alto, CA, January 1999.
Sprint Advanced Technology Research Laboratories, San Francisco, CA, January 1999.

A Better-Than-Best-Effort Service For UDP: Lightweight Active Router-Queue Management for Multimedia Networking

University of Virginia, January 1999.

Congestion Control Mechanisms for Real-Time Communications on the Internet

IBM Networking Systems, Research Triangle Park, NC, November 1998.

A Better Than Best-Effort Forwarding Service For UDP

Microsoft Research, Redmond, WA, March 1998.
IBM Networking Systems, Research Triangle Park, NC, March 1998.

Multimedia Networking Research at UNC Chapel Hill

IBM Networking Systems, Research Triangle Park, NC, February 1998.
Lucent Technologies, Bell Laboratories, Holmdel, NJ, June 1997.

Design Principles for Distributed, Interactive, Virtual Laboratories

Mitsubishi Electric Research Laboratory, Cambridge, MA, January 1998.
Lucent Technologies, Bell Laboratories, Holmdel, NJ, June 1997.

The Performance of Two-Dimensional Media Scaling for Internet Videoconferencing

Mitsubishi Electric Research Laboratory, Cambridge, MA, January 1998.
Carnegie Mellon University, Pittsburgh, PA, March 1997.

Some Approaches to Enabling Real-Time Computation on Desktop Operating Systems

Honeywell Technology Center, Minneapolis, MN, October 1996.

Two-Dimensional Scaling Techniques for Adaptive, Rate-Based Transmission Control of Live Audio and Video Streams

Oregon State University, Corvallis, OR, May 1996.

A Router-Based Congestion Control Scheme For Real-Time Continuous Media

Intel Architecture Development Laboratory, Hillsboro, OR, May 1996.
NetEdge Inc., Research Triangle Park, NC, March 1996.
North Carolina State University, Raleigh, NC, March 1996.

A Hybrid Reservation-Based/Best-Effort Transmission Scheme For Real-Time Transmission of Multimedia Data

Intel Research Council, Hillsboro, OR, November 1995.

Operating System Support For Multimedia Computing

IBM Networking Systems, Research Triangle Park, NC, July 1995.

Network Support For Multimedia Computing

IBM Networking Systems, Research Triangle Park, NC, July 1995.

A Rate-Based Execution Abstraction For Multimedia Computing

Tektronix Computer Research Laboratory, Beaverton, OR, May 1996.
INRIA, Rocquencourt, France, December 1995.
AT&T Bell Laboratories, Murray Hill, NJ, July 1995.

A Theory of Rate-Based Scheduling

Carnegie Mellon University, Pittsburgh, PA, August 1994.

Demonstration of Videoconferencing Over Packet-Switched Internetworks

Global Lecture Hall of the U.S.-Russian Electronic Distance Education System/TELE-TEACHING '93, Trondheim, Norway (via satellite from Chapel Hill), August 1993.

Transport and Display Mechanisms For Multimedia Conferencing Across Packet-Switched Networks

York University, York, England, November 1993.

Purdue University, West Lafayette, IN, February 1993.

Intel Architecture Development Laboratory, Hillsboro, OR, February 1993.

Oregon Graduate Institute, Beaverton, OR, February 1993.

Second MCNC/NSF Packet Video Workshop, Research Triangle Park, NC, December 1992.

Carnegie Mellon University, Pittsburgh, PA, November 1992.

Multimedia and Conferencing Research at UNC-CH

IBM Multimedia Networking, Research Triangle Park, NC, September 1992.

System Support for Synchronous Collaboration

North Carolina Artificial Intelligence and Advanced Computing Symposium, Raleigh, NC, March 1992.

Software Architectures for Predictable Real-Time Computer Systems

Carnegie Mellon University, Pittsburgh, PA, March 1992.

Operating System Requirements for Digital Audio and Video

MCNC/NSF Packet Video Videoconferencing Workshop, Research Triangle Park, NC, December 1991.

Some Experiments With Live Digital Audio and Video on a Local-Area Network

IBM European Networking Center, Heidelberg, Germany, November 1991.

Network and Operating System Support for Digital Audio and Video

Duke University, Durham, NC, November 1994.

Carnegie Mellon University, Pittsburgh, PA, April 1994.

Intel Corporation, Hillsboro, OR, December 1993.

IBM Networking Systems, Research Triangle Park, NC, June 1992.

IBM TJ Watson Research Center, Yorktown Heights, NY, March 1992.

University of Washington, Seattle, WA, February 1992.

Old Dominion University, Norfolk, VA, October 1991.

Systems Research in the UNC Collaboration Project

Intel Architecture Development Laboratory, Hillsboro, OR, May 1992.

University of Colorado, Boulder, CO, March 1991.

Some Deterministic Resource Allocation Problems in Real-Time Computer Systems

Research Triangle Institute, Research Triangle Park, NC, June 1990.

University of North Carolina at Chapel Hill, Department of Operations Research, Chapel

Hill, NC, October 1989.

The Real-Time Producer/Consumer Paradigm: Towards Verifiable Real-Time Computations

Carnegie-Mellon University, Pittsburgh, March 1991.
Duke University, Durham, NC, June 1990.
Technical University of Denmark, Lyngby, Denmark, September 1989.
University of California at Davis, Davis, CA, April 1989.
University of Minnesota, Minneapolis, MN, April 1989.
Purdue University, West Lafayette, IN, April 1989.
University of North Carolina at Chapel Hill, Chapel Hill, NC, April 1989.
University of British Columbia, Vancouver, BC, Canada, April 1989.
Rice University, Houston, TX, March 1989.
University of Arizona, Tucson, AZ, March 1989.
Oregon Graduate Center, Beaverton, OR, March 1989.
Tektronix Computer Research Laboratory, Beaverton, OR, March 1989.
University of Colorado, Boulder, CO, March 1989.
IBM TJ Watson Research Center, Yorktown Heights, NY, March 1989.
IBM Systems Integration Division, Owego, NY, March 1989.
New York University, New York, NY, March 1989.
Bell Communications Research, Morristown, NJ, March 1989.

Concurrent Programming With Time

Olivetti Research Center, Menlo Park, CA, December 1987.
IBM TJ Watson Research Center, Yorktown Heights, NY, September 1987.
Columbia University, New York, NY, September 1987.

Short Courses

Trends in Congestion Control and Quality-of-Service: Active queue management on the Internet of the future

Mälardalen University, Sweden, February 2001.

Rate-Based Execution Models For Real-Time Multimedia Computing

Scuola Superiore Santa Anna, Pisa, Italy, September 1997.

Tutorials

Issues in Multimedia Delivery Over Today's Internet

IEEE International Conference on Multimedia Computing Systems, Austin, TX, June 1998.

Systems Issues in the Design and Realization of Desktop Videoconferencing Systems,

Second ACM International Conference on Multimedia, San Francisco, CA, October 1994.