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12 Attorneys for Plaintiff
 13 ADOBE SYSTEMS INCORPORATED

14 UNITED STATES DISTRICT COURT
 15 NORTHERN DISTRICT OF CALIFORNIA
 16 SAN JOSE DIVISION

17 ADOBE SYSTEMS INCORPORATED, a
 18 Delaware Corporation,

19 Plaintiff,

20 v.

21 WOWZA MEDIA SYSTEMS, INC., a
 22 California Corporation,

23 Defendant.

CASE NO. **CV 11-02243**

COMPLAINT FOR:

LB

- 1) PATENT INFRINGEMENT;
- 2) FALSE ADVERTISING (15 U.S.C. § 1125(a));
- 3) UNFAIR COMPETITION (California common law);
- 4) FALSE ADVERTISING UNDER CALIFORNIA LAW (Cal. Bus. & Prof. Code § 17500 et seq.); and
- 5) UNFAIR COMPETITION UNDER CALIFORNIA LAW (Cal. Bus. & Prof. Code § 17200 et seq.).

JURY TRIAL DEMANDED

Filed

MAY - 6 2011

RICHARD W. WIEKING
 CLERK, U.S. DISTRICT COURT
 NORTHERN DISTRICT OF CALIFORNIA
 SAN JOSE

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1
2 Plaintiff Adobe Systems Incorporated (“Adobe”), for its Complaint against Wowza
3 Media Systems, Inc. (“Wowza,” or “Defendant”), hereby alleges as follows:

4 **PARTIES**

5 1. Plaintiff Adobe is a Delaware corporation with its principal place of business at 345
6 Park Avenue, San Jose, CA 95110.

7 2. On information and belief, Defendant Wowza is a California corporation with a
8 principal place of business at 32560 El Diente Ct., Evergreen, CO 80439, and with offices and/or
9 employees in the Silicon Valley, Stockton, San Diego, and San Francisco Bay areas of
10 California. Wowza’s California agent for service of process is Timothy E. Herr, 152 N. 3rd
11 Street, Suite 500, San Jose, CA 95112.

12 3. Defendant engages in the design, manufacture, sale within the United States, offering
13 for sale in the United States, use within the United States, importation into the United States,
14 and/or sale after importation into the United States of server software that streams content,
15 including software related thereto. On information and belief, Defendant markets and sells this
16 software worldwide.

17 **JURISDICTION, VENUE, AND INTRADISTRICT ASSIGNMENT**

18 4. This is an action for patent infringement arising under the patent laws of the United
19 States, Title 35, United States Code; false advertising under Section 43(a) of the Lanham Act,
20 15 U.S.C. § 1125(a); unfair competition under California common law; false advertising under
21 Cal. Bus. & Prof. Code § 17500 et seq.; and unfair competition under Cal. Bus. & Prof. Code
22 § 17200 et seq.

23 5. **Jurisdiction**: This Court has subject matter jurisdiction over Plaintiff’s claims for
24 relief for violation of the patent laws of the United States, 35 U.S.C. § 100 et seq. under 28
25 U.S.C. §§ 1331 and 1338(a). This Court has subject matter jurisdiction over Plaintiff’s claims
26 for relief for violation of the Lanham Act under 15 U.S.C. § 1121(a) and 28 U.S.C. §§ 1331 and
27 1338(a). This Court has supplemental jurisdiction over Plaintiff’s state law claims pursuant to
28 28 U.S.C. § 1367(a), and jurisdiction over Plaintiff’s unfair competition claims pursuant to 28

1 U.S.C. 1338(b) in that those claims are joined with substantial and related claims under the
2 Lanham Act and the patent laws of the United States, 35 U.S.C. § 100 et seq.

3 6. Defendant is subject to this Court's personal jurisdiction because it is organized and
4 exists under the laws of the State of California, it has designated an agent for service of process
5 in this District, it regularly transacts business in this district, including by developing, marketing,
6 offering for sale, and selling infringing products as described below, and it has committed patent
7 infringement and other unlawful acts as described below in this District.

8 7. Venue is proper in this District under 28 U.S.C. §§ 1391(b) and (c), and 1400(b).

9 8. **Intradistrict Assignment**. This is an Intellectual Property case assigned on a
10 district-wide basis pursuant to Local Rule 3-2(c).

11 **FACTUAL BACKGROUND**

12 **A. Adobe's Flash Platform**

13 9. Adobe is in the business of developing and distributing software for the deployment
14 of content over the Internet using an integrated set of application programming technologies
15 called the Adobe® Flash® Platform. The Flash Platform is one of the most popular multimedia
16 platforms for integrating video, animation, and interactivity into Internet content, and more
17 recently, to build rich Internet applications. Through the Flash Platform and other high-quality
18 products, Adobe has developed and maintained a strong reputation for quality and security, and
19 derives substantial benefit and goodwill from its efforts.

20 10. Adobe's Flash Media Server and Flash Player products are an integral part of the
21 Flash Platform, providing content owners such as major music, movie, and television producers
22 efficient and secure means for meeting the enormous online demand for streaming their video,
23 audio and data ("content"). Flash Media Server streams content to Flash Player using
24 technologies such as Adobe's Real-Time Messaging Protocol ("RTMP"), which Adobe designed
25 for high-performance transmission of digital content.

26 11. Because Internet content is in purely digital form, its unprotected transmission
27 presents a heightened risk of illegal modification, copying, and distribution. Without appropriate
28 safeguards, valuable content can be digitally altered, such as to remove advertising, or

1 unlawfully downloaded, copied, and transmitted repeatedly without degradation of the clarity
2 and overall quality. Once copies of content are “in the clear” and in the hands of others, repeated
3 reproduction and distribution are possible, and these unlawful processes can be replicated
4 endlessly in ways content owners never intended or authorized. Thus, ensuring the protection of
5 streaming content is an essential prerequisite before many content owners will make their
6 copyrighted content available online.

7 12. To address Adobe’s customers’ need for content protection technologies, Adobe
8 invests heavily in developing secure solutions for content distribution. A major portion of this
9 effort involves developing and maintaining technological measures to secure content streamed
10 via RTMP. One of these measures is Encrypted RTMP (“RTMPe”), Adobe’s enhanced version
11 of RTMP that incorporates security measures to prevent unauthorized access to, copying, and
12 downloading content streamed over the Internet using the Flash Platform. Adobe customers rely
13 on the security provided by RTMPe in making their valuable content available online. Adobe
14 introduced RTMPe in December 2007 with the release of Flash Media Server 3.0. To maintain
15 the security of RTMPe, for the benefit of its customers, Adobe has not made the RTMPe
16 specification publicly available.

17 13. Adobe invests heavily in developing updates and enhancements to RTMPe to
18 maintain its effectiveness in preventing illegal modification, copying, and distribution of its
19 customers’ valuable content. These updates and enhancements are incorporated seamlessly into
20 the Adobe Flash Platform products supporting RTMPe, including Flash Media Server and Flash
21 Player. Adobe’s customers desire and rely on these updates and enhancements to RTMPe to
22 protect valuable copyrighted content online. Circumventions or unauthorized versions of
23 RTMPe can undermine the security provided by RTMPe and its effectiveness in protecting
24 valuable content online, including the valuable content of Adobe’s customers.

25 **B. The Patents-in-Suit**

26 14. Implementations of RTMP and RTMPe are covered by Adobe’s intellectual property
27 rights, including U.S. Patent Number 7,272,658, entitled “Real-time priority-based media
28 communication” issued on September 18, 2007 (“the ’658 Patent”), and U.S. Patent Number

1 7,587,509, entitled "Real-time priority-based media communication" issued September 8, 2009
2 ("the '509 Patent," collectively, the "Patents-in-Suit").

3 15. In April 2009, Adobe openly licensed the RTMP Specification to Flash developers
4 worldwide under the RTMP Specification License (available at
5 <http://www.adobe.com/devnet/rtmp.html>), to promote the widespread adoption of Flash Platform
6 technologies by content developers and distributors. A true and correct copy of the RTMP
7 Specification License is attached as Exhibit A.

8 16. In the RTMP Specification License, Adobe provides a license under its patents,
9 conditioned upon full compliance with both the RTMP Specification and the terms of the RTMP
10 Specification License. For example, the RTMP Specification requires specific handshaking
11 sequences (and not others) to initialize an RTMP connection. It also defines specific message
12 formats for transmitting data between the client and server once the RTMP connection is
13 initialized. To obtain a license under Adobe's patents, a party must first fully comply with these
14 and all other requirements set forth in the RTMP Specification. If a party does not comply with
15 such requirements, it is not licensed under Adobe's patents, including the Patents-in-Suit.

16 17. Additionally, one of the requirements set forth in the RTMP Specification License is
17 that a party must not circumvent any of Adobe's secure RTMP measures (e.g., RTMPe). More
18 specifically, a party must agree "not to make, have made, use, sell, offer to sell, import or
19 distribute ... any technology that circumvents technological measures for the protection of audio,
20 video and/or data content, including any of Adobe's secure RTMP measures." Preventing the
21 circumvention of the secure RTMPe measures helps maintain effective protection for valuable
22 content, including the valuable content of Adobe's customers. Thus, any party who engages in
23 such prohibited activities is not licensed under Adobe's patents, including the Patents-in-Suit, for
24 any implementations of RTMP.

25 18. Accompanying the specification and license, Adobe explains on its website that the
26 materials "do not include information or license around any other Flash Media Server
27 technology," and specifically that "the open RTMP specification does not include Adobe's
28 unique secure RTMP measures." Indeed, the RTMP Specification does not provide the

1 requirements for enabling an RTMPe connection. To protect the valuable content of Adobe's
2 customers, RTMPe is not licensed under the RTMP Specification License or otherwise
3 designated by Adobe as an open standard. As Adobe further explains on its website, "[n]or does
4 the license that accompanies the specification allow developers to circumvent such [secure
5 RTMP] measures."

6 **C. Wowza's Unlawful Use of Adobe Technology**

7 19. Wowza develops and sells the Wowza Media Server, which competes directly with
8 Adobe's Flash Media Server. The Wowza Media Server streams content using unauthorized
9 versions of RTMP and RTMPe.

10 20. On information and belief, Wowza Media Server was developed by former Adobe
11 employees David Stubenvoll and Charlie Good. Stubenvoll and Good met while working at
12 Adobe on network publishing products, and were let go by Adobe in 2005 as part of a reduction
13 in force following Adobe's acquisition of Macromedia. Wowza introduced the Wowza Media
14 Server in February 2007, including its unauthorized version of RTMP. In July 2008, Wowza
15 went further by including its unauthorized version of RTMPe with the release of Wowza Media
16 Server version 1.5.2. Wowza's unauthorized versions of RTMP and RTMPe infringe Adobe's
17 intellectual property, including the Patents-in-Suit. Wowza's circumvention efforts and its
18 unauthorized version of RTMPe threaten to undermine the security provided by RTMPe.

19 21. On information and belief, Wowza's unauthorized version of RTMPe is based on its
20 efforts to circumvent RTMPe incorporated into Adobe's Flash Platform products, including
21 Flash Media Server and Flash Player. Wowza's unauthorized version of RTMPe is not
22 compliant with the RTMP Specification. Moreover, by implementing RTMPe, Wowza has
23 failed to comply with the requirements of the RTMP Specification License, including the
24 requirement not to circumvent Adobe's secure RTMP measures. Accordingly, Wowza is not
25 licensed under the RTMP Specification License since it did not fulfill the requirements of the
26 agreement. In any event, Wowza does not have a license to RTMPe because Adobe does not
27 openly license that technology to the public, in order to protect its customers and their valuable
28 content.

1 22. Adobe and Wowza have engaged in discussions regarding Wowza's unauthorized
2 use of Adobe technology. During these discussions, Adobe notified Wowza in writing that it
3 was infringing the Patents-in-Suit. Wowza continues to willfully infringe the Patents-in-Suit by
4 making, using, selling, offering to sell, and/or importing Wowza Media Server with its
5 unauthorized versions of RTMP and RTMPE.

6 **D. Wowza's Misleading Activities**

7 23. Wowza's advertising materials, product descriptions, and public statements and
8 claims have misled consumers into believing that its products and activities, including the
9 Wowza Media Server and the development and distribution of its unauthorized version of
10 RTMPE, are legally sanctioned by Adobe.

11 24. For example, in 2007 a Wowza user identified as "tehnomaag" posted an inquiry on
12 Wowza's public user forum entitled "Legal issues?" and asking "How does Wowza stand in
13 legal terms... Are you cleared by Adobe legal from any potential sticky problems in the future?"
14 A Wowza forum administrator identified as "WowzaDave" posted a reply entitled "No legal
15 issues" and stating "We have no legal issues with Adobe at this time and we don't expect any in
16 the future."

17 25. As another example, in 2008 a Wowza user identified as "alesgregorc" posted an
18 inquiry on the same forum regarding how Adobe patents "could affect future licensing of Wowza
19 Media Server? For us and maybe for others this is [a] very crucial question right now." Again,
20 Wowza's forum administrator "WowzaDave" replied, stating that "We continually review this
21 matter" and "...do not expect any legal problems with Adobe on this matter."

22 26. Given Wowza's willful infringement of Adobe intellectual property, the legal status
23 of Wowza's products and activities has rightfully been characterized as "a very crucial question"
24 by its users. However, Wowza has never corrected these statements and claims, which continue
25 to mislead consumers into believing that its products and activities are legally sanctioned by
26 Adobe.

27 27. Wowza has also misled customers into believing that its unauthorized version of
28 RTMPE provides security comparable or equivalent to the security provided by Adobe's RTMPE.

1 28. As noted above, Adobe has invested heavily in developing updates and
2 enhancements to RTMPe, which are incorporated into upgrades of Flash Platform products such
3 as Flash Media Server and Flash Player. These updates and enhancements maintain the
4 continued effectiveness of RTMPe in protecting valuable copyrighted content for Adobe's
5 customers. Wowza has not invested in developing or maintaining RTMPe, and instead unfairly
6 rides on Adobe's coattails by circumventing the secure measures incorporated into Adobe's
7 Flash Platform products, including Adobe's Flash Media Server and/or Flash Player. Wowza
8 does this in order to produce its unauthorized version of RTMPe, which is not maintained by
9 Adobe.

10 29. Wowza's customers do not receive the benefit of the most up to date and authorized
11 version of RTMPe, which is deployed by Adobe through upgrades to Flash Platform products.
12 Rather, Wowza customers either miss out on critical updates altogether, or must wait for Wowza
13 developers to circumvent the Adobe updates and issue software patches for Wowza Media
14 Server. In either case, Wowza's unauthorized version of RTMPe can leave Wowza customers
15 exposed to security breaches.

16 30. Yet, Wowza's statements and claims mislead customers into believing that its
17 unauthorized version of RTMPe provides security comparable or equivalent to the security
18 provided by Adobe's RTMPe. For example, it states that Wowza Media Server offers "a
19 complete interactive Flash media streaming feature set," and offers to potential customers a side-
20 by-side "FMS Comparison" chart intended to convey that both Wowza Media Server and Flash
21 Media Server provide comparable or equivalent RTMPe security.

22 **E. Wowza Has Benefitted and Continues to Benefit From Its Unlawful Activities**

23 31. Wowza has unfairly benefitted financially from its unauthorized use of Adobe
24 technology by misleading customers into believing that its products and activities are somehow
25 legally sanctioned by Adobe, and that its unauthorized version of RTMPe is comparable or
26 equivalent to RTMPe provided by Adobe. Wowza has attained substantial growth and market
27 share for Wowza Media Server over a short period of time due to its unauthorized use of Adobe
28 technology, and its unfair comparisons and misleading statements and claims.

1 32. Wowza has benefited substantially from its unauthorized version of RTMPe. For
2 users wishing to accept only secure connections, Wowza provides instructions on how to disable
3 all non-secure protocols except its unauthorized version of RTMPe and SSL encryption, and
4 includes a setting specifically for this purpose. When Wowza customers expressed concerns that
5 videos streamed via Wowza Media Server could be downloaded using stream recording
6 software, Wowza directed customers to use its unauthorized version of RTMPe to protect their
7 content. Rather than direct customers to use other secure streaming options such as SSL
8 encryption, Wowza directed them towards its unauthorized version of RTMPe, saying “[it] is
9 probably better to use rtmpe which is equally secure and does not require any additional setup.”
10 Wowza told its customers that compared to SSL encryption, “RTMPE is a better way to go” and
11 “offers similar security and performs better.”

12 33. Wowza features its unauthorized version of RTMPe on its website and in its
13 promotional and marketing materials, to drive demand for Wowza Media Server. Its
14 unauthorized version of RTMPe is included in a special “MediaSecurity” add-on package for
15 Wowza Media Server, identifying “RTMPE” as one of the “features that are needed to properly
16 secure your content.” To protect streamed content, Wowza advised users that “a combination of
17 RTMPE and SecureToken security is suggested.” Wowza instructed customers that “simply
18 streaming your content does not always provide sufficient security against content intrusion,
19 unauthorized diversion and stream ripping.” To address this problem, Wowza told users that it
20 “implements content URL protection, domain verification and link encryption (RTMPS,
21 RTMPE, RTMPTE).” When asked why prospective customers should choose Wowza Media
22 Server rather than a competing server product, Wowza’s chief marketing officer cited to the rival
23 product’s lack of support for RTMPe as a significant reason.

24 34. Wowza has benefited and continues to benefit from the widespread market demand
25 for RTMPe. At the same time, it offers an unauthorized version of RTMPe to keep its own costs
26 low and undercut Adobe in the streaming server market. Given Wowza’s business model, it
27 comes as no surprise that Stubenvoll and Good created what they referred to as “the only
28

1 commercially available alternative to Adobe's Flash Media Server" in a matter of months, "did it
2 ourselves and became profitable very, very quickly" and "without any venture money at all."

3 35. Wowza has been able to keep costs low by avoiding the substantial expenses
4 associated with researching, developing, and maintaining Flash Platform technologies such as
5 RTMPE, and by free-riding on the widespread demand for Adobe's proprietary technology.

6 36. Adobe has been and continues to be irreparably harmed by Wowza's activities, and
7 therefore brings this action to enjoin Wowza's unauthorized use of Adobe proprietary
8 technology.

9 **FIRST CLAIM FOR RELIEF**

10 **(Infringement of U.S. Pat. No. 7,587,509)**

11 37. Adobe restates and incorporates by reference the allegations set forth in paragraphs 1
12 through 36.

13 38. Adobe is the owner of the '509 Patent entitled "Real-time priority-based media
14 communication," which issued September 8, 2009. A true and correct copy of the '509 Patent is
15 attached as Exhibit B.

16 39. The '509 Patent covers implementations of both RTMP and RTMPE. For example,
17 implementations of RTMP and RTMPE operate by communicating media streams comprised of a
18 plurality of "chunks," where each chunk is associated with a plurality of states. A header of each
19 of the chunks includes a state association representing the state and indicating the following
20 possible purposes: a new stream chunk associated with a new stream, wherein said new stream
21 chunk includes a plurality of new parameters in said header and uses no parameters from a
22 previous header; a new media chunk associated with said new stream wherein said new media
23 chunk includes a plurality of new parameters in said header and uses at least one other parameter
24 from a previous header; a new time chunk associated with said new stream wherein said new
25 time chunk includes at least one new parameter in said header and uses a plurality of other
26 parameters from a previous header; and a continuation chunk requiring no new parameters in
27 said header and using a plurality of parameters from a previous header.

28

1 40. Wowza has been and now is manufacturing, using, selling, offering to sell and/or
2 importing the Wowza Media Server with unauthorized versions of RTMP and RTMPe, in the
3 State of California, in this District, and elsewhere in the United States.

4 41. With knowledge of the '509 Patent, defendant Wowza has been and now is directly
5 infringing, and/or indirectly infringing by way of inducing infringement and/or contributing to
6 the infringement of the '509 Patent in the State of California, in this judicial District, and
7 elsewhere in the United States by manufacturing, using, selling, offering to sell and/or importing
8 the Wowza Media Server with unauthorized versions of RTMP and RTMPe, by, among other
9 things, communicating media streams comprised of a plurality of "chunks" in accordance with
10 one or more claims of the '509 Patent. Defendant Wowza is thus liable for infringement of the
11 '509 Patent pursuant to 35 U.S.C. § 271(a), (b) and (c).

12 42. Wowza's customers and licensees are also liable for direct infringement of the '509
13 Patent pursuant to 35 U.S.C. § 271(a) for use of Wowza Media Server to stream content via
14 RTMP and/or RTMPe.

15 **SECOND CLAIM FOR RELIEF**

16 **(Infringement of U.S. Pat. No. 7,272,658)**

17 43. Adobe restates and incorporates by reference the allegations set forth in paragraphs 1
18 through 42.

19 44. Adobe is the owner of the '658 Patent entitled "Real-time priority-based media
20 communication," which issued September 18, 2007. A true and correct copy of the '658 Patent
21 is attached as Exhibit C.

22 45. The '658 Patent covers implementations of both RTMP and RTMPe. For example,
23 implementations of RTMP and RTMPe contain a chunk configurator for dividing media message
24 sub-streams into chunks, and a state machine to provide state associations. State associations are
25 written into a header for each chunk, identifying possible purposes consisting of: a new stream
26 chunk, wherein said new stream chunk includes a plurality of new parameters in said header and
27 uses no parameters from a previous header; a new media chunk, wherein said new media chunk
28 includes a plurality of new parameters in said header and uses at least one other parameter from a

1 previous header; a new time chunk, wherein said new time chunk includes at least one new
2 parameter in said header and uses a plurality of other parameters from a previous header; and a
3 continuation chunk requiring no new parameters in said header and using a plurality of
4 parameters from a previous header. Implementations of RTMP and RTMPe contain a queue for
5 holding chunks waiting to be transmitted, and a processor for executing a scheduling algorithm
6 that determines which queued chunks to transmit next.

7 46. Wowza has been and now is manufacturing, using, selling, offering to sell and/or
8 importing Wowza Media Server with unauthorized versions of RTMP and RTMPe, in the State
9 of California, in this District, and elsewhere in the United States.

10 47. With knowledge of the '658 Patent, defendant Wowza has been and now is directly
11 infringing, and indirectly infringing by way of inducing infringement and/or contributing to the
12 infringement of the '658 Patent in the State of California, in this judicial District, and elsewhere
13 in the United States by manufacturing, using, selling, offering to sell and/or importing the
14 Wowza Media Server with unauthorized versions of RTMP and RTMPe, by, among other things
15 providing a chunk configurator and a state machine with the Wowza Media Server, which are
16 covered by one or more claims of the '658 Patent. Defendant Wowza is thus liable for
17 infringement of the '658 Patent pursuant to 35 U.S.C. § 271(a), (b) and (c).

18 48. Wowza's customers and licensees are also liable for direct infringement of the '658
19 Patent pursuant to 35 U.S.C. § 271(a) for use of Wowza Media Server to stream content via
20 RTMP and/or RTMPe.

21 **THIRD CLAIM FOR RELIEF**

22 **(Lanham Act – False Advertising)**

23 **(15 U.S.C. § 1125(a))**

24 49. Adobe restates and incorporates by reference the allegations set forth in paragraphs 1
25 through 48.

26 50. Wowza's marketing and advertising of its competing Wowza Media Server product
27 constitutes false advertising under the Lanham Act.

28

1 51. As discussed above, Wowza has made, and continues to make, false and misleading
2 statements and claims about its Wowza Media Server product. For example, as discussed above,
3 Wowza's statements and claims have misled consumers into believing that its products and
4 activities, including the Wowza Media Server and the development and distribution of its
5 unauthorized version of RTMPe, are legally sanctioned by Adobe. Additionally, as discussed
6 above, Wowza's statements and claims have misled customers into believing that its
7 unauthorized version of RTMPe provides security comparable or equivalent to the security
8 provided by Adobe's RTMPe.

9 52. Wowza intentionally misrepresents the nature, characteristics, qualities and/or origin
10 of its commercial activities and products in order to influence consumer purchasing decisions.

11 53. Wowza's false and misleading statements and claims constitute commercial
12 advertising or promotion within the meaning of the Lanham Act.

13 54. Wowza intentionally placed these misleading advertising statements and claims in
14 interstate commerce.

15 55. Wowza's misleading statements and claims are material in that they are likely to
16 influence, and on information and belief have influenced, consumer purchasing decisions, and
17 have a tendency to deceive, and on information and belief have deceived, a substantial segment
18 of its audience, which may have otherwise purchased Adobe's Flash Media Server.

19 56. Wowza's actions have a tendency to cause and on information and belief have
20 caused, and unless enjoined will continue to cause, irreparable harm, damage, loss and injury to
21 Adobe, for which it has no adequate remedy at law.

22 57. Wowza's actions have resulted in an improper financial benefit and gain to Wowza,
23 which amount should be disgorged.

24 58. On information and belief, Wowza has engaged in this activity intentionally,
25 knowingly, willfully, with actual malice, and in bad faith, justifying the assessment of enhanced
26 damages against it.

27 59. Wowza's acts make this an exceptional case under 15 U.S.C. § 1117(a), and Adobe
28 is thus entitled to an award of attorneys' fees and costs.

1 **FOURTH CLAIM FOR RELIEF**

2 **(Unfair Competition)**

3 **(California Common Law)**

4 60. Adobe restates and incorporates by reference the allegations set forth in paragraphs 1
5 through 59.

6 61. Adobe has expended significant time and expense in researching and developing its
7 Flash Platform products and technology. Adobe's high quality products have allowed Adobe to
8 develop and maintain a strong reputation for quality and security, and Adobe derives substantial
9 benefit and goodwill from its efforts.

10 62. Through its actions as described above, Wowza has misappropriated Adobe's efforts
11 and is exploiting Adobe's technology and reputation to market and sell its competing Flash
12 Media Server products. These actions constitute unfair competition.

13 63. Wowza's actions have caused and unless enjoined will continue to cause, irreparable
14 harm, damage, loss and injury to Adobe, for which it has no adequate remedy at law.

15 64. In performing the conduct described herein, on information and belief Wowza acted
16 with oppression and malice, intending to injure Adobe and to wrongfully advantage itself at
17 Adobe's expense. Adobe is entitled to an award of compensatory and punitive damages against
18 Wowza, in an amount to be ascertained at trial.

19 **FIFTH CLAIM FOR RELIEF**

20 **(False Advertising Under California Law)**

21 **(Cal. Bus. & Prof. Code § 17500 et seq.)**

22 65. Adobe restates and incorporates by reference the allegations set forth in paragraphs 1
23 through 64.

24 66. As detailed above, Wowza has made and disseminated untrue and misleading
25 advertising statements in the State of California about its media server product, by
26 misrepresenting the nature, characteristics, qualities or origin of its unauthorized version of
27 RTMPe.

28 67. Wowza knew or should have known that its statements were untrue and misleading.

1 68. Wowza's acts, as described above, constitute false and misleading advertising
2 pursuant to Cal. Bus. & Prof. Code § 17500 et seq.

3 69. Adobe has been harmed and will continue to be harmed by Wowza's false and
4 misleading advertising as described above. Accordingly, Adobe is entitled to an injunction
5 prohibiting Wowza from continuing the practices described above, pursuant to Cal. Bus. & Prof.
6 Code § 17535.

7 **SIXTH CLAIM FOR RELIEF**

8 **(Unfair Competition Under California Law)**

9 **(Cal. Bus. & Prof. Code § 17200 et seq.)**

10 70. Adobe restates and incorporates by reference the allegations set forth in paragraphs 1
11 through 69.

12 71. Wowza's conduct, as described above, constitutes unlawful and fraudulent conduct,
13 including violations of the Patent Act, the Lanham Act, Cal. Bus. & Prof. Code § 17500, and
14 California common law.

15 72. Wowza's acts accordingly constitute unfair competition and unfair business practices
16 pursuant to Cal. Bus. & Prof. Code § 17200 et seq.

17 73. Absent injunctive relief, Adobe has no means by which to control Wowza's
18 deceptive and confusing activities. Adobe is thus entitled to injunctive relief prohibiting Wowza
19 from continuing its acts of unfair competition.

20 **JURY DEMAND**

21 Adobe hereby requests a trial by jury pursuant to Rule 38 of the Federal Rules of Civil
22 Procedure.

23 **PRAYER FOR RELIEF**

24 WHEREFORE, Adobe requests that this Court enter:

25 1. A judgment in favor of Adobe that Wowza has infringed directly, and/or by way of
26 inducing infringement by others, and/or contributing to the infringement by others of the Patents-
27 in-Suit.

28

1 2. A judgment and order awarding Adobe damages, costs, expenses, and prejudgment
2 and post-judgment interest for Wowza's infringement of the Patents-in-Suit as provided under
3 35 U.S.C. § 284.

4 3. A judgment and order finding Wowza's infringement of the Patents-in-Suit to be
5 willful and deliberate, and a trebling of damages pursuant to 35 U.S.C. § 284.

6 4. A judgment and order finding that this is an exceptional case within the meaning
7 of 35 U.S.C. § 285 and/or 15 U.S.C. § 1117(a), and awarding to Adobe its reasonable attorneys'
8 fees and costs.

9 5. A preliminary and permanent injunction, enjoining Wowza, its officers, directors,
10 agents, servants, attorneys, affiliates, employees, divisions, branches, subsidiaries, parents,
11 assigns, and successors in interest of Wowza, and all others acting in concert, participation or
12 privity with any of them (the "Wowza Entities"); and Wowza's customers and licensees, and all
13 others acting in concert, participation or privity with any of them, from continued acts of
14 infringement of the Patents-in-Suit.

15 6. A judgment finding that Wowza has not complied with the terms of the RTMP
16 Specification License, and accordingly has no right or license to any Adobe intellectual property,
17 including the Patents-in-Suit.

18 7. A judgment and order finding that Wowza has committed the following unlawful
19 acts:

20 a. False advertising in connection with goods offered for sale, under 15 U.S.C.
21 § 1125(a);

22 b. Unfair competition under California common law;

23 c. False advertising under Cal. Bus. & Prof. Code § 17500 et seq.; and

24 d. Unfair competition under Cal. Bus. & Prof. Code § 17200 et seq.

25 8. A preliminary and permanent injunction, enjoining the Wowza Entities from:

26 a. Making false and/or misleading advertising claims and statements about
27 Wowza Media Server; and
28

1 b. Unfairly competing with Adobe in any manner whatsoever, or engaging in
 2 any unfair, fraudulent, or deceptive business practices that relate in any way to
 3 the use of the marketing and advertising of Wowza Media Server.

4 9. An order directing Wowza to file with this Court and serve upon Adobe's counsel,
 5 within thirty (30) days after entry of the order of injunction, a report setting forth the manner and
 6 form in which Wowza has complied with the injunction, pursuant to 15 U.S.C. § 1116(a).

7 10. For an order pursuant to 15 U.S.C. § 1117(a) compelling Wowza to account to
 8 Adobe for any and all profits derived by it from its unlawful and misleading conduct.

9 11. For an order that Wowza must pay and provide for appropriate corrective
 10 advertisements.

11 12. With respect to the unlawful activities described above, that the Court order Wowza
 12 to pay Adobe:

13 a. General, special, actual and/or statutory damages, according to proof at
 14 trial, trebled and increased due to the nature of Wowza's conduct as
 15 provided above;

16 b. All of Wowza's profits or gains of any kind from its acts of false
 17 advertising and unfair competition;

18 c. Pre-judgment and post-judgment interest; and

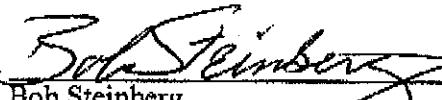
19 d. Punitive and exemplary damages.

20 13. Any and all other relief to which the Court may deem Adobe entitled.

22 Dated: May 6, 2011

Respectfully submitted,

LATHAM & WATKINS LLP
 Bob Steinberg
 Jennifer Barry
 Ryan Hatch

By: 
 Bob Steinberg
 Attorney for Plaintiff
 Adobe Systems Incorporated

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Published April 2009

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US007587509B1

(12) **United States Patent**
Edelman et al.

(10) **Patent No.:** **US 7,587,509 B1**
(45) **Date of Patent:** ***Sep. 8, 2009**

(54) **REAL-TIME PRIORITY-BASED MEDIA COMMUNICATION**

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(73) **Assignee:** **Adobe Systems Incorporated**, San Jose, CA (US)

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 142 days.

This patent is subject to a terminal disclaimer.

(21) **Appl. No.:** **11/841,517**

(22) **Filed:** **Aug. 20, 2007**

Related U.S. Application Data

(63) Continuation of application No. 10/366,646, filed on Feb. 13, 2003, now Pat. No. 7,272,658.

(51) **Int. Cl.**
G06F 15/16 (2006.01)
H04N 7/173 (2006.01)

(52) **U.S. Cl.** **709/231; 709/219**

(58) **Field of Classification Search** **709/231, 709/219; 725/103**

See application file for complete search history.

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Primary Examiner—Ario Etienne
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(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

Representative embodiments are disclosed of a real-time priority-based communication system and method for communicating media streams made up of multiple media message sub-streams, the communication system comprising a chunk configurator for dividing media message sub-streams into chunks, a state machine configured to translate between information regarding the media message sub-streams and the chunks and state associations to the information, the state associations written into a header for each of the chunks, a queue for holding the chunks waiting to be transmitted, and a processor for executing a scheduling algorithm, wherein the scheduling algorithm determines ones of the chunks in the queue to transmit next.

31 Claims, 7 Drawing Sheets

CHUNK	CHUNK STREAM ID	CHUNK TYPE	HEADER DATA	NUMBER OF BYTES AFTER HEADER	TOTAL CHUNK BYTES
500	4	0	Δ: 20 L: 435 TYPE: 9 STREAM ID: 12346	128	139
501	4	3	<NONE>	128	129
502	4	3	<NONE>	128	129
503	4	3	<NONE>	51	52

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FIG. 5A

	CHUNK	CHUNK STREAM ID	CHUNK TYPE	HEADER DATA	NUMBER OF BYTES AFTER HEADER	TOTAL CHUNK BYTES
500	CHUNK	4	0	Δ: 20 L: 435 TYPE: 9 STREAM ID: 12346	128	139
501	CHUNK	4	3	<NONE>	128	129
502	CHUNK	4	3	<NONE>	128	129
503	CHUNK	4	3	<NONE>	51	52

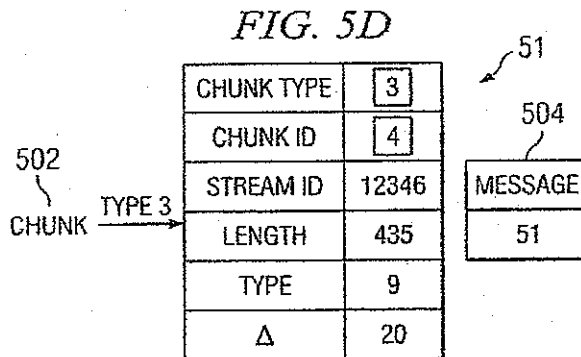
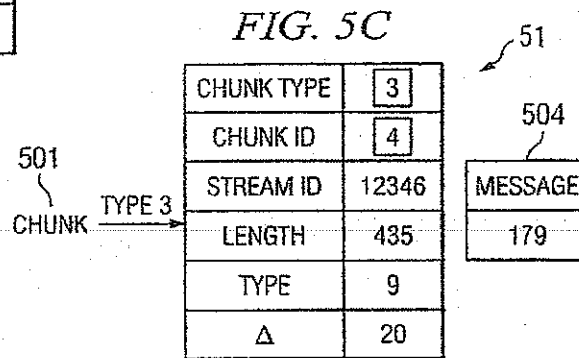
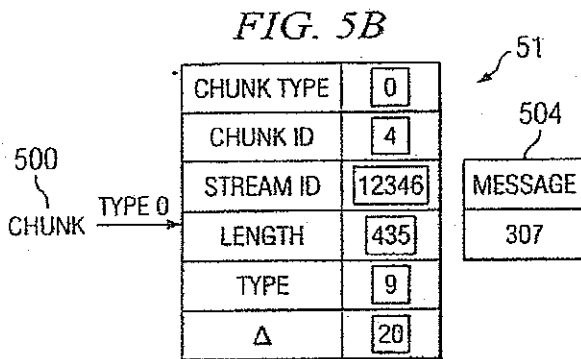


FIG. 5E

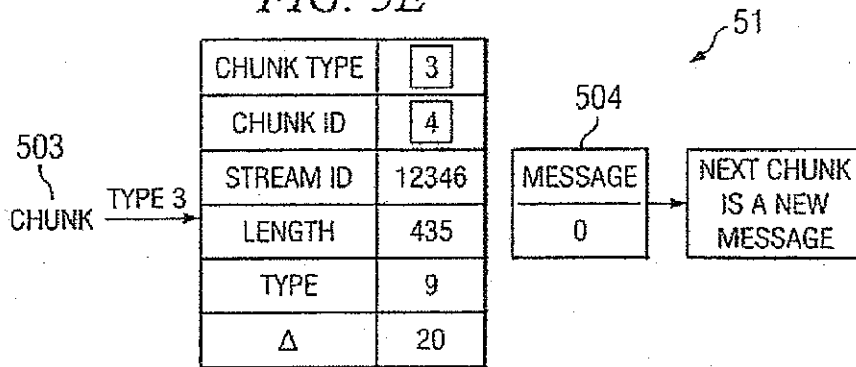
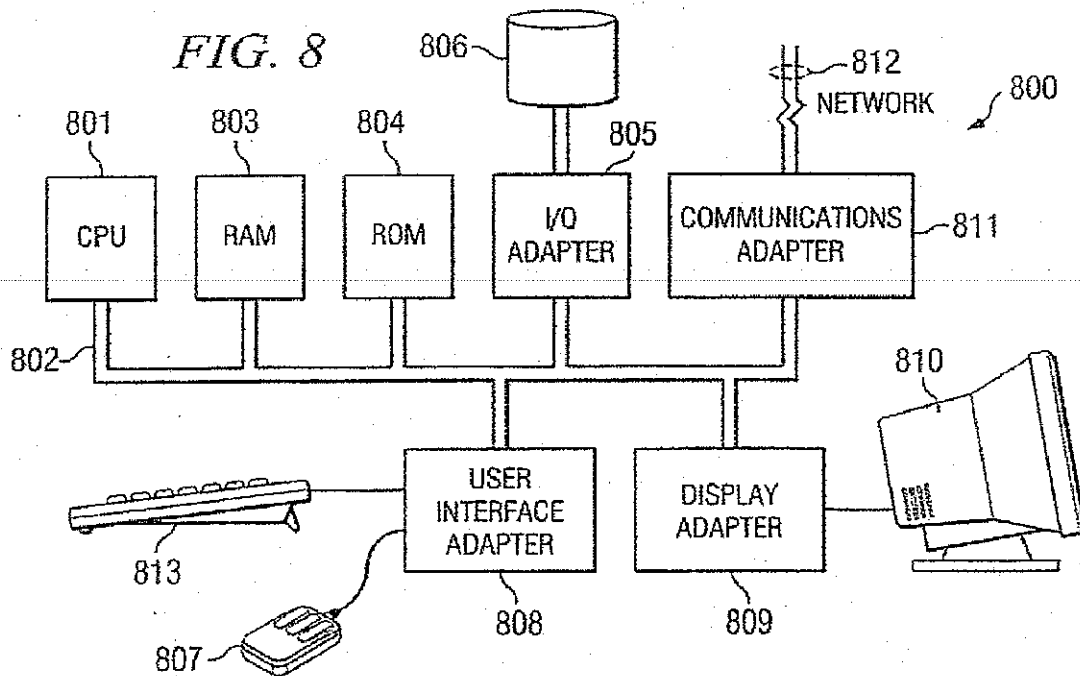
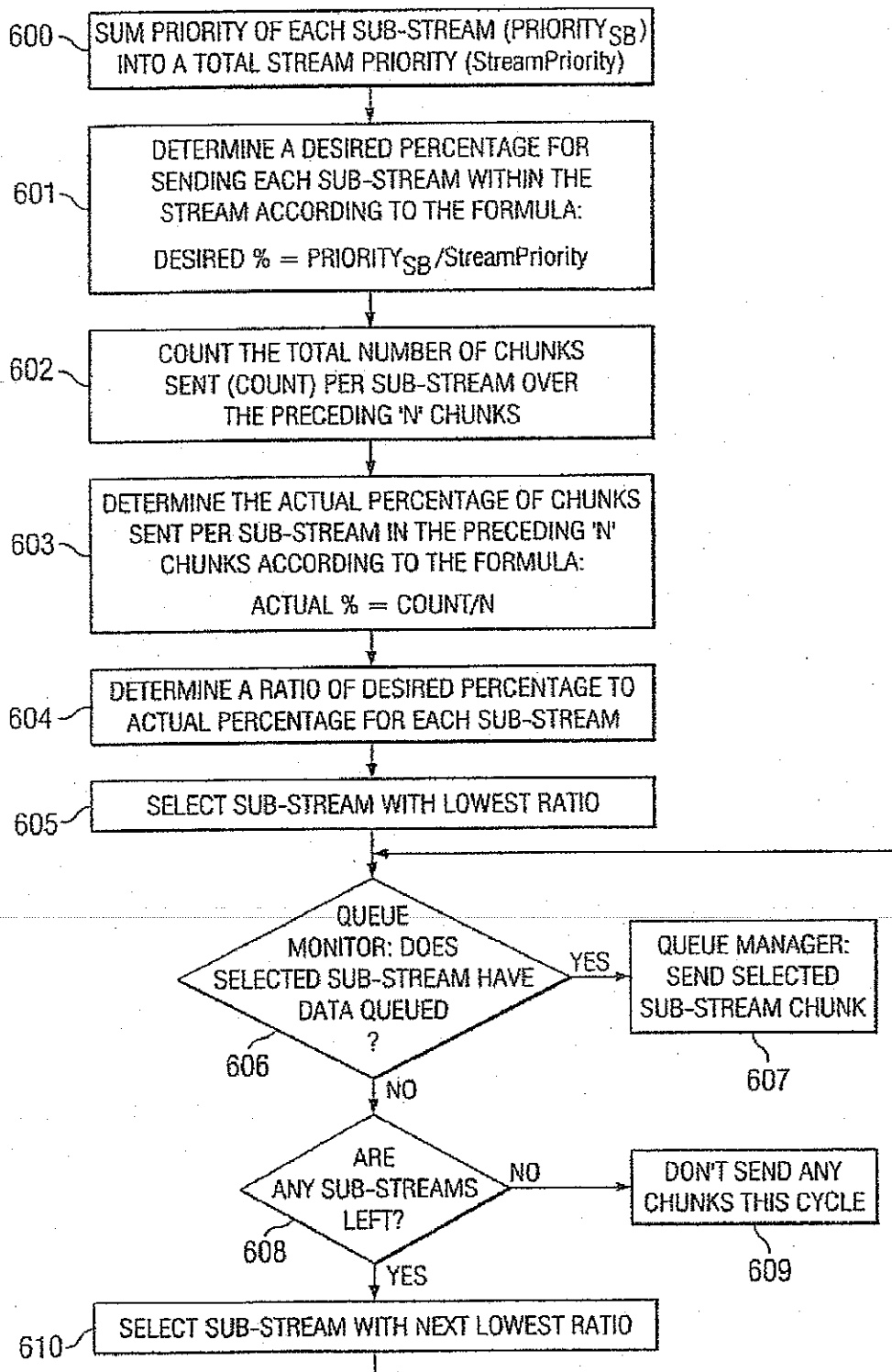


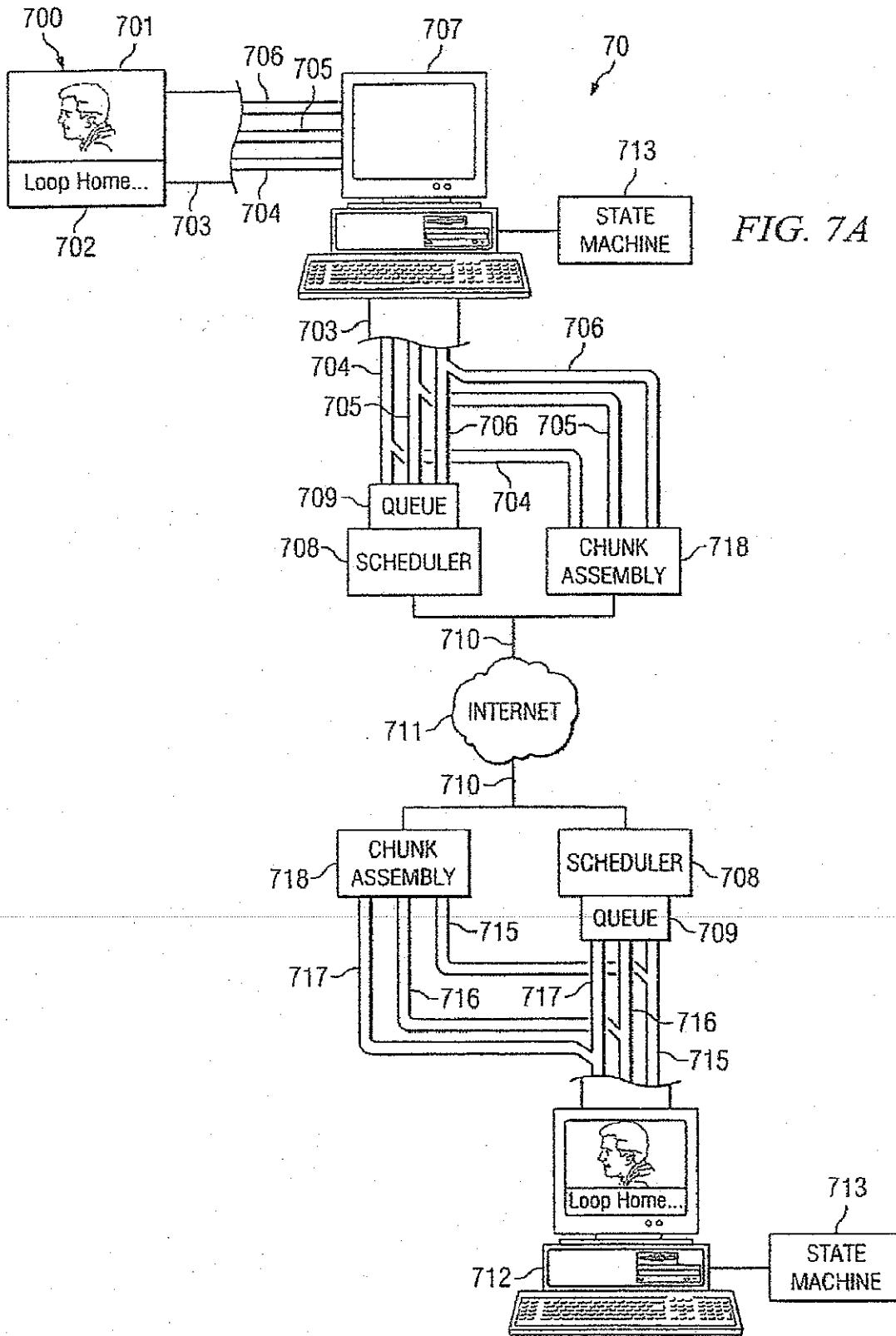
FIG. 8



60

FIG. 6





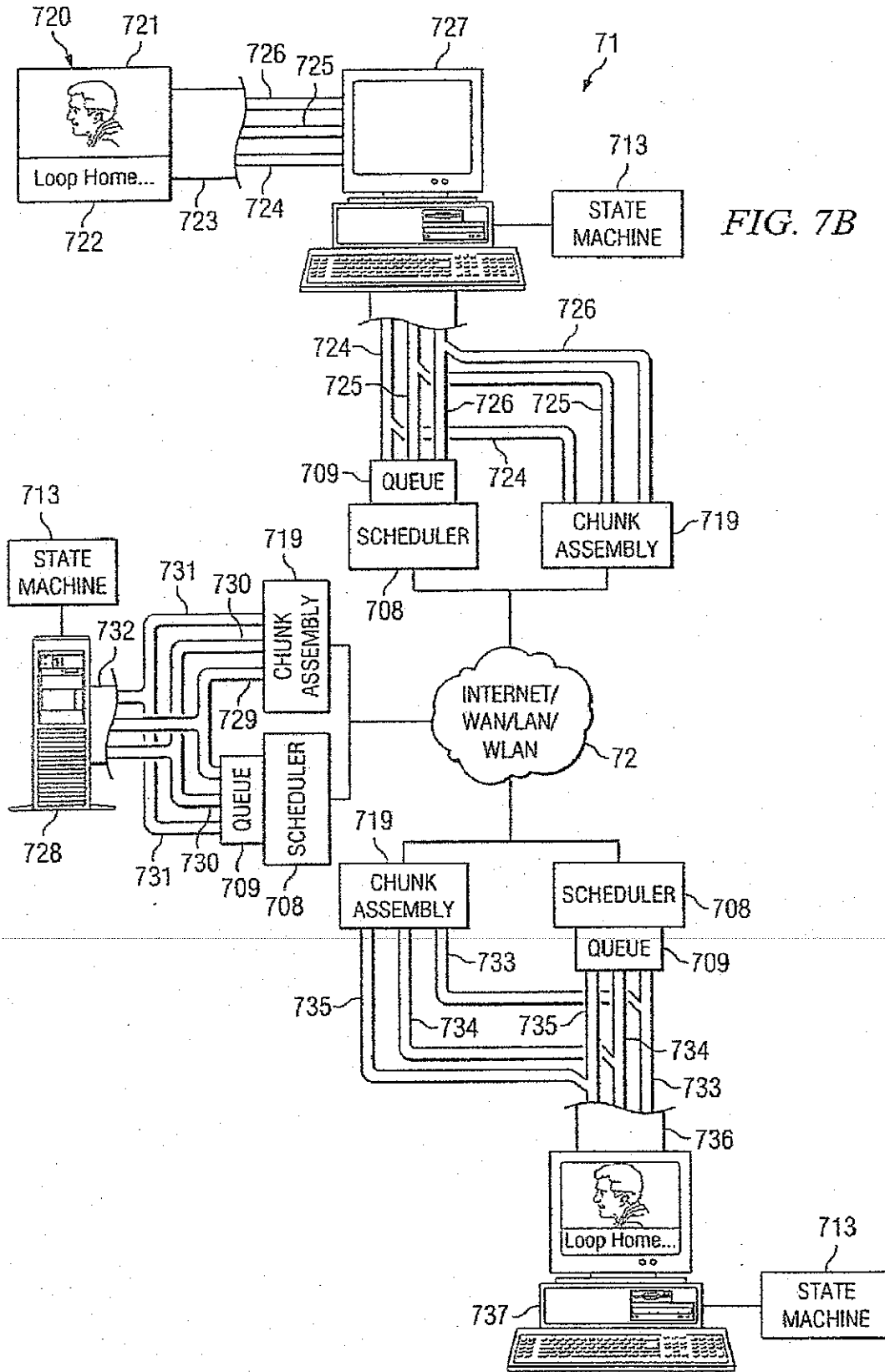
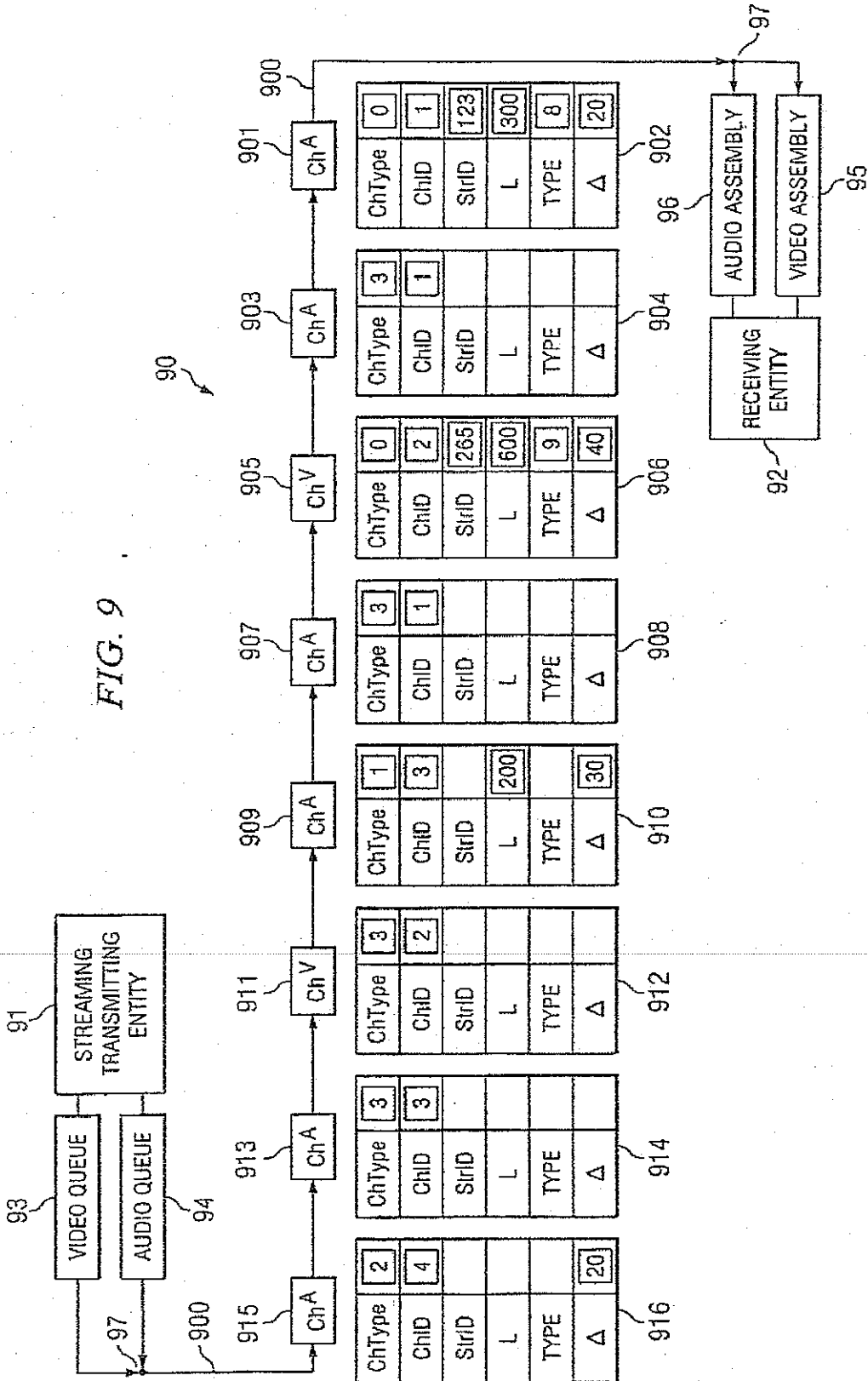


FIG. 9



REAL-TIME PRIORITY-BASED MEDIA COMMUNICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of co-pending, commonly assigned, U.S. patent application Ser. No. 10/366,646 entitled "REAL-TIME PRIORITY-BASED MEDIA COMMUNICATION," filed Feb. 13, 2003, the disclosure of which is hereby incorporated herein by reference.

TECHNICAL FIELD

The present invention relates, in general, to media communications, and, more specifically, to a system and method for a real-time priority-based communication system.

BACKGROUND OF THE INVENTION

In the early years of the Internet, its primary use was for the reliable transmission of data with minimal or no delay constraints. Transmission Control Protocol (TCP), of the TCP/Internet Protocol (IP) protocol suite, was designed for this type of delay-independent data traffic. TCP typically works well in this context where the reliability of the packet delivery is much more important than any packet delays. In order to achieve this reliability, TCP sets up a connection at both ends and attaches a header to each packet that contains the source and destination ports as well as the sequence number of the packet and other such administrative information. The destination typically receives a number of TCP packets before sending an acknowledgement to the source. If the acknowledgment fails, the source will generally presume the packets were lost and retransmit the "lost" packets. While this process ensures reliable delivery, packets may be delayed which, in multimedia streams, may cause noticeable and unacceptable degradation of quality in the multimedia playback.

An alternative transmission protocol in the TCP/IP protocol suite is User Datagram Protocol (UDP). Unlike TCP, UDP is connectionless and unreliable, meaning that it does not establish a connection at both ends and does not include a resource for resending lost packets. Instead, the UDP packets are sent out with a packet header that typically includes only the source and destination ports along with a 16-bit segment length and 16-bit checksum for minimal error detection. Because UDP does not include the additional administrative information, it generally makes no delivery guarantees, offers no flow control, and performs only minimal error detection. As such, UDP has useful timing characteristics for real-time audio or video transmission, where the delivery of every packet is not as important as the timely delivery of packets. UDP was generally used as the early transport protocol for real-time multimedia applications because it typically offers these beneficial characteristics for delay-sensitive data delivery. However, by itself, UDP usually does not provide any general purpose tools that may be useful for real-time applications.

In response to the limitations of UDP, Real-time Transport Protocol (RTP) was developed to operate as a thin layer on top of UDP to create a generalized multipurpose real-time transport protocol. An RTP fixed header may generally include: a 7-bit payload type field for identifying the format of the RTP payload; a 16-bit sequence number which is incremented by one for each subsequent RTP data packet transmitted; a 32-bit timestamp that corresponds to the time that the first RTP data

packet was generated at the source; a 32-bit synchronization source identifier which is a randomly generated value that uniquely identifies the source within a particular real-time session; as well as other administrative information. With this information, RTP provides support for applications with real-time properties including timing reconstruction, loss detection, security, and content identification without the reliability-induced delays associated with TCP or the lack of timing information associated with UDP.

Real-Time Control Protocol (RTCP) works in conjunction with RTP to provide control support to the application for maintaining the RTP session. RTCP generally performs four functions: (1) providing information to the application regarding the quality of transmission, such as number of packets sent, number of packets lost, interarrival jitter, and the like; (2) identifying the RTP source through a transport-level identifier, called a canonical name (CNAME), to keep track of the participants in any particular RTP session; (3) controlling the RTCP transmission interval to prevent control traffic from overwhelming network resources; and (4) conveying minimal session control information to all session participants. The RTCP packets are typically transmitted periodically by each participant in an RTP session to all other participants. Therefore, RTCP provides performance and diagnostic information that may be used by the application.

One of the major problems associated with streaming multimedia information arises in attempting to stream the media through firewalls, Network Address Translation (NAT) devices, and the like. The major purpose of firewalls is to prevent unauthorized and/or hostile access to a computer system or network. As such, firewalls are generally configured with strict rules specifying specific, static ports through which desired and/or authorized data traffic can pass, while blocking undesirable data. The majority of all IP protocols use RTP for transporting the media streams. RTP is built over UDP, which generally has no fixed ports associated with it. Thus, there is no guarantee that a port associated with the incoming RTP/UDP stream will be allowed through the firewall. Moreover, each media stream typically has multiple channels, which generally requires its own opening through the firewall. This means that for the media stream to traverse the firewall, the firewall will have to open many UDP openings for each call session, which defeats the purpose for the firewall in the first place.

NAT devices are used to translate an IP address used within one network to a different IP address known within another network. NAT devices typically maintain a map of addresses within an "inside" network. Any communications directed to users within the inside network usually pass first through the NAT device for translation to the inside address. Thus, users within the inside network may see out, but outside users can only typically communicate with the inside users through the NAT device's translation. NAT devices may allow a network to support many more users or clients than it has fixed IP addresses. The NAT device may be addressed from the outside using the few fixed IP addresses, yet service many other address within the inside network.

Another problem with the existing streaming protocols is the amount of header information attached to any given piece of data on the stream. As mentioned above, UDP and TCP messages contain considerable header information concerning the timing, sequence, data type, and the like. Because multiple streams are typically running at once, each piece of data generally has a stream ID to tell the destination which stream any particular piece of data belongs to. In a situation where an audio stream is established where the message type is constant for a period of time and the formatting of the

message type requires a constant number of bits per message, the header information on the type, length, and the like congests the stream with useless information, thus taking away from the maximum available data bandwidth.

BRIEF SUMMARY OF THE INVENTION

Representative embodiments of the present invention are directed to a real-time priority-based communication system for communicating media streams made up of multiple media message sub-streams, the communication system comprising a chunk configurator for dividing media message sub-streams into chunks, a state machine configured to translate between information regarding the media message sub-streams and the chunks and state associations to the information, the state associations written into a header for each of the chunks, a queue for holding the chunks waiting to be transmitted, and a processor for executing a scheduling algorithm, wherein the scheduling algorithm determines ones of the chunks in the queue to transmit next.

Additional representative embodiments are directed to a method for communicating media streams, comprised of a plurality of sub-streams, in a real-time priority-based communication protocol, the method comprising dividing each one of the plurality of sub-streams into a plurality of chunks, assigning states to each of the plurality of chunks representative of information regarding the associated sub-streams and the associated media streams, writing the states into a header of each of the plurality of chunks, queuing the plurality of chunks for transmission, and transmitting ones of the plurality of chunks according to a scheduling algorithm.

Further representative embodiments are directed to a computer program product having, a computer readable medium with computer program logic recorded thereon, the computer program product comprising code for breaking down each one of a plurality of media sub-streams making up a message stream into a plurality of associated chunks, code for implementing a state machine that processes state assignments for each of the plurality of associated chunks representative of information regarding the media sub-streams and the message streams, code for writing the state assignments into a header of each of the plurality of associated chunks, code for building a queue for the plurality of associated chunks waiting for transmission, and code for transmitting ones of the plurality of associated chunks according to a scheduling algorithm.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is

provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a conceptual block diagram illustrating a data packet which is part of a typical media stream;

FIG. 2 is a conceptual block diagram illustrating a typical message stream comprising multiple message packets;

FIG. 3 is a conceptual block diagram illustrating one example embodiment of a chunk configured according to the real-time priority-based communication system of the present invention;

FIG. 4 is a conceptual block diagram detailing a chunk control byte;

FIG. 5A is a conceptual block diagram illustrating a chunk stream comprising multiple chunks;

FIG. 5B is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication systems as described herein, receiving a Type 0 chunk;

FIG. 5C is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 3 chunk;

FIG. 5D is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 3 chunk;

FIG. 5E is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 3 chunk;

FIG. 6 is a flowchart disclosing representative steps of an example scheduling algorithm used in representative embodiments of the present invention;

FIG. 7A is a conceptual block diagram illustrating a real-time communication system configured using a representative embodiment of the real-time priority-based protocol of the present invention in a peer-to-peer application;

FIG. 7B is a conceptual block diagram illustrating a real-time communication system configured using a representative embodiment of the real-time priority-based protocol of the present invention in a client-server application;

FIG. 8 illustrates a computer system adapted to use the present invention; and

FIG. 9 illustrates a sequence of interleaved audio and video chunks in a real-time priority-based communication system configured according to various embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Before beginning a discussion of the various embodiments of the present invention, it may be helpful to review how media streams are carried through transmission.

FIG. 1 is a conceptual block diagram illustrating data packet 10 which is part of a media stream. Data packet 10 not only comprises data—payload 104, but also comprises header information that is used to assemble and play the media stream at the destination entity. The header information typically comprises message stream ID 100, message

type ID 101, time 102, and length 103. Message stream ID 100 identifies the particular stream that data packet 10 is a part of. In a typical multimedia application, such as an audio/video conference, for example, the outgoing stream may be a first stream, while the outgoing video stream may be a second stream. There are possible scenarios that include a large number of streams and sub-streams going back and forth to the different participants over a single connection. In a typical application a media stream is comprised of multiple media message sub-streams that make up the different aspects of the main media stream. In order to deal with the many different streams, each stream is designated with a unique ID, such as message stream ID 100. Thus, when data packet 10 enters the destination, the media application reads message stream ID 100 and assembles data packet 10 into the appropriate message stream. In a typical application, media stream ID 100 may comprise a 32-bit designator.

The header information may also comprise message type ID 101. Message type ID 101 identifies the specific format of data packet 10. For example, message type ID 101 may identify data packet 10 as an audio data format (or a particular type of audio data format, such as a wave data format (.wav), MP3, and the like), a video data format (or a particular type of video data format, such as a motion picture experts group (MPEG)-2 or -4, a MICROSOFT™ WINDOWS MEDIA AUDIO™ (.wma), and the like), or a pure data format. By designating the type of data format, the destination application will likely know how to play or display the incoming media stream.

Because a media stream generally comprises a group of packets transmitted over some network, it is important for the destination application to be able to assemble and play the data packets in order and according to the timing of the original image/media. Therefore, the header information also includes time 102, which is typically a time stamp for the recording or sampling of the particular packet. The destination application may use time 102 to synchronize each of the packets that it receives in the stream. The application will then know to play a packet with time 102 designating 1020 before a packet with time 102 designating 1040. The time stamp may be a real-time, start time, or the like. The purpose is to determine when the message occurred so that things may be synchronized later during broadcast or playback.

Length 103 is also a typical piece of header information that identifies the length of data packet 10. By designating the specific length of data packet 10, the destination application knows when the current data packet or media message has been fully received.

It may often be the case where a message stream carries data packets in which message stream ID 100, message type ID 101, and length 103 may be the same value. Where packets are received consecutively, message stream ID 100 should generally be the same. Furthermore, if the stream is an audio stream, for example, message type ID 101 should also generally be the same. Length 103 can vary to some extent, however, some media formats, such as constant bit-rate MP3, Nellymoser, and the like, may divide all packets into the same length. Therefore, in such cases, length 103 will also be the same for each packet.

FIG. 2 is a conceptual block diagram illustrating typical message stream 20 comprising message packets 21-24. Message packet 21 begins with the header information: message stream ID 100 of 12345, message type ID 101 of 8 (for audio), time 102 of 1000, and length 103 of 32 bytes. This header information is important for the destination application to associate the message packets with the correct stream and play them in the right manner and in the right order. Message

packet 22 also includes the header information: message stream ID of 12345, message type ID 101 of 8, time 102 of 1020, and length 103 of 32 bytes. As may be seen in FIG. 2, message packet 22 contains much of the same header information as message packet 21. In fact, the only difference in the two message packets is the time stamp of time 103; message packet 21 has time 103 of 1000 while message packet 22 has time 103 of 1020. A difference of 20 seconds. Message 23 and 24 also comprise the same information for the header information of message stream ID 100, message type ID 101, and length 103, with time-stamps, time 102, differing by exactly 20 seconds per packet. The repeated information in message packets 21-24 clogs the available bandwidth of the entire system.

In an ideal system, it would be most efficient to send a data payload without any header information. However, without header information, it is practically impossible to assemble and playback data packets in a media stream with the current technology, let alone do so efficiently. FIG. 3 is a conceptual block diagram illustrating one example embodiment of chunk 30 configured according to the real-time priority-based communication system of the present invention. A chunk is a piece of a message stream that has been broken down or divided by a chunk configurator or some other message processing. Chunk 30 comprises chunk control byte 300 and data payload 301. Chunk control byte 300 preferably contains much of the header-type information necessary for managing the chunk stream.

It should be noted that in additional embodiments of the present invention, version byte 302 may be written transmitted to provide information on the particular version of the transport protocol being used. The inclusion of this information usually allows easier maintenance of future protocol versions and backwards compatibility. In operation, only a single version byte would likely be necessary per connection. Therefore, version byte 302 would likely not add any overhead on a per chunk basis.

In attempting to reduce the overhead of stream messages, certain assumptions may be leveraged into bandwidth savings. One such assumption involves the necessity of a 32-bit message stream ID. Statistically, there are usually less than sixty-one (61) message streams (having unique message stream IDs) in a server at any given time for any given client. Sixty-one (61) message streams may be uniquely represented in only 6 bits. Thus, having a 32-bit message stream ID is typically a waste of space. FIG. 4 is a conceptual block diagram detailing chunk control byte 300. Chunk control byte 300 comprises a chunk identifier, such as chunk stream ID 40 and chunk type ID 41. While the statistics suggest that there are a maximum of sixty-one (61) message streams in a server at any one time for a particular client artificially limiting the maximum number of streams does not present itself as an efficient means for obtaining bandwidth at the expense of stream capacity. Instead, chunk stream ID 40, as configured according to the embodiment illustrated in FIG. 4, provides a mechanism for supporting 65,597 total simultaneous streams (using a range of 3 to 65,599).

Chunk stream ID 40 comprises bits 0-5 of chunk control byte 300. As provided in Table 1, when the value of chunk stream ID 40 lies between 3 and 63 in certain embodiments of the present invention, chunk stream ID 40 is assigned at face value. Statistically, this situation will occur most often, resulting in a 6-bit chunk stream ID. However, when the value of chunk stream ID 40 is 0 in certain embodiments of the present invention, a second byte is added to chunk stream ID 40 that represents the range of 64 to 319. When the value of chunk stream ID is 1 in certain embodiments of the present inven-

tion, two additional bytes, a second byte and a third byte, are added to chunk stream ID 40 that represent the range of 320 to 65,599. Therefore, the embodiment illustrated in FIGS. 3 and 4 supports up to 65,597 streams, while still conserving bandwidth on a statistically large number of messages. A chunk stream ID 40 value of 2 in certain embodiments of the present invention represents that the chunk contains a low-level protocol message, which are used to control administrative aspects of the embodiment illustrated in FIGS. 3 and 4.

TABLE 1

CHUNK STREAM ID (Bits 0-5 OF CHUNK CONTROL BYTE)	
Value	Meaning of Value
3-63	Chunk Stream ID is the face value of 3-63.
0	There is another byte that represents the range 64-319 (Second byte + 64).
1	There are two more bytes representing the range 320-65,599 ((Third byte) * 256 + (Second byte + 64)).
2	The Chunk is a Low-Level Protocol Message.

The configuration of the real-time priority-based protocol illustrated in FIGS. 3 and 4 advantageously leverages the statistical maximum of sixty-one (61) streams. Because there are usually less than sixty-one (61) streams in the server at any given time for a client, only the 6 bits of chunk stream ID 40 will generally be sent. Thus, the 32-bit header for message stream IDs of the current technologies is preferably reduced to only 6 bits for the majority of data streams. In rare cases, in which the number of streams exceeds 61, the additional bytes of information may be included to support those extra streams.

The configuration of chunk stream ID 40 in certain embodiments of the present invention, as provided in Table 1, demonstrates implementation of a state machine having different state associations using its first 2 bits to address many different levels of streams. In furtherance of the state machine concept implementing the embodiments of the present invention, chunk type ID 41 provides four states/types for classifying each chunk message. Unlike the media type indicator of message type ID 101 (FIG. 1) that identifies the format of the data payload, chunk type ID 41 identifies the type or purpose of the chunk.

As provided in Table 2, bits 6 and 7 of chunk control byte 300 comprise chunk type ID 41. When the value of chunk type ID 41 is 0 in certain embodiments of the present invention, the chunk state or type indicator is a new/reset message type (Type 0) or indicates a new stream. This signifies the first message sent on the chunk stream in certain embodiments of the present invention. As is described in Table 2, a Type 0 message may comprise additional bytes of information that include the typical header information of the current stream methods, such as message length, message type ID, and message stream ID. Instead of using a timestamp, however, the embodiment of the present invention illustrated in FIGS. 3 and 4 uses a time delta (Δ), or the change in time from the previous message. The time-delta (Δ) is essentially an absolute time because it is usually added to '0' time. Because the Type 0 chunk includes a considerable amount of information, it will generally be larger than the subsequent chunks in the stream.

When the value of chunk type ID 41 is 1 in certain embodiments of the present invention, the chunk state or type is a new media indicator of a specified new time change/time delta, length, and any new message type ID (Type 1). This state may signify a new chunk that is measured using the new specified

time delta (i.e., the time stamp change from the last message) and the specific length. Thus, a subsequent message in a chunk stream that belongs to the same chunk stream ID, but that is a different type/format and a different time delta than the previous chunk only has to include header information on the message type ID, time delta, and the length. A Type 1 chunk may, therefore, have fewer bytes of header information than the Type 0 chunk, because the state machine implementing the illustrated embodiment of the present invention has been set with certain information by the Type 0 chunk that remains unchanged for the Type 1 chunk.

A value for chunk type ID 41 of 2 in certain embodiments of the present invention represents the chunk state or type for a new message defined only by a single piece of header information, such as the time delta (Type 2) in a new time indicator. A Type 2 chunk preferably has all of the same information from the previous chunk except possibly for a change in the time delta. Therefore, the state machine may only need to use the new time delta to change to the proper new state.

The least amount of overhead or header information in the representative embodiment illustrated in FIGS. 3 and 4 accompanies the Type 3 chunk in certain embodiments of the present invention, when the value of chunk type ID 41 is 3. A Type 3 chunk is a continuation indicator. A continuation indicator chunk preferably uses the same message stream ID, the same message type ID, the same time change/time delta, and the same length of the previous chunks. Therefore, the state machine implementing this embodiment of the present invention is preferably already set to the appropriate state. One design goal may be to optimize the streaming process to get the chunks to Type 3 chunks as soon as possible. Therefore, Type 3 chunks that are essentially continuations of a same message are transmitted with a 0-length header.

The 0-length header of the Type 3 chunks is especially interesting when the Type 3 chunk represents the beginning of a new message. This scenario may occur when two consecutive chunks use the same message stream ID, the same message type ID, the same time change/time delta, and the same length as the previous chunk. In this case, a new message is enabled without any required header information, a 0-length header.

TABLE 2

CHUNK TYPE (BITS 6-7 OF CHUNK CONTROL BYTE)	
Chunk Type Bits	Description
00	(Type 0) Begin new message. Reset all information. Type 0 is used when the time moves backwards or for the first message sent on the chunk stream. A Type 0 chunk message resets the time to 0 before adding the supplied time delta (Δ). A Type 0 chunk message will contain the following header information: 3 bytes - message time delta (Δ) 3 bytes - message length 1 byte - message type ID 4 bytes - message stream ID
01	(Type 1) Begin new message using specified Δ , new length, and/or new message type ID. A Type 1 chunk message will generally contain the following header information: 3 bytes - Δ 3 bytes - new message length 1 byte - message type ID
10	(Type 2) Begin new message using specified Δ . A Type 2 chunk message will generally contain the following header information: 3 bytes - Δ

TABLE 2-continued

Chunk Type Bits	CHUNK TYPE
	(BITS 6-7 or CHUNK CONTROL BYTE)
Chunk Type Bits	Description
11	(Type 3) Continuation (possibly start new message). A Type 3 chunk message will generally contain no header information, but just the raw data/payload.

FIG. 5A is a conceptual block diagram illustrating chunk stream 50 comprising chunks 500-503. Chunk 500 is a Type 0 chunk with a chunk stream ID of 4. Because chunk 500 is a Type 0 chunk it includes additional header data 504. The additional data includes the message stream ID (12346), the message type ID (9), the message length (435), and the time delta (20). This header information is set into the state machine of the present invention. Chunk 501 is a Type 3 chunk belonging to the same chunk stream ID 4. Because chunk 501 belongs to the same media stream ID and is the same type and length as chunk 500, the state set by the extra header information of chunk 500 already defines how to handle chunk 501. According to the teachings of the present invention, chunk 501 only needs to designate the chunk stream ID and chunk type. Therefore, only a single byte of overhead is added to the data payload of chunk 501. Chunks 502 and 503 are also Type 3 continuation chunks that require only an additional byte of header information to adequately handle those chunks.

FIG. 5B is a block diagram illustrating state machine 51 configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 0 chunk. State machine 51 sees that chunk 500 is a Type 0 chunk and expects each of the state variables to be set with the header information contained in chunk 500. In some embodiments, state machine 51 may also include message count 504 that keeps track of the progress of each receiving message. Chunk 500 brings 128 bytes of data payload. Therefore, using the message length parameter, state machine 51 can subtract 128 bytes from the total length, 435 bytes, to hold the remaining message expected length of 307 bytes in message 504. The state machine illustrated in FIG. 5B is used in both the send direction and the receive direction. As chunks arrive at the receiver system, the state machine is used in reverse to translate the state assignments necessary to play the data stream chunk. Therefore, the state machine for the real-time priority-based communication system may be located at least at the sending entity and the receiving entity.

FIGS. 5C-5E are block diagrams illustrating state machine 51 receiving Type 3 chunks. In FIG. 5C, state machine 51 reads that chunk 501 is a Type 3 chunk, and therefore, expects that only the chunk type and chunk stream ID state variables will be changed. Because chunk 501 could belong to a different sub-stream than that of chunk 500, the chunk stream ID is used in the Type 3 continuation chunks. The remaining state variables set by chunk 500 remain the same. Message 504 is changed again to reflect the 128 bytes of payload data delivered by chunk 501. 179 bytes now remain in the message. In FIG. 5D state machine 51 reads that chunk 502 is also a Type 3 chunk, and therefore, also expects that only the chunk type and chunk stream ID state variables will be changed. The remaining state variables set by chunk 500 continue remain the same. Message 504 is again changed to reflect the 128 bytes of payload data delivered by chunk 501. 179 bytes now remain in the message. FIG. 5E also illustrates state machine 51 receiving a Type 3 continuation chunk. With this receipt, because state machine 51 knows the maximum chunk data payload length is 128, state machine 51 knows that this will be the last chunk for this particular message, as reflected in message 504 zeroing out. The next chunk will, by process of elimination, have to be for a new message (or be a low-level protocol message).

When compared to the header information included with each data packet in media stream 20 (FIG. 2), instead of resending the same header with each data packet, the teachings of the present invention preferably allow this information to be sent only once, with subsequent chunks leveraging the state machine in order to reduce the overhead sent with each subsequent chunk. The amount of repetitive information is, therefore, favorably reduced, increasing the available bandwidth over the collection.

Referring back to Table 1, when the value of chunk stream ID 40 is 2, in certain embodiments of the present invention, the state is designed to change for the system to expect a low-level protocol message. Table 3 describes two low-level protocol messages that may be implemented into various embodiments of the present invention. In such embodiments, a message ID of 1 represents a change to the maximum chunk size. The parameter passed with such a message ID may be an integer representing the size for all future chunks. Another message ID, shown as message ID 2 in Table 3, may allow for an abort signal to be sent to the network corresponding to a particular chunk stream ID. For example, if a communication session is in mid-stream when the transmitting end shuts-down, or other such event, the abort message would generally inform the network that it should not expect any further chunks, thus, aborting the stream. Many other optional low-level protocol messages may also be provided for in various embodiments of the present invention. The two messages provided for in Table 3 are merely examples.

TABLE 3

LOW-LEVEL PROTOCOL MESSAGES			
Message	Message ID	Message Data	Description
Set Chunk Size	1	4 bytes representing an integer. Bytes are sent in "network" order (i.e., order of significance)	The integer represents the new maximum chunk size for all future chunks.
Abort Message	2	4 bytes representing an integer. Sent in "network" order.	The integer represents a chunk stream ID. If that chunk stream is currently waiting to complete a message (i.e., expecting more chunks). The message stream is aborted.

The embodiments of the present invention obtain benefits from breaking the individual messages further down into chunks. While it may appear more simple to send one message and then the next, a linear process, such as this, is actually much less efficient. A stream representing some media presentation may be comprised of several different sub-streams. One sub-stream may be for the audio, one for the video, and another for data. The combination of each of these sub-streams makes up the entire streaming presentation. Therefore, it becomes important to coordinate smooth delivery of each of the sub-streams to facilitate the smooth playback of the entire stream. For example, a video key frame may have a large amount of data, 20k-30k bytes, in contrast to audio messages that are generally very small. However, the audio messages are much more time sensitive than the video messages due to the idiosyncrasies of human hearing. Therefore, if an audio message is sent from the audio sub-stream, followed by a very large video message from the video sub-stream, followed by the next audio message, the audio stream may typically stall because the next audio message simply may not arrive in time.

In operation, the larger video messages are typically much less frequent, even though they may be much larger. Therefore, interleaving other messages in between the video messages is acceptable as long as the video message eventually arrives in time for the smooth playback of the video sub-stream. Considering this balancing process, breaking the messages into chunks that may be more easily balanced and interleaved increases the efficiency of the streaming. While no one maximum chunk size is best for all situations, a given maximum may be beneficially set in which the video and data messages arrive without too much effect on the timely arrival of the audio chunks.

In certain embodiments of the present invention, the maximum chunk size is set to correspond to the complete length of a standard audio message in the audio sub-streams in order to ensure timely delivery of the complete audio message. For example, the sampling rate for the audio compression algorithm, Nellymoser, is typically 8 kHz. The 8 kHz sampling typically generates messages that are 128 bytes long. Therefore, in certain embodiments of the present invention that may use the Nellymoser compression algorithm, the maximum chunk size may preferably be set to 128 bytes. Other audio compression formats may produce messages that are either greater than or less than 128 bytes. In such cases, a low-level protocol message could be used to change the maximum chunk size of the applicable embodiments of the present invention to ensure an optimal efficiency algorithm.

Balancing the transmission of the chunks in the different media sub-streams is preferably controlled by a scheduling algorithm that directs which chunk of which stream or sub-stream to send next. Each type of media may preferably be assigned a specific priority value. For example, because audio messages are the most sensitive, they may be assigned the highest priority value. Video and data messages would each likely be assigned lower priority values. FIG. 6 is a flowchart disclosing representative steps of scheduling algorithm 60 used in representative embodiments of the present invention. In step 600, the priority of each sub-stream (PrioritySB) is summed into a total stream priority (StreamPriority). In step 601, a desired percentage for sending each sub-stream within the stream according to formula (1):

$$\text{Desired \%} = \text{PrioritySB} / \text{StreamPriority} \quad (1)$$

The total number of chunks sent (count) are counted per sub-stream over the preceding 'N' chunks in step 602. 'N' represents a scheduling sampling window that may be pre-set

by a user or developer. In step 603, the actual percentage of chunks sent per sub-stream in the preceding 'N' chunks is developed according to formula (2):

$$\text{Actual \%} = \text{count} / N \quad (2)$$

In step 604, a ratio of desired percentage to actual percentage is determined for each sub-stream. A selection criteria, which selects the sub-stream with lowest ratio is executed in step 605. In step 606, a queue monitor searches or determines whether the selected sub-stream has a chunk queued. In step 607, if a chunk is queued for the selected sub-stream, a queue manner selects the sub-stream chunk to send. If no data is queued for the selected sub-stream, the determination is made whether there are any other waiting sub-streams left, in step 608. If there are no remaining sub-streams, then no chunks are sent in the cycle, in step 609. However, if there are remaining sub-streams, a new sub-stream is selected, in step 610, that has the next lowest ratio of desired to actual percentages. Steps 606-610 are repeated until all chunks in each sub-stream are sent.

Scheduling algorithm 60 preferably results in a favorable balance of streams. If all sub-streams always have data to send, not only does scheduling algorithm 60 provide for those streams to obtain the proper percentage of chunks sent, but also provides a good interleaving mix over the scheduling window. When some sub-streams do not have data or, at least, do not have data queued, scheduling algorithm 60 allows the lower priority sub-streams to use a greater bandwidth. Thus, bandwidth use is routinely optimized. One embodiment of the present invention may achieve desired results with audio having a priority of 100, data priority of 10, and video priority of 1. However, other various priority assignments may prove better for different situations and known or expected data types or data loads.

FIG. 7A is a conceptual block diagram illustrating real-time communication system 70 configured using a representative embodiment of the real-time priority-based protocol of the present invention. Stream presentation 700, which may include video sub-stream 704 for providing visual rendering 701, data sub-stream 705 for providing data visual 702, and audio sub-stream 706 for supporting the audio for visual rendering 701, is intended to be streamed from computer 707 to client 712 in a peer-to-peer application. Stream 703 includes each of video, data, and audio sub-streams 704-706. Computer 707, which includes a processor capable of running the real-time priority-based protocol described herein, breaks the video, data, and audio messages into chunks according to a maximum chunk size preferably set to accommodate the sampling rate of the audio information. As video, data, and audio sub-streams 704-706 are broken into the appropriated chunk size, the necessary header information is placed on each chunk according to the teachings described herein at state machine 713. The chunks are then queued in chunk queue 709 awaiting the determination of which chunks to send. Sub-queues for audio, video, and data chunks may each be maintained for more efficient determinations of the chunks. Scheduler 708 implements a scheduling algorithm, such as scheduling algorithm 60 (FIG. 6), to schedule and prioritize the transmission of each of the chunks for the different sub-streams.

It should be noted that if a stream were being received by computer 707 instead of transmitting the stream, chunk assembly 718 would be used to assemble the received chunks into the resulting message stream.

The example embodiment shown in FIG. 7A also includes single socket connection 710 between Internet 711 and both of computer 707 and client 712. Scheduler 708 controls

which chunks are sent in order to accommodate delivering stream 703 to client 712, in such a manner that a user at client 712 may view, in real-time, stream presentation 700 with a minimum amount of interference or disturbance in the playback over single socket connection 710. As the data chunks are received, chunk assembly 718 on client 712 operates with instructions from state machine 713 within client 712 to reassemble the received chunks into presentation stream 714 with video, audio, and data sub-streams 715-717. It should be noted that instances of state machine 713 are preferably included in each entity compatible with the real-time, priority-based communication system of the present invention. Furthermore, if client 712 were transmitting the message stream instead of receiving the chunk stream, queue 709 and scheduler 708 on client 712 would be used to transmit the chunks associated with the message stream.

FIG. 7B is a conceptual block diagram illustrating real-time communication system 71 configured using a representative embodiment of the real-time priority-based protocol of the present invention in a client-server application. Similar to the example shown in FIG. 7A, stream presentation 720, which may include video sub-stream 726 for providing visual rendering 721, data sub-stream 725 for providing data visual 722, and audio sub-stream 724 for supporting the audio for visual rendering 721, may originate from computer 727 and viewed on entity 737 through server 728 in a client-server topology.

The processing capabilities of computer 727 divides video, audio, and data sub-streams 724-726 into chunks for streaming over the connection to server 728. As the chunks are assembled, state machine 713 provide the necessary header information for each chunk as the chunks are queued in chunk queue 709. Scheduler 708 executes a scheduling algorithm to determine which chunks should be transmitted in which order. It should be noted that, as above, if a stream were being received by computer 727 instead of transmitting the stream, chunk assembly 718 would be used to assemble the received chunks into the resulting message stream. Through connection 72, which may be the Internet, wide area network (WAN), local area network (LAN), wireless local area networks (WLAN), or the like, chunks are transmitted to server 728. Using an instance of state machine 713 on server 728, the chunks may be received and reassembled, at server 728, using chunk assembly 718. Stream 732 at server 728 is comprised also of audio, video, and data sub-streams 729-731. Server 728 acts as the middle-ware providing stream presentation 720 to each entity subscriber, such as entity 737. As such, when stream 732 is to be sent to client 737, scheduler 708 and queue 709 on server 728 facilitate streaming the chunks via connection 72.

State machine 713 at server 728 assists the streaming of the chunks of audio, video, and data sub-streams 729-731 using connection 72 to entity 737. Upon receiving the chunks, state machine 713 at entity 737 helps decipher and assemble the header invention with chunk assembly 719. Audio, video, and data sub-streams 733-735 of stream 736 are then assembled and may be displayed at entity 737. In such an embodiment, while stream presentation 720 may likely be blocked by a firewall or NAT from reaching entity 737 directly. This complication is preferably avoided by using the middle-ware functionality of server 728. Server 728 preferably has authorized access to entity 737 though any given firewall or NAT. Furthermore, if entity 737 were transmitting the message stream instead of receiving the chunk stream, queue 709 and scheduler 708 on entity 737 would be used to transmit the chunks associated with the message stream.

When implemented in software, the elements of the present invention are essentially the code segments to perform the necessary tasks. The program or code segments can be stored in a computer readable medium or transmitted by a computer data signal embodied in a carrier wave, or a signal modulated by a carrier, over a transmission medium. The "computer readable medium" may include any medium that can store or transfer information. Examples of the computer readable medium include an electronic circuit, a semiconductor memory device, a ROM, a flash memory, an erasable ROM (EROM), a floppy diskette, a compact disk CD-ROM, an optical disk, a hard disk, a fiber optic medium, a radio frequency (RF) link, etc. The computer data signal may include any signal that can propagate over a transmission medium such as electronic network channels, optical fibers, air, electromagnetic, RF links, and the like. The code segments may be downloaded via computer networks such as the Internet, Intranet, and the like.

FIG. 8 illustrates computer system 800 adapted to use the present invention. Central processing unit (CPU) 801 is coupled to system bus 802. The CPU 801 may be any general purpose CPU, such as an INTERNATIONAL BUSINESS MACHINE (IBM) POWERPC™, INTEL™ PENTIUM™-type processor, or the like. However, the present invention is not restricted by the architecture of CPU 801 as long as CPU 801 supports the inventive operations as described herein. Bus 802 is coupled to random access memory (RAM) 803, which may be SRAM, DRAM, or SDRAM. ROM 804 is also coupled to bus 802, which may be PROM, EPROM, EEPROM, Flash ROM, or the like. RAM 803 and ROM 804 hold user and system data and programs as is well known in the art.

Bus 802 is also coupled to input/output (I/O) controller card 805, communications adapter card 811, user interface card 808, and display card 809. The I/O adapter card 805 connects to storage devices 806, such as one or more of a hard drive, a CD drive, a floppy disk drive, a tape drive, to the computer system. The I/O adapter 805 would also allow the system to print paper copies of information, such as documents, photographs, articles, etc. Such output may be produced by a printer (e.g. dot matrix, laser, and the like), a fax machine, a copy machine, or the like. Communications card 811 is adapted to couple the computer system 800 to a network 812, which may be one or more of a telephone network, a local (LAN) and/or a wide-area (WAN) network, an Ethernet network, and/or the Internet network. User interface card 808 couples user input devices, such as keyboard 813 and pointing device 807 to the computer system 800. The display card 809 is driven by CPU 801 to control the display on display device 810.

FIG. 9 illustrates a sequence of interleaved audio and video chunks in real-time priority-based communication system 90 configured according to various embodiments of the present invention. System 90 shows a one-way communication session of streaming media occurring from transmitting entity 91 to receiving player 92 over connection 900. The messages to be streamed may comprise audio, video, and data messages. FIG. 9 shows a message that comprises video and audio sub-streams. As the video and audio sub-streams are broken into video and audio chunks, the state machine of the various embodiments of the present invention supply the necessary header information for the chunks. Transmitting entity 91 places the chunks in either video queue 93 or audio queue 94 to await transmission.

The scheduling algorithm run by transmitting entity 91 controls when chunks are sent to connection interface 97 from either video or audio queue 93 and 94. Chunks 901, 903, 905,

907, 909, 911, 913, and 915 are illustrated on connection 900 along with corresponding header parameters 902, 904, 906, 908, 910, 912, 914, and 916 configured according to the illustrated example of the present invention. Because audio chunks are more sensitive than video chunks, the scheduler sends audio chunk 901 over connection 900 first. Audio chunk 901 includes header 902. Header 902 describes audio chunk as a Type 0 chunk and gives the necessary information that accompanies a Type 0 new message chunk, including the chunk ID, message stream ID, length, message type, and time delta. The state machine at receiving player 92 sets the state for the audio sub-stream beginning with audio chunk 901. Audio chunk 903 is the next chunk sent by the scheduler at transmitting entity 91 and includes header 904. Header 904 identifies chunk 903 as a Type 3 continuation header belonging to chunk ID 1, the chunk ID assigned to the first audio sub-stream. Because audio chunk 903 is a continuation chunk, only the chunk type and chunk ID are required in the header information. The state machine at receiving entity 92 reads that chunk 903 is a Type 3 continuation chunk and keeps all states fixed for the audio sub-stream of chunk ID 1.

The scheduler at transmitting entity 91 sends video chunk 905 next along with header 906. Because video chunk 905 is the first of the video sub-stream, it is designated a Type 0 chunk and includes all of the necessary header information to go along with the first chunk of the video sub-stream. Thus, video chunk 905 may include a different chunk ID, message stream ID, length, message type, and time delta. The state machine at the receiving entity sets the necessary states for the video sub-stream of chunk ID 2. The next chunk sent by the scheduler is audio chunk 907 and header 908. Header 908 identifies chunk 907 as a Type 3 continuation chunk of chunk ID 1. The state machine refers to the states set for the audio sub-stream of chunk ID 1 and maintains those settings for the first audio sub-stream.

The scheduler then sends audio chunk 909 and header 910 across connection 900. Header 910 identifies audio chunk 909 as a Type 0 new message chunk. The state machine at receiving entity 92 resets all information in the states of the audio sub-streams and sets the new states according to header 910. The next chunk in the interleaved sequence is video chunk 911 along with header 912. Header 912 identifies video chunk 911 as a Type 3 continuation chunk of video sub-stream chunk ID 2. The state machine at receiving entity 92 accesses the states set for chunk ID 2 and keeps all of the state information in tact for video chunk 911. The next chunk sent on connection 900 is audio chunk 913 and header 914. Header 914 identifies chunk 913 as a Type 3 continuation chunk of chunk ID 3. The state machine accesses the states saved for the audio sub-stream of chunk ID 3 and maintains each state intact. The final chunk illustrated in FIG. 9 is audio chunk 915 and header 916. Header 916 identifies chunk 915 as a type 2 chunk representing a new message having a new time delta. The state machine reads that chunk 915 is a Type 2 chunk and expects the beginning of a new audio sub-stream with only a change to one of the states for a new chunk ID 4.

As each of chunks 901, 903, 905, 907, 909, 911, 913, and 915 are received at receiving entity 92 through connection interface 97, the audio chunks are re-assembled in audio assembly 96, while the video chunks are re-assembled in video assembly 95 before being played back at receiving entity 92. The state machine at receiving entity 92 preferably reads the parameters in each of headers 902, 904, 906, 908, 910, 912, 914, and 916 controls the re-assembly of the chunks in audio assembly 96 and video assembly 95. In additional embodiments of the present invention other interleaving scheduling algorithms and/or efficiency algorithms may be

implemented. The goal is to achieve an efficient mix of audio, video, and data chunks that results in a good playback that minimizes the audio or video jitter in the playback.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. A method comprising:

communicating a media stream comprised of a one or more streams, wherein each of said one or more streams is divided into a plurality of chunks; and

associating a state of a plurality of states with each chunk of said plurality of chunks, a header of each of said chunks including a state association representing said state, the state association indicating one of a plurality of possible purposes for each respective chunk, wherein said possible purposes indicated by said state association consist of:

- a new stream chunk associated with a new stream, wherein said new stream chunk includes a plurality of new parameters in said header and uses no parameters from a previous header,
- a new media chunk associated with said new stream wherein said new media chunk includes a plurality of new parameters in said header and uses at least one other parameter from a previous header,
- a new time chunk associated with said new stream wherein said new time chunk includes at least one new parameter in said header and uses a plurality of other parameters from a previous header, and
- a continuation chunk requiring no new parameters in said header and using a plurality of parameters from a previous header.

2. The method of claim 1, wherein said state associations provide information regarding an associated one of said one or more streams and said media stream.

3. The method of claim 1, wherein said communicating said media stream comprises receiving a transmitted plurality of chunks, and said associating a state of said plurality of states with each chunk of said plurality of chunks comprises translating state associations from each of said plurality of chunks into information regarding an associated one of said one or more streams and said media stream.

4. The method of claim 1, wherein said parameters include one or more of:

- a stream ID parameter;
- a length parameter;
- a media type parameter; and
- a time delta parameter.

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5. The method of claim 1, further comprising:
queuing said plurality of chunks for transmission; and
transmitting ones of said plurality of chunks according to a scheduling algorithm.
6. The method of claim 5, wherein said queuing includes:
queuing said plurality of chunks according to a media type of said chunk, wherein said media type comprises one of:
an audio format chunk;
a video format chunk; and
a data format chunk.
7. The method of claim 6, wherein said scheduling algorithm further interleaves said audio format chunks, said video format chunks, and said data format chunks according to an interleaving algorithm.
8. The method of claim 5, further comprising:
assigning a priority to each stream of said one or more streams;
totaling a priority for each media stream;
calculating a desired transmission rate for each stream of said one or more streams using said assigned priority and said totaled priority;
counting a sub-total of chunks transmitted per each said stream during a preset period;
counting a total number of chunks transmitted during said preset period;
calculating an actual transmission rate for each said stream using said sub-total and said total; and
calculating a ratio between said desired transmission rate and said actual transmission rate.
9. The method of claim 8, wherein said scheduling algorithm includes:
determining a stream of said one or more streams having a lowest ratio;
checking said queue of said plurality of chunks for a chunk associated with said determined stream; and
transmitting said chunk associated with said determined stream when found in said queue.
10. A computer program product having a computer readable medium with computer program logic recorded thereon, said computer program product comprising:
code for communicating a media stream comprised of one or more streams, wherein each of said one or more streams is divided into a plurality of chunks; and
code for implementing a state machine that processes state assignments for each of said plurality of chunks, wherein a header of each of said chunks includes at least one of said state assignments, the state assignments indicating one of a plurality of purposes for each corresponding chunk, and wherein the possible purposes indicated by said state assignments consist of:
a new stream chunk associated with a new stream wherein said new stream chunk includes a plurality of new parameters in said header and uses no parameters from a previous header,
a new media chunk associated with said new stream wherein said new media chunk includes a plurality of new parameters in said header and uses at least one other parameter from a previous header,
a new time chunk associated with said new stream wherein said new time chunk includes at least one new parameter in said header and uses a plurality of other parameters from a previous header, and
a continuation chunk requiring no new parameters in said header and using a plurality of parameters from a previous header.

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11. The computer program product of claim 10, further comprising:
code for writing a corresponding one of said state assignments into said header of each of said plurality of associated chunks.
12. The computer program product of claim 10, further comprising:
code for breaking down each one of said one or more streams into a plurality of associated chunks.
13. The computer program product of claim 10, wherein said code for communicating comprises code for receiving said plurality of associated chunks.
14. The computer program product of claim 13, further comprising:
code for reading said state assignments from said header of each of said received plurality of chunks.
15. The computer program product of claim 10, wherein said code for implementing comprises code for translating said state assignments for each of said plurality of associated chunks into information regarding said one or more streams and said media stream.
16. The computer program product of claim 10, wherein said code for implementing comprises code for assigning a chunk ID for associating said chunk with one of said one or more streams, wherein said chunk ID is smaller than an ID related to said one of said one or more streams.
17. The computer program product of claim 10, wherein said parameters include at least one of:
a stream ID parameter;
a length parameter;
a media type parameter; and
a time delta parameter.
18. The computer program product of claim 10, further comprising:
code for queuing ones of said plurality of chunks waiting for transmission according to a scheduling algorithm.
19. The computer program product of claim 18, wherein said code for queuing includes:
code for queuing said plurality of chunks according to a media type of said chunk, wherein said media type comprises one of:
an audio format chunk;
a video format chunk; and
a data format chunk.
20. The computer program product of claim 18, further comprising:
code for assigning a priority to each stream of said one or more streams;
code for totaling a priority for each media stream;
code for calculating a desired transmission rate for each stream of said one or more streams using said assigned priority and said totaled priority;
code for counting a sub-total of said plurality of associated chunks transmitted per said one or more streams during a preset period;
code for counting a total number of said plurality of associated chunks transmitted during said preset period;
code for calculating an actual transmission rate for each stream of said one or more streams using said sub-total and said total; and
code for calculating a ratio between said desired transmission rate and said actual transmission rate.
21. The computer program product of claim 20, wherein said scheduling algorithm comprises:
code for selecting said stream of said one or more streams having a lowest of said calculated ratio;

code for searching said queue for one of said plurality of chunks related to said selected stream; and
code for transmitting said one of said plurality of chunks related to said determined stream.

22. A method comprising:
receiving a multimedia stream including a plurality of media message chunks, each chunk having a control header and data payload associated therewith;
reading a chunk type identifier of each said control header, wherein said chunk type identifiers indicate a purpose of a plurality of possible purposes for said chunk, and wherein the possible purposes indicated by said chunk type identifiers consist of:

a new stream chunk, wherein said control header of said new stream chunk includes a plurality of new parameters and uses no parameters from a control header of a previous chunk,

a new media chunk, wherein said control header of said new media chunk includes a plurality of new parameters and uses at least one other parameter from a control header of a previous chunk,

a new time chunk, wherein said control header of said new time chunk includes at least one new parameter and uses a plurality of other parameters from a control header of a previous chunk, and

a continuation chunk, wherein said control header of said continuation chunk includes no new parameters and uses a plurality of parameters from a control header of a previous chunk.

23. The method of claim 22, further comprising:
selecting, using an associated one of said chunk type identifiers, particular parameters of said plurality of parameters for use with respect to one or more subsequent chunks of said multimedia stream.

24. The method of claim 23, further comprising:
controlling a state machine to set said particular parameters for use by said one or more subsequent chunks.

25. The method of claim 22, further comprising:
reading a chunk stream identifier of each said control headers; and
determining, using an associated one of said chunk stream identifiers, whether a corresponding chunk is a low-level protocol message or a media stream content message.

26. The method of claim 22, further comprising:
reading a chunk stream identifier of each said control headers; and
determining, using an associated one of said chunk stream identifiers, a number of bytes of a chunk control byte used to identify a chunk stream said chunk is associated with.

27. A computer program product having a computer readable medium with computer program logic recorded thereon, said computer program product comprising:

code for receiving a multimedia stream including a plurality of media message chunks, said chunks each having a control header and data payload associated therewith;
code for reading a chunk type identifier of each said control header, wherein said chunk type identifiers indicate a purpose of a plurality of possible purposes for said chunk, and wherein the possible purposes indicated by said chunk type identifiers consist of:

a new stream chunk, wherein said control header of said new stream chunk includes a plurality of new parameters and uses no parameters from a control header of a previous chunk,

a new media chunk, wherein said control header of said new media chunk includes a plurality of new parameters and uses at least one other parameter from a control header of a previous chunk,

a new time chunk, wherein said control header of said new time chunk includes at least one new parameter and uses a plurality of other parameters from a control header of a previous chunk, and

a continuation chunk, wherein said control header of said continuation chunk includes no new parameters and uses a plurality of parameters from a control header of a previous chunk.

28. The computer program product of claim 27, further comprising:
code for selecting, using an associated one of said chunk type identifiers, particular parameters of said plurality of parameters for use with respect to one or more subsequent chunks of said multimedia stream.

29. The computer program product of claim 28, further comprising:
code for controlling a state machine to set said particular parameters for use by said one or more subsequent chunks.

30. The computer program product of claim 27, further comprising:
code for reading a chunk stream identifier of each said control headers; and
code for determining, using an associated one of said chunk stream identifiers, whether a corresponding chunk is a low-level protocol message or a media stream content message.

31. The computer program product of claim 27, further comprising:
code for reading a chunk stream identifier of each said control headers; and
code for determining, using an associated one of said chunk stream identifiers, a number of bytes of a chunk control byte used to identify a chunk stream said chunk is associated with.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,587,509 B1
APPLICATION NO. : 11/841517
DATED : September 8, 2009
INVENTOR(S) : Bradley A. Edelman et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title Page

right column, OTHER PUBLICATIONS, line 1:
delete "Sreaming", and replace with --Streaming--

Title Page:

right column, OTHER PUBLICATIONS, line 2:
delete "Compter", and replace with --Computer--

In the Specification:

column 1, line 7:
delete "co-pending, commonly assigned,"

In the Specification:

column 1, line 10:
after "Feb. 13, 2003," insert --now U.S. Patent 7,272,658--

Claim 21:

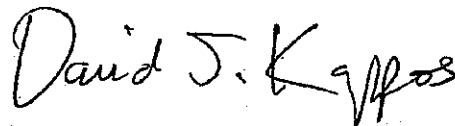
column 19, line 4:
delete "determined", and replace with --selected--

Claim 25:

column 19, line 38:
delete "comprising.", and replace with --comprising:--

Signed and Sealed this

Third Day of November, 2009



David J. Kappos
Director of the United States Patent and Trademark Office



US007272658B1

(12) **United States Patent**
Edelman et al.

(10) **Patent No.:** **US 7,272,658 B1**
(45) **Date of Patent:** **Sep. 18, 2007**

(54) **REAL-TIME PRIORITY-BASED MEDIA COMMUNICATION**

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(73) **Assignee:** **Adobe Systems Incorporated**, San Jose, CA (US)

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(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 759 days.

Primary Examiner—Glenton B. Burgess
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(51) **Int. Cl.**
G06F 15/16 (2006.01)
H04N 7/173 (2006.01)

(52) **U.S. Cl.** **709/231; 709/219**

(58) **Field of Classification Search** **709/231; 725/103**

See application file for complete search history.

(57) **ABSTRACT**

Representative embodiments are disclosed of a real-time priority-based communication system and method for communicating media streams made up of multiple media message sub-streams, the communication system comprising a chunk configurator for dividing media message sub-streams into chunks, a state machine configured to translate between information regarding the media message sub-streams and the chunks and state associations to the information, the state associations written into a header for each of the chunks, a queue for holding the chunks waiting to be transmitted, and a processor for executing a scheduling algorithm, wherein the scheduling algorithm determines ones of the chunks in the queue to transmit next.

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28 Claims, 7 Drawing Sheets

CHUNK	CHUNK STREAM ID	CHUNK TYPE	HEADER DATA	NUMBER OF BYTES AFTER HEADER	TOTAL CHUNK BYTES
500	4	0	Δ: 20 L: 435 TYPE: 9 STREAM ID: 12346	128	139
501	4	3	<NONE>	128	129
502	4	3	<NONE>	128	129
503	4	3	<NONE>	51	52

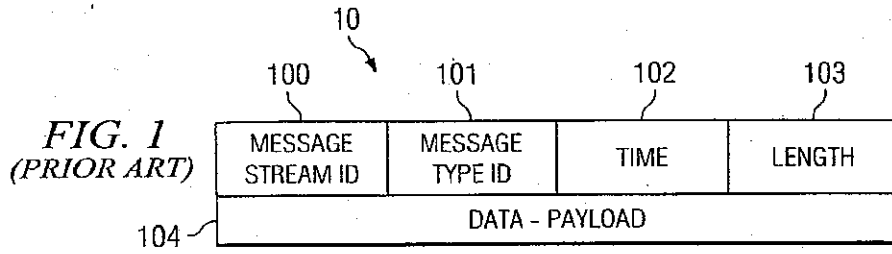


FIG. 2
(PRIOR ART)

	100	101	102	103
	MESSAGE STREAM ID	MESSAGE TYPE ID	TIME	LENGTH
MSG 21	1 2 3 4 5	8 (AUDIO)	1000	32
MSG 22	1 2 3 4 5	8	1020	32
MSG 23	1 2 3 4 5	8	1040	32
MSG 24	1 2 3 4 5	8	1060	32

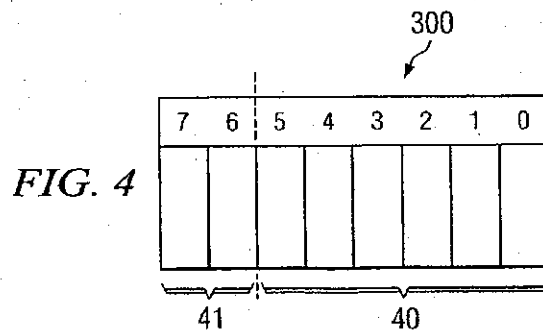
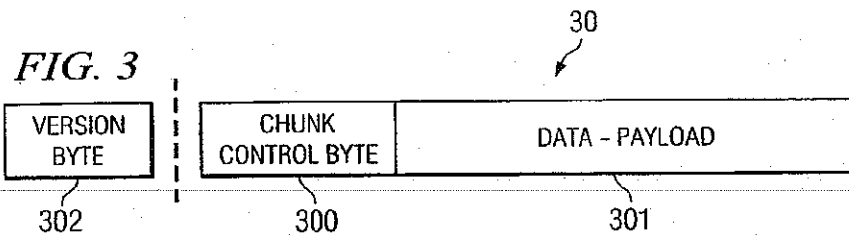


FIG. 5A

CHUNK	CHUNK STREAM ID	CHUNK TYPE	HEADER DATA	NUMBER OF BYTES AFTER HEADER	TOTAL CHUNK BYTES
500	4	0	Δ: 20 L: 435 TYPE: 9 STREAM ID: 12346	128	139
501	4	3	<NONE>	128	129
502	4	3	<NONE>	128	129
503	4	3	<NONE>	51	52

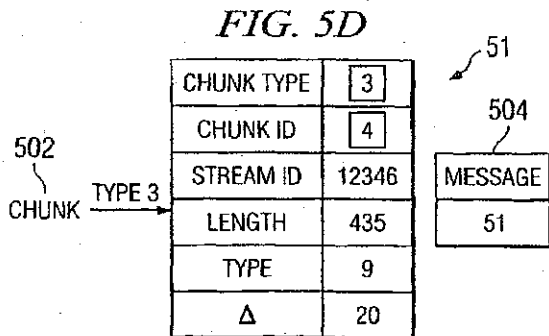
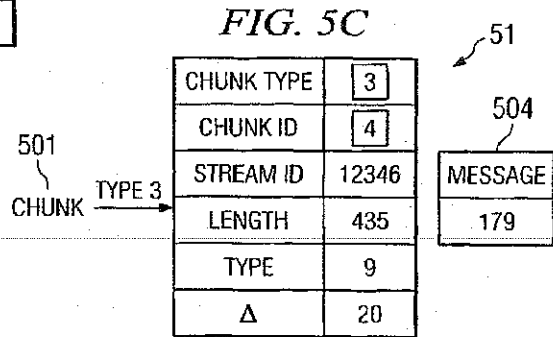
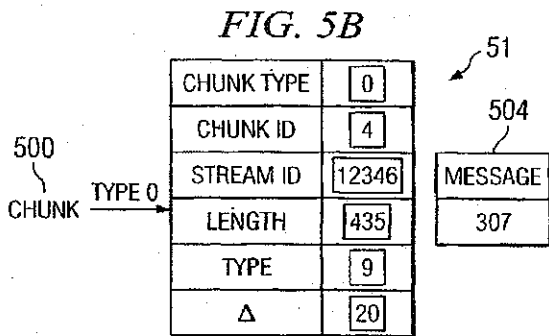


FIG. 5E

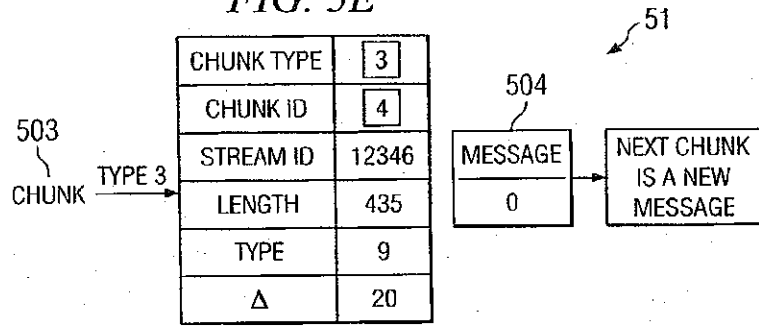
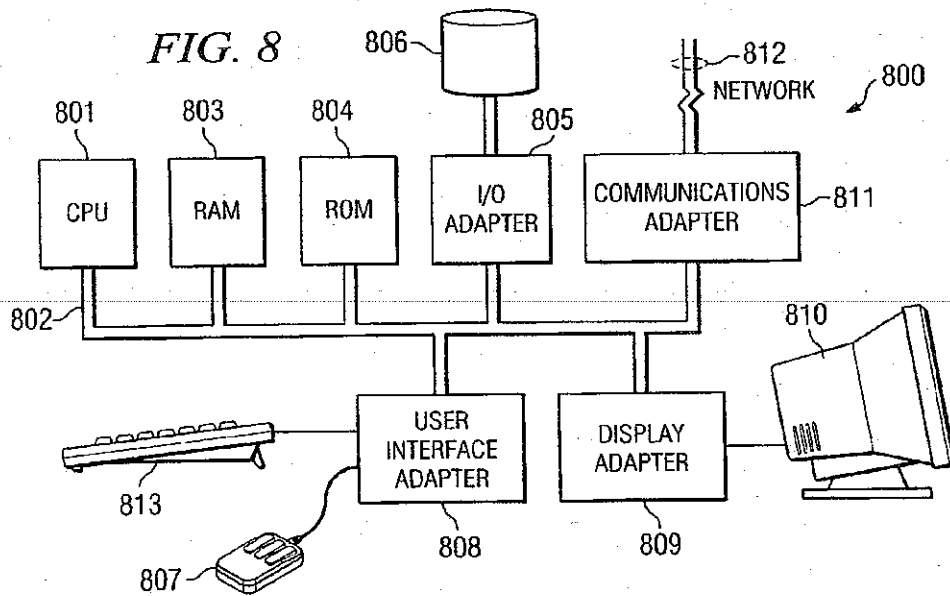
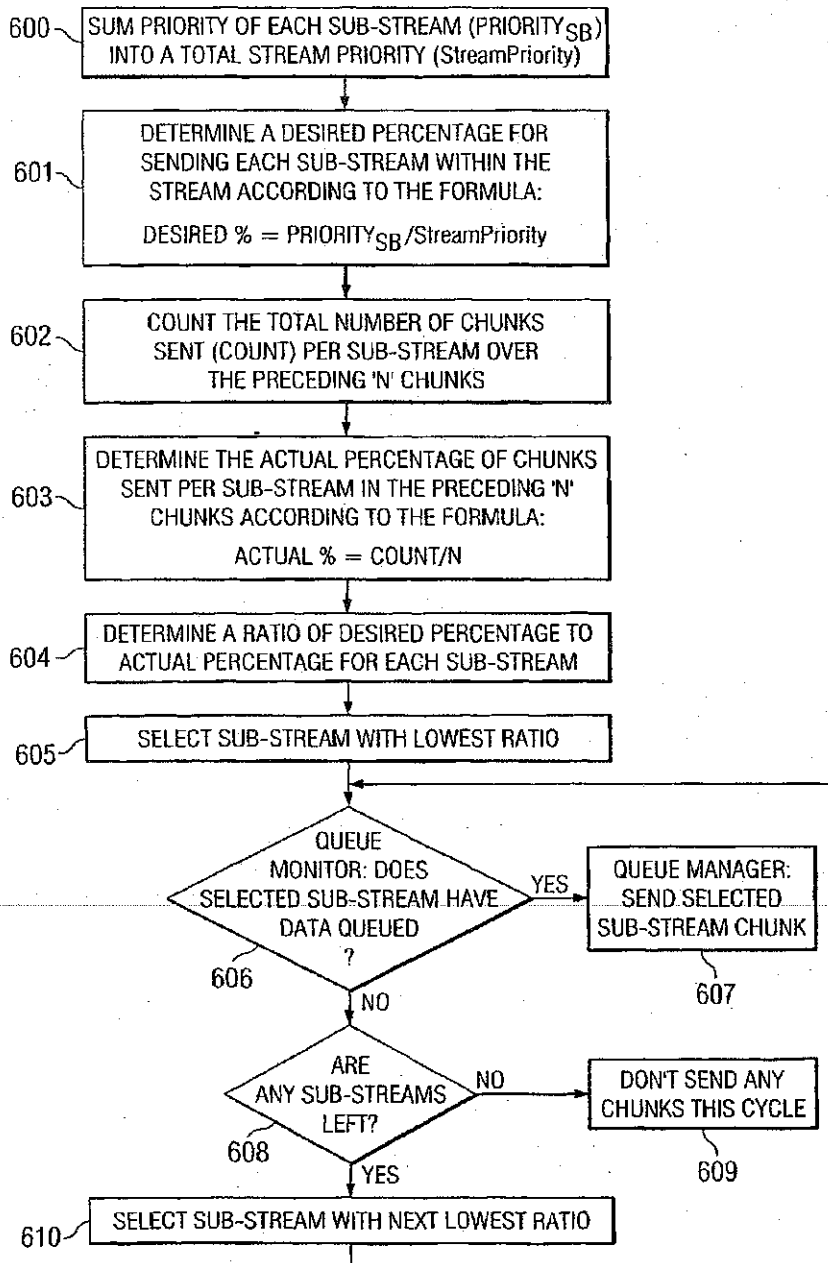


FIG. 8



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FIG. 6



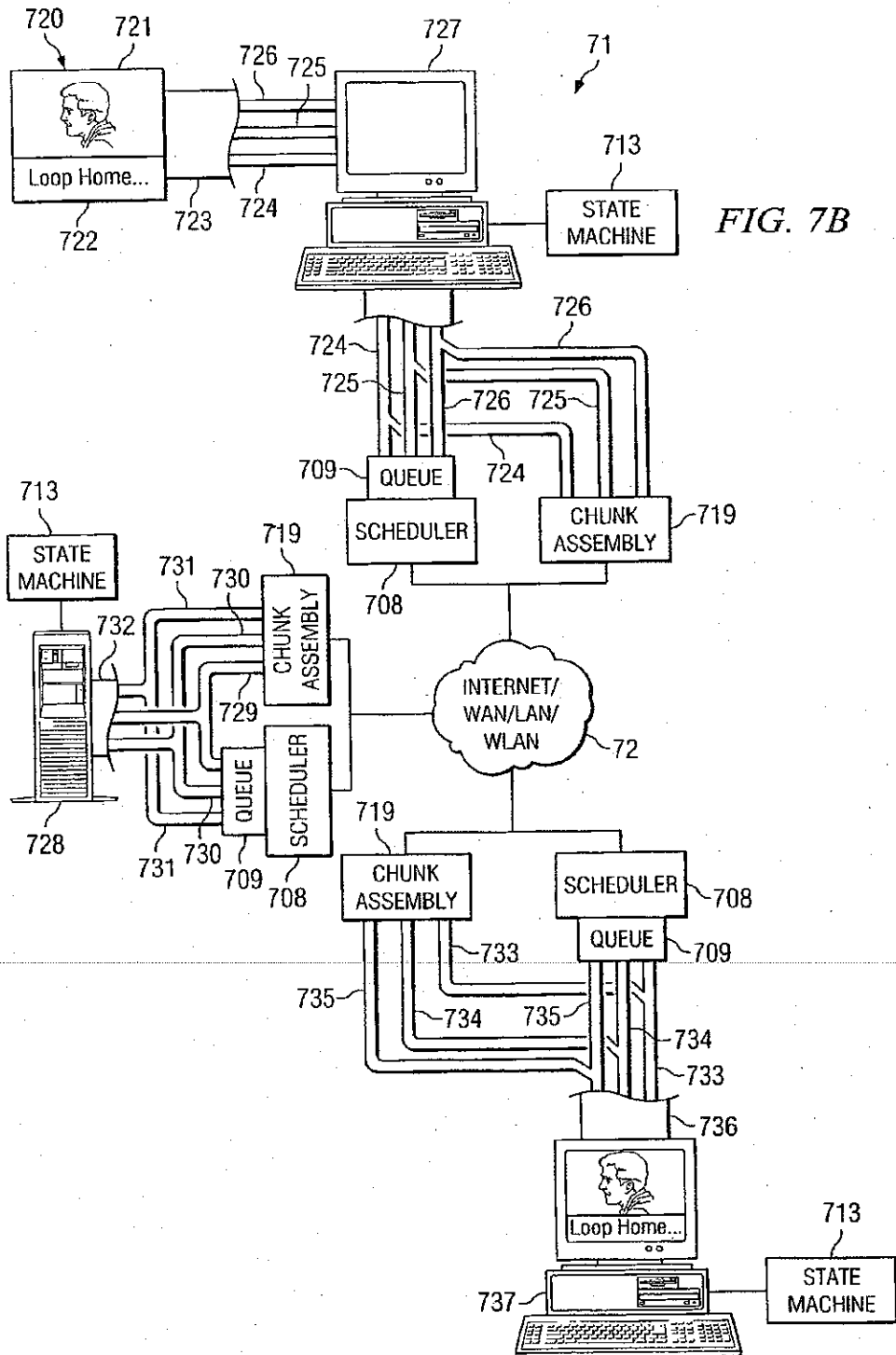
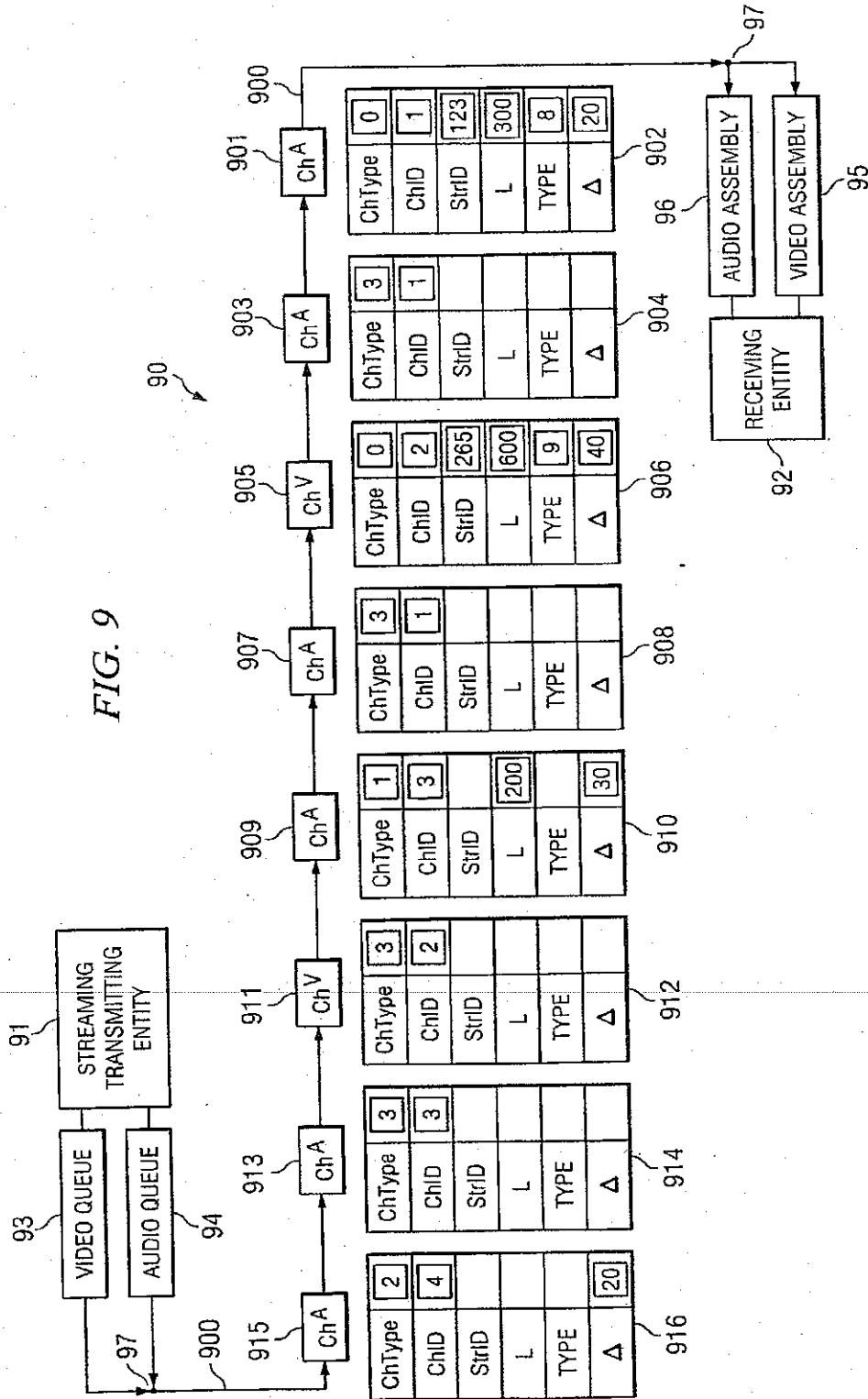


FIG. 9



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REAL-TIME PRIORITY-BASED MEDIA COMMUNICATION

TECHNICAL FIELD

The present invention relates, in general, to media communications, and, more specifically, to a system and method for a real-time priority-based communication system.

BACKGROUND OF THE INVENTION

In the early years of the Internet, its primary use was for the reliable transmission of data with minimal or no delay constraints. Transmission Control Protocol (TCP), of the TCP/Internet Protocol (IP) protocol suite, was designed for this type of delay-independent data traffic. TCP typically works well in this context where the reliability of the packet delivery is much more important than any packet delays. In order to achieve this reliability, TCP sets up a connection at both ends and attaches a header to each packet that contains the source and destination ports as well as the sequence number of the packet and other such administrative information. The destination typically receives a number of TCP packets before sending an acknowledgement to the source. If the acknowledgment fails, the source will generally presume the packets were lost and retransmit the "lost" packets. While this process ensures reliable delivery, packets may be delayed which, in multimedia streams, may cause noticeable and unacceptable degradation of quality in the multimedia playback.

An alternative transmission protocol in the TCP/IP protocol suite is User Datagram Protocol (UDP). Unlike TCP, UDP is connectionless and unreliable, meaning that it does not establish a connection at both ends and does not include a resource for resending lost packets. Instead, the UDP packets are sent out with a packet header that typically includes only the source and destination ports along with a 16-bit segment length and 16-bit checksum for minimal error detection. Because UDP does not include the additional administrative information, it generally makes no delivery guarantees, offers no flow control, and performs only minimal error detection. As such, UDP has useful timing characteristics for real-time audio or video transmission, where the delivery of every packet is not as important as the timely delivery of packets. UDP was generally used as the early transport protocol for real-time multimedia applications because it typically offers these beneficial characteristics for delay-sensitive data delivery. However, by itself, UDP usually does not provide any general purpose tools that may be useful for real-time applications.

In response to the limitations of UDP, Real-time Transport Protocol (RTP) was developed to operate as a thin layer on top of UDP to create a generalized multipurpose real-time transport protocol. An RTP fixed header may generally include: a 7-bit payload type field for identifying the format of the RTP payload; a 16-bit sequence number which is incremented by one for each subsequent RTP data packet transmitted; a 32-bit timestamp that corresponds to the time that the first RTP data packet was generated at the source; a 32-bit synchronization source identifier which is a randomly generated value that uniquely identifies the source within a particular real-time session; as well as other administrative information. With this information, RTP provides support for applications with real-time properties including timing reconstruction, loss detection, security, and content identi-

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fication without the reliability-induced delays associated with TCP or the lack of timing information associated with UDP.

Real-Time Control Protocol (RTCP) works in conjunction with RTP to provide control support to the application for maintaining the RTP session. RTCP generally performs four functions: (1) providing information to the application regarding the quality of transmission, such as number of packets sent, number of packets lost, interarrival jitter, and the like; (2) identifying the RTP source through a transport-level identifier, called a canonical name (CNAME), to keep track of the participants in any particular RTP session; (3) controlling the RTCP transmission interval to prevent control traffic from overwhelming network resources; and (4) conveying minimal session control information to all session participants. The RTCP packets are typically transmitted periodically by each participant in an RTP session to all other participants. Therefore, RTCP provides performance and diagnostic information that may be used by the application.

One of the major problems associated with streaming multimedia information arises in attempting to stream the media through firewalls, Network Address Translation (NAT) devices, and the like. The major purpose of firewalls is to prevent unauthorized and/or hostile access to a computer system or network. As such, firewalls are generally configured with strict rules specifying specific, static ports through which desired and/or authorized data traffic can pass, while blocking undesirable data. The majority of all IP protocols use RTP for transporting the media streams. RTP is built over UDP, which generally has no fixed ports associated with it. Thus, there is no guarantee that a port associated with the incoming RTP/UDP stream will be allowed through the firewall. Moreover, each media stream typically has multiple channels, which generally requires its own opening through the firewall. This means that for the media stream to traverse the firewall, the firewall will have to open many UDP openings for each call session, which defeats the purpose for the firewall in the first place.

NAT devices are used to translate an IP address used within one network to a different IP address known within another network. NAT devices typically maintain a map of addresses within an "inside" network. Any communications directed to users within the inside network usually pass first through the NAT device for translation to the inside address. Thus, users within the inside network may see out, but outside users can only typically communicate with the inside users through the NAT device's translation. NAT devices may allow a network to support many more users or clients than it has fixed IP addresses. The NAT device may be addressed from the outside using the few fixed IP addresses, yet service many other address within the inside network.

Another problem with the existing streaming protocols is the amount of header information attached to any given piece of data on the stream. As mentioned above, UDP and TCP messages contain considerable header information concerning the timing, sequence, data type, and the like. Because multiple streams are typically running at once, each piece of data generally has a stream ID to tell the destination which stream any particular piece of data belongs to. In a situation where an audio stream is established where the message type is constant for a period of time and the formatting of the message type requires a constant number of bits per message, the header information on the type, length, and the like congests the stream with useless infor-

mation, thus taking away from the maximum available data bandwidth.

BRIEF SUMMARY OF THE INVENTION

Representative embodiments of the present invention are directed to a real-time priority-based communication system for communicating media streams made up of multiple media message sub-streams, the communication system comprising a chunk configurator for dividing media message sub-streams into chunks, a state machine configured to translate between information regarding the media message sub-streams and the chunks and state associations to the information, the state associations written into a header for each of the chunks, a queue for holding the chunks waiting to be transmitted, and a processor for executing a scheduling algorithm, wherein the scheduling algorithm determines ones of the chunks in the queue to transmit next.

Additional representative embodiments are directed to a method for communicating media streams, comprised of a plurality of sub-streams, in a real-time priority-based communication protocol, the method comprising dividing each one of the plurality of sub-streams into a plurality of chunks, assigning states to each of the plurality of chunks representative of information regarding the associated sub-streams and the associated media streams, writing the states into a header of each of the plurality of chunks, queuing the plurality of chunks for transmission, and transmitting ones of the plurality of chunks according to a scheduling algorithm.

Further representative embodiments are directed to a computer program product having a computer readable medium with computer program logic recorded thereon, the computer program product comprising code for breaking down each one of a plurality of media sub-streams making up a message stream into a plurality of associated chunks, code for implementing a state machine that processes state assignments for each of the plurality of associated chunks representative of information regarding the media sub-streams and the message streams, code for writing the state assignments into a header of each of the plurality of associated chunks, code for building a queue for the plurality of associated chunks waiting for transmission, and code for transmitting ones of the plurality of associated chunks according to a scheduling algorithm.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a conceptual block diagram illustrating a data packet which is part of a typical media stream;

FIG. 2 is a conceptual block diagram illustrating a typical message stream comprising multiple message packets;

FIG. 3 is a conceptual block diagram illustrating one example embodiment of a chunk configured according to the real-time priority-based communication system of the present invention;

FIG. 4 is a conceptual block diagram detailing a chunk control byte;

FIG. 5A is a conceptual block diagram illustrating a chunk stream comprising multiple chunks;

FIG. 5B is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 0 chunk;

FIG. 5C is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 3 chunk;

FIG. 5D is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 3 chunk;

FIG. 5E is a block diagram illustrating a state machine configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 3 chunk;

FIG. 6 is a flowchart disclosing representative steps of an example scheduling algorithm used in representative embodiments of the present invention;

FIG. 7A is a conceptual block diagram illustrating a real-time communication system configured using a representative embodiment of the real-time priority-based protocol of the present invention in a peer-to-peer application;

FIG. 7B is a conceptual block diagram illustrating a real-time communication system configured using a representative embodiment of the real-time priority-based protocol of the present invention in a client-server application;

FIG. 8 illustrates a computer system adapted to use the present invention; and

FIG. 9 illustrates a sequence of interleaved audio and video chunks in a real-time priority-based communication system configured according to various embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Before beginning a discussion of the various embodiments of the present invention, it may be helpful to review how media streams are carried through transmission.

FIG. 1 is a conceptual block diagram illustrating data packet 10 which is part of a media stream. Data packet 10 not only comprises data-payload 104, but also comprises header information that is used to assemble and play the media stream at the destination entity. The header information typically comprises message stream ID 100, message type ID 101, time 102, and length 103. Message stream ID 100 identifies the particular stream that data packet 10 is a part of. In a typical multimedia application, such as an

audio/video conference, for example, the outgoing stream may be a first stream, while the outgoing video stream may be a second stream. There are possible scenarios that include a large number of streams and sub-streams going back and forth to the different participants over a single connection. In a typical application a media stream is comprised of multiple media message sub-streams that make up the different aspects of the main media stream. In order to deal with the many different streams, each stream is designated with a unique ID, such as message stream ID 100. Thus, when data packet 10 enters the destination, the media application reads message stream ID 100 and assembles data packet 10 into the appropriate message stream. In a typical application, media stream ID 100 may comprise a 32-bit designator.

The header information may also comprise message type ID 101. Message type ID 101 identifies the specific format of data packet 10. For example, message type ID 101 may identify data packet 10 as an audio data format (or a particular type of audio data format, such as a wave data format (.wav), MP3, and the like), a video data format (or a particular type of video data format, such as a motion picture experts group (MPEG)-2 or -4, a MICROSOFT™ WINDOWS MEDIA AUDIO™ (.wma), and the like), or a pure data format. By designating the type of data format, the destination application will likely know how to play or display the incoming media stream.

Because a media stream generally comprises a group of packets transmitted over some network, it is important for the destination application to be able to assemble and play the data packets in order and according to the timing of the original image/media. Therefore, the header information also includes time 102, which is typically a time stamp for the recording or sampling of the particular packet. The destination application may use time 102 to synchronize each of the packets that it receives in the stream. The application will then know to play a packet with time 102 designating 1020 before a packet with time 102 designating 1040. The time stamp may be a real-time, start time, or the like. The purpose is to determine when the message occurred so that things may be synchronized later during broadcast or playback.

Length 103 is also a typical piece of header information that identifies the length of data packet 10. By designating the specific length of data packet 10, the destination application knows when the current data packet or media message has been fully received.

It may often be the case where a message stream carries data packets in which message stream ID 100, message type ID 101, and length 103 may be the same value. Where packets are received consecutively, message stream ID 100 should generally be the same. Furthermore, if the stream is an audio stream, for example, message type ID 101 should also generally be the same. Length 103 can vary to some extent, however, some media formats, such as constant bit-rate MP3, Nellymoser, and the like, may divide all packets into the same length. Therefore, in such cases, length 103 will also be the same for each packet.

FIG. 2 is a conceptual block diagram illustrating typical message stream 20 comprising message packets 21-24. Message packet 21 begins with the header information: message stream ID 100 of 12345, message type ID 101 of 8 (for audio), time 102 of 1000, and length 103 of 32 bytes. This header information is important for the destination application to associate the message packets with the correct stream and play them in the right manner and in the right order. Message packet 22 also includes the header information: message stream ID of 12345, message type ID 101 of

8, time 102 of 1020, and length 103 of 32 bytes. As may be seen in FIG. 2, message packet 22 contains much of the same header information as message packet 21. In fact, the only difference in the two message packets is the time stamp of time 103; message packet 21 has time 103 of 1000, while message packet 22 has time 103 of 1020. A difference of 20 seconds. Message 23 and 24 also comprise the same information for the header information of message stream ID 100, message type ID 101, and length 103, with time-stamps, time 102, differing by exactly 20 seconds per packet. The repeated information in message packets 21-24 clogs the available bandwidth of the entire system.

In an ideal system, it would be most efficient to send a data payload without any header information. However, without header information, it is practically impossible to assemble and playback data packets in a media stream with the current technology, let alone do so efficiently. FIG. 3 is a conceptual block diagram illustrating one example embodiment of chunk 30 configured according to the real-time priority-based communication system of the present invention. A chunk is a piece of a message stream that has been broken down or divided by a chunk configurator or some other message processing. Chunk 30 comprises chunk control byte 300 and data payload 301. Chunk control byte 300 preferably contains much of the header-type information necessary for managing the chunk stream.

It should be noted that in additional embodiments of the present invention, version byte 302 may be written/transmitted to provide information on the particular version of the transport protocol being used. The inclusion of this information usually allows easier maintenance of future protocol versions and backwards compatibility. In operation, only a single version byte would likely be necessary per connection. Therefore, version byte 302 would likely not add any overhead on a per chunk basis.

In attempting to reduce the overhead of stream messages, certain assumptions may be leveraged into bandwidth savings. One such assumption involves the necessity of a 32-bit message stream ID. Statistically, there are usually less than sixty-one (61) message streams (having unique message stream IDs) in a server at any given time for any given client. Sixty-one (61) message streams may be uniquely represented in only 6 bits. Thus, having a 32-bit message stream ID is typically a waste of space. FIG. 4 is a conceptual block diagram detailing chunk control byte 300. Chunk control byte 300 comprises a chunk identifier, such as chunk stream ID 40 and chunk type ID 41. While the statistics suggest that there are a maximum of sixty-one (61) message streams in a server at any one time for a particular client, artificially limiting the maximum number of streams does not present itself as an efficient means for obtaining bandwidth at the expense of stream capacity. Instead, chunk stream ID 40, as configured according to the embodiment illustrated in FIG. 4, provides a mechanism for supporting 65,597 total simultaneous streams (using a range of 3 to 65,599).

Chunk stream ID 40 comprises bits 0-5 of chunk control byte 300. As provided in Table 1, when the value of chunk stream ID 40 lies between 3 and 63 in certain embodiments of the present invention, chunk stream ID 40 is assigned at face value. Statistically, this situation will occur most often, resulting in a 6-bit chunk stream ID. However, when the value of chunk stream ID 40 is 0 in certain embodiments of the present invention, a second byte is added to chunk stream ID 40 that represents the range of 64 to 319. When the value of chunk stream ID is 1 in certain embodiments of the present invention, two additional bytes, a second byte and a third byte, are added to chunk stream ID 40 that

represent the range of 320 to 65,599. Therefore, the embodiment illustrated in FIGS. 3 and 4 supports up to 65,597 streams, while still conserving bandwidth on a statistically large number of messages. A chunk stream ID 40 value of 2 in certain embodiments of the present invention represents that the chunk contains a low-level protocol message, which are used to control administrative aspects of the embodiment illustrated in FIGS. 3 and 4.

TABLE 1

CHUNK STREAM ID (BITS 0-5 OF CHUNK CONTROL BYTE)	
Value	Meaning of Value
3-63	Chunk Stream ID is the face value of 3-63.
0	There is another byte that represents the range 64-319 (Second byte + 64).
1	There are two more bytes representing the range 320-65,599 ((Third byte)*256 + (Second byte + 64)).
2	The Chunk is a Low-Level Protocol Message.

The configuration of the real-time priority-based protocol illustrated in FIGS. 3 and 4 advantageously leverages the statistical maximum of sixty-one (61) streams. Because there are usually less than sixty-one (61) streams in the server at any given time for a client, only the 6 bits of chunk stream ID 40 will generally be sent. Thus, the 32-bit header for message stream IDs of the current technologies is preferably reduced to only 6 bits for the majority of data streams. In rare cases, in which the number of streams exceeds 61, the additional bytes of information may be included to support those extra streams.

The configuration of chunk stream ID 40 in certain embodiments of the present invention, as provided in Table 1, demonstrates implementation of a state machine having different state associations using its first 2 bits to address many different levels of streams. In furtherance of the state machine concept implementing the embodiments of the present invention, chunk type ID 41 provides four states/types for classifying each chunk message. Unlike the media type indicator of message type ID 101 (FIG. 1) that identifies the format of the data payload, chunk type ID 41 identifies the type or purpose of the chunk.

As provided in Table 2, bits 6 and 7 of chunk control byte 300 comprise chunk type ID 41. When the value of chunk type ID 41 is 0 in certain embodiments of the present invention, the chunk state or type indicator is a new/reset message type (Type 0) or indicates a new stream. This signifies the first message sent on the chunk stream in certain embodiments of the present invention. As is described in Table 2, a Type 0 message may comprise additional bytes of information that include the typical header information of the current stream methods, such as message length, message type ID, and message stream ID. Instead of using a timestamp, however, the embodiment of the present invention illustrated in FIGS. 3 and 4 uses a time delta (Δ), or the change in time from the previous message. The time-delta (Δ) is essentially an absolute time because it is usually added to '0' time. Because the Type 0 chunk includes a considerable amount of information, it will generally be larger than the subsequent chunks in the stream.

When the value of chunk type ID 41 is 1 in certain embodiments of the present invention, the chunk state or type is a new media indicator of a specified new time change/time delta, length, and any new message type ID (Type 1). This state may signify a new chunk that is

measured using the new specified time delta (i.e., the time stamp change from the last message) and the specific length. Thus, a subsequent message in a chunk stream that belongs to the same chunk stream ID, but that is a different type/format and a different time delta than the previous chunk only has to include header information on the message type ID, time delta, and the length. A Type 1 chunk may, therefore, have fewer bytes of header information than the Type 0 chunk, because the state machine implementing the illustrated embodiment of the present invention has been set with certain information by the Type 0 chunk that remains unchanged for the Type 1 chunk.

A value for chunk type ID 41 of 2 in certain embodiments of the present invention represents the chunk state or type for a new message defined only by a single piece of header information, such as the time delta (Type 2) in a new time indicator. A Type 2 chunk preferably has all of the same information from the previous chunk except possibly for a change in the time delta. Therefore, the state machine may only need to use the new time delta to change to the proper new state.

The least amount of overhead or header information in the representative embodiment illustrated in FIGS. 3 and 4 accompanies the Type 3 chunk in certain embodiments of the present invention, when the value of chunk type ID 41 is 3. A Type 3 chunk is a continuation indicator. A continuation indicator chunk preferably uses the same message stream ID, the same message type ID, the same time change/time delta, and the same length of the previous chunks. Therefore, the state machine implementing this embodiment of the present invention is preferably already set to the appropriate state. One design goal may be to optimize the streaming process to get the chunks to Type 3 chunks as soon as possible. Therefore, Type 3 chunks that are essentially continuations of a same message are transmitted with a 0-length header.

The 0-length header of the Type 3 chunks is especially interesting when the Type 3 chunk represents the beginning of a new message. This scenario may occur when two consecutive chunks use the same message stream ID, the same message type ID, the same time change/time delta, and the same length as the previous chunk. In this case, a new message is enabled without any required header information, a 0-length header.

TABLE 2

CHUNK TYPE (BITS 6-7 OF CHUNK CONTROL BYTE)	
Chunk Type Bits	Description
00	(Type 0) Begin new message. Reset all information. Type 0 is used when the time moves backwards or for the first message sent on the chunk stream. A Type 0 chunk message resets the time to 0 before adding the supplied time delta (Δ). A Type 0 chunk message will contain the following header information: 3 bytes - message time delta (Δ) 3 bytes - message length 1 byte - message type ID 4 bytes - message stream ID
01	(Type 1) Begin new message using specified Δ , new length, and/or new message type ID. A Type 1 chunk message will generally contain the following header information: 3 bytes - Δ 3 bytes - new message length 1 byte - message type ID

TABLE 2-continued

CHUNK TYPE (BITS 6-7 OF CHUNK CONTROL BYTE)	
Chunk Type Bits	Description
10	(Type 2) Begin new message using specified A. A Type 2 chunk message will generally contain the following header information: 3 bytes - A
11	(Type 3) Continuation (possibly start new message). A Type 3 chunk message will generally contain no header information, but just the raw data/payload.

FIG. 5A is a conceptual block diagram illustrating chunk stream 50 comprising chunks 500-503. Chunk 500 is a Type 0 chunk with a chunk stream ID of 4. Because chunk 500 is a Type 0 chunk, it includes additional header data 504. The additional data includes the message stream ID (12346), the message type ID (9), the message length (435), and the time delta (20). This header information is set into the state machine of the present invention. Chunk 501 is a Type 3 chunk belonging to the same chunk stream ID 4. Because chunk 501 belongs to the same media stream ID and is the same type and length as chunk 500, the state set by the extra header information of chunk 500 already defines how to handle chunk 501. According to the teachings of the present invention, chunk 501 only needs to designate the chunk stream ID and chunk type. Therefore, only a single byte of overhead is added to the data payload of chunk 501. Chunks 502 and 503 are also Type 3 continuation chunks that require only an additional byte of header information to adequately handle those chunks.

FIG. 5B is a block diagram illustrating state machine 51 configured for a representative embodiment of a real-time priority-based communication system, as described herein, receiving a Type 0 chunk. State machine 51 sees that chunk 500 is a Type 0 chunk and expects each of the state variables to be set with the header information contained in chunk 500. In some embodiments, state machine 51 may also include message count 504 that keeps track of the progress of each receiving message. Chunk 500 brings 128 bytes of data payload. Therefore, using the message length parameter, state machine 51 can subtract 128 bytes from the total length, 435 bytes, to hold the remaining message expected length of 307 bytes in message 504. The state machine illustrated in FIG. 5B is used in both the send direction and the receive direction. As chunks arrive at the receiver system, the state machine is used in reverse to translate the state assignments necessary to play the data stream chunk. Therefore, the state machine for the real-time priority-based communication system may be located at least at the sending entity and the receiving entity.

FIGS. 5C-5E are block diagrams illustrating state machine 51 receiving Type 3 chunks. In FIG. 5C, state machine 51 reads that chunk 501 is a Type 3 chunk, and therefore, expects that only the chunk type and chunk stream ID state variables will be changed. Because chunk 501 could belong to a different sub-stream than that of chunk 500, the chunk stream ID is used in the Type 3 continuation chunks. The remaining state variables set by chunk 500 remain the same. Message 504 is changed again to reflect the 128 bytes of payload data delivered by chunk 501. 179 bytes now remain in the message. In FIG. 5D, state machine 51 reads that chunk 502 is also a Type 3 chunk, and therefore, also expects that only the chunk type and chunk stream ID state variables will be changed. The remaining state variables set

by chunk 500 continue remain the same. Message 504 is again changed to reflect the 128 bytes of payload data delivered by chunk 501. 179 bytes now remain in the message. FIG. 5E also illustrates state machine 51 receiving a Type 3 continuation chunk. With this receipt, because state machine 51 knows the maximum chunk data payload length is 128, state machine 51 knows that this will be the last chunk for this particular message, as reflected in message 504 zeroing out. The next chunk will, by process of elimination, have to be for a new message (or be a low-level protocol message).

When compared to the header information included with each data packet in media stream 20 (FIG. 2), instead of resending the same header with each data packet, the teachings of the present invention preferably allow this information to be sent only once, with subsequent chunks leveraging the state machine in order to reduce the overhead sent with each subsequent chunk. The amount of repetitive information is, therefore, favorably reduced, increasing the available bandwidth over the connection.

Referring back to Table 1, when the value of chunk stream ID 40 is 2, in certain embodiments of the present invention, the state is designed to change for the system to expect a low-level protocol message. Table 3 describes two low-level protocol messages that may be implemented into various embodiments of the present invention. In such embodiments, a message ID of 1 represents a change to the maximum chunk size. The parameter passed with such a message ID may be an integer representing the size for all future chunks. Another message ID, shown as message ID 2 in Table 3, may allow for an abort signal to be sent to the network corresponding to a particular chunk stream ID. For example, if a communication session is in mid-stream when the transmitting end shuts-down, or other such event, the abort message would generally inform the network that it should not expect any further chunks, thus, aborting the stream. Many other optional low-level protocol messages may also be provided for in various embodiments of the present invention. The two messages provided for in Table 3 are merely examples.

TABLE 3

LOW-LEVEL PROTOCOL MESSAGES			
Message	Message ID	Message Data	Description
Set Chunk Size	1	4 bytes representing an integer. Bytes are sent in "network" order (i.e., order of significance)	The integer represents the new maximum chunk size for all future chunks.
Abort Message	2	4 bytes representing an integer. Sent in "network" order.	The integer represents a chunk stream ID. If that chunk stream is currently waiting to complete a message (i.e., expecting more chunks), the message stream is aborted.

The embodiments of the present invention obtain benefits from breaking the individual messages further down into chunks. While it may appear more simple to send one message and then the next, a linear process, such as this, is actually much less efficient. A stream representing some media presentation may be comprised of several different sub-streams. One sub-stream may be for the audio, one for the video, and another for data. The combination of each of

these sub-streams makes up the entire streaming presentation. Therefore, it becomes important to coordinate smooth delivery of each of the sub-streams to facilitate the smooth playback of the entire stream. For example, a video key frame may have a large amount of data, 20 k-30.k bytes, in contrast to audio messages that are generally very small. However, the audio messages are much more time sensitive than the video messages due to the idiosyncrasies of human hearing. Therefore, if an audio message is sent from the audio sub-stream, followed by a very large video message from the video sub-stream, followed by the next audio message, the audio stream may typically stall because the next audio message simply may not arrive in time.

In operation, the larger video messages are typically much less frequent, even though they may be much larger. Therefore, interleaving other messages in between the video messages is acceptable as long as the video message eventually-arrives in time for the smooth playback of the video sub-stream. Considering this balancing process, breaking the messages into chunks that may be more easily balanced and interleaved increases the efficiency of the streaming. While no one maximum chunk size is best for all situations, a given maximum may be beneficially set in which the video and data messages arrive without too much effect on the timely arrival of the audio chunks.

In certain embodiments of the present invention, the maximum chunk size is set to correspond to the complete length of a standard audio message in the audio sub-streams in order to ensure timely delivery of the complete audio message. For example, the sampling rate for the audio compression algorithm, Nellymoser, is typically 8 kHz. The 8 kHz sampling typically generates messages that are 128 bytes long. Therefore, in certain embodiments of the present invention that may use the Nellymoser compression algorithm, the maximum chunk size may preferably be set to 128 bytes. Other audio compression formats may produce messages that are either greater than or less than 128 bytes. In such cases, a low-level protocol message could be used to change the maximum chunk size of the applicable embodiments of the present invention to ensure an optimal efficiency algorithm.

Balancing the transmission of the chunks in the different media sub-streams is preferably controlled by a scheduling algorithm that directs which chunk of which stream or sub-stream to send next. Each type of media may preferably be assigned a specific priority value. For example, because audio messages are the most sensitive, they may be assigned the highest priority value. Video and data messages would each likely be assigned lower priority values. FIG. 6 is a flowchart disclosing representative steps of scheduling algorithm 60 used in representative embodiments of the present invention. In step 600, the priority of each sub-stream ($Priority_{SB}$) is summed into a total stream priority ($StreamPriority$). In step 601, a desired percentage for sending each sub-stream within the stream according to formula (1):

$$\text{Desired \%} = \text{Priority}_{SB} / \text{StreamPriority} \quad (1)$$

The total number of chunks sent (count) are counted per sub-stream over the preceding 'N' chunks in step 602. 'N' represents a scheduling sampling window that may be pre-set by a user or developer. In step 603, the actual percentage of chunks sent per sub-stream in the preceding 'N' chunks is developed according to formula (2):

$$\text{Actual \%} = \text{count} / N \quad (2)$$

In step 604, a ratio of desired percentage to actual percentage is determined for each sub-stream. A selection

criteria, which selects the sub-stream with lowest ratio is executed in step 605. In step 606, a queue monitor searches or determines whether the selected sub-stream has a chunk queued. In step 607, if a chunk is queued for the selected sub-stream, a queue manager selects the sub-stream chunk to send. If no data is queued for the selected sub-stream, the determination is made whether there are any other waiting sub-streams left, in step 608. If there are no remaining sub-streams, then no chunks are sent in the cycle, in step 609. However, if there are remaining sub-streams, a new sub-stream is selected, in step 610, that has the next lowest ratio of desired to actual percentages. Steps 606-610 are repeated until all chunks in each sub-stream are sent.

Scheduling algorithm 60 preferably results in a favorable balance of streams. If all sub-streams always have data to send, not only does scheduling algorithm 60 provide for those streams to obtain the proper percentage of chunks sent, but also provides a good interleaving mix over the scheduling window. When some sub-streams do not have data or, at least, do not have data queued, scheduling algorithm 60 allows the lower priority sub-streams to use a greater bandwidth. Thus, bandwidth use is routinely optimized. One embodiment of the present invention may achieve desired results with audio having a priority of 100, data priority of 10, and video priority of 1. However, other various priority assignments may prove better for different situations and known or expected data types or data loads.

FIG. 7A is a conceptual block diagram illustrating real-time communication system 70 configured using a representative embodiment of the real-time priority-based protocol of the present invention. Stream presentation 700, which may include video sub-stream 704 for providing visual rendering 701, data sub-stream 705 for providing data visual 702, and audio sub-stream 706 for supporting the audio for visual rendering 701, is intended to be streamed from computer 707 to client 712 in a peer-to-peer application. Stream 703 includes each of video, data, and audio sub-streams 704-706. Computer 707, which includes a processor capable of running the real-time priority-based protocol described herein, breaks the video, data, and audio messages into chunks according to a maximum chunk size preferably set to accommodate the sampling rate of the audio information. As video, data, and audio sub-streams 704-706 are broken into the appropriated chunk size, the necessary header information is placed on each chunk according to the teachings described herein at state machine 713. The chunks are then queued in chunk queue 709 awaiting the determination of which chunks to send. Sub-queues for audio, video, and data chunks may each be maintained for more efficient determinations of the chunks. Scheduler 708 implements a scheduling algorithm, such as scheduling algorithm 60 (FIG. 6), to schedule and prioritize the transmission of each of the chunks for the different sub-streams.

It should be noted that if a stream were being received by computer 707 instead of transmitting the stream, chunk assembly 718 would be used to assemble the received chunks into the resulting message stream.

The example embodiment shown in FIG. 7A also includes single socket connection 710 between Internet 711 and both of computer 707 and client 712. Scheduler 708 controls which chunks are sent in order to accommodate delivering stream 703 to client 712, in such a manner that a user at client 712 may view, in real-time, stream presentation 700 with a minimum amount of interference or disturbance in the playback over single socket connection 710. As the data chunks are received, chunk assembly 718 on client 712 operates with instructions from state machine 713 within

client 712 to reassemble the received chunks into presentation stream 714 with video, audio, and data sub-streams 715-717. It should be noted that instances of state machine 713 are preferably included in each entity compatible with the real-time, priority-based communication system of the present invention. Furthermore, if client 712 were transmitting the message stream instead of receiving the chunk stream, queue 709 and scheduler 708 on client 712 would be used to transmit the chunks associated with the message stream.

FIG. 7B is a conceptual block diagram illustrating real-time communication system 71 configured using a representative embodiment of the real-time priority-based protocol of the present invention in a client-server application. Similar to the example shown in FIG. 7A, stream presentation 720, which may include video sub-stream 726 for providing visual rendering 721, data sub-stream 725 for providing data visual 722, and audio sub-stream 724 for supporting the audio for visual rendering 721, may originate from computer 727 and viewed on entity 737 through server 728 in a client-server topology.

The processing capabilities of computer 727 divides video, audio, and data sub-streams 724-726 into chunks for streaming over the connection to server 728. As the chunks are assembled, state machine 713 provide the necessary header information for each chunk as the chunks are queued in chunk queue 709. Scheduler 708 executes a scheduling algorithm to determine which chunks should be transmitted in which order. It should be noted that, as above, if a stream were being received by computer 727 instead of transmitting the stream, chunk assembly 718 would be used to assemble the received chunks into the resulting message stream. Through connection 72, which may be the Internet, wide area network (WAN), local area network (LAN), wireless local area networks (WLAN), or the like, chunks are transmitted to server 728. Using an instance of state machine 713 on server 728, the chunks may be received and reassembled, at server 728, using chunk assembly 718. Stream 732 at server 728 is comprised also of audio, video, and data sub-streams 729-731. Server 728 acts as the middle-ware providing stream presentation 720 to each entity subscriber, such as entity 737. As such, when stream 732 is to be sent to client 737, scheduler 708 and queue 709 on server 728 facilitate streaming the chunks via connection 72.

State machine 713 at server 728 assists the streaming of the chunks of audio, video, and data sub-streams 729-731 using connection 72 to entity 737. Upon receiving the chunks, state machine 713 at entity 737 helps decipher and assemble the header invention with chunk assembly 719. Audio, video, and data sub-streams 733-735 of stream 736 are then assembled and may be displayed at entity 737. In such an embodiment, while stream presentation 720 may likely be blocked by a firewall or NAT from reaching entity 737 directly. This complication is preferably avoided by using the middle-ware functionality of server 728. Server 728 preferably has authorized access to entity 737 though any given firewall or NAT. Furthermore, if entity 737 were transmitting the message stream instead of receiving the chunk stream, queue 709 and scheduler 708 on entity 737 would be used to transmit the chunks associated with the message stream.

When implemented in software, the elements of the present invention are essentially the code segments to perform the necessary tasks. The program or code segments can be stored in a computer readable medium. The "computer readable medium" may include any medium that can store or transfer information. Examples of the computer readable

medium include an electronic circuit, a semiconductor memory device, a ROM, a flash memory, an erasable ROM (EROM), a floppy diskette, a compact disk CD-ROM, an optical disk, a hard disk, a fiber optic medium, a radio frequency (RF) link, etc. The code segments may be downloaded via computer networks such as the Internet, Intranet, and the like.

FIG. 8 illustrates computer system 800 adapted to use the present invention. Central processing unit (CPU) 801 is coupled to system bus 802. The CPU 801 may be any general purpose CPU, such as an INTERNATIONAL BUSINESS MACHINE (IBM) POWERPC™, INTEL™ PENTIUM™-type processor, or the like. However, the present invention is not restricted by the architecture of CPU 801 as long as CPU 801 supports the inventive operations as described herein. Bus 802 is coupled to random access memory (RAM) 803, which may be SRAM, DRAM, or SDRAM. ROM 804 is also coupled to bus 802, which may be PROM, EPROM, EEPROM, Flash ROM, or the like. RAM 803 and ROM 804 hold user and system data and programs as is well known in the art.

Bus 802 is also coupled to input/output (I/O) controller card 805, communications adapter card 811, user interface card 808, and display card 809. The I/O adapter card 805 connects to storage devices 806, such as one or more of a hard drive, a CD drive, a floppy disk drive, a tape drive, to the computer system. The I/O adapter 805 would also allow the system to print paper copies of information, such as documents, photographs, articles, etc. Such output may be produced by a printer (e.g. dot matrix, laser, and the like), a fax machine, a copy machine, or the like. Communications card 811 is adapted to couple the computer system 800 to a network 812, which may be one or more of a telephone network, a local (LAN) and/or a wide-area (WAN) network, an Ethernet network, and/or the Internet network. User interface card 808 couples user input devices, such as keyboard 813 and pointing device 807 to the computer system 800. The display card 809 is driven by CPU 801 to control the display on display device 810.

FIG. 9 illustrates a sequence of interleaved audio and video chunks in real-time priority-based communication system 90 configured according to various embodiments of the present invention. System 90 shows a one-way communication session of streaming media occurring from transmitting entity 91 to receiving player 92 over connection 900. The messages to be streamed may comprise audio, video, and data messages. FIG. 9 shows a message that comprises video and audio sub-streams. As the video and audio sub-streams are broken into video and audio chunks, the state machine of the various embodiments of the present invention supply the necessary header information for the chunks. Transmitting entity 91 places the chunks in either video queue 93 or audio queue 94 to await transmission.

The scheduling algorithm run by transmitting entity 91 controls when chunks are sent to connection interface 97 from either video or audio queue 93 and 94. Chunks 901, 903, 905, 907, 909, 911, 913, and 915 are illustrated on connection 900 along with corresponding header parameters 902, 904, 906, 908, 910, 912, 914, and 916 configured according to the illustrated example of the present invention. Because audio chunks are more sensitive than video chunks, the scheduler sends audio chunk 901 over connection 900 first. Audio chunk 901 includes header 902. Header 902 describes audio chunk as a Type 0 chunk and gives the necessary information that accompanies a Type 0 new message chunk, including the chunk ID, message stream ID, length, message type, and time delta. The state machine at

receiving player 92 sets the state for the audio sub-stream beginning with audio chunk 901. Audio chunk 903 is the next chunk sent by the scheduler at transmitting entity 91 and includes header 904. Header 904 identifies chunk 903 as a Type 3 continuation header belonging to chunk ID 1, the chunk ID assigned to the first audio sub-stream. Because audio chunk 903 is a continuation chunk, only the chunk type and chunk ID are required in the header information. The state machine at receiving entity 92 reads that chunk 903 is a Type 3 continuation chunk and keeps all states fixed for the audio sub-stream of chunk ID 1.

The scheduler at transmitting entity 91 sends video chunk 905 next along with header 906. Because video chunk 905 is the first of the video sub-stream, it is designated a Type 0 chunk and includes all of the necessary header information to go along with the first chunk of the video sub-stream. Thus, video chunk 905 may include a different chunk ID, message stream ID, length, message type, and time delta. The state machine at the receiving entity sets the necessary states for the video sub-stream of chunk ID 2. The next chunk sent by the scheduler is audio chunk 907 and header 908. Header 908 identifies chunk 907 as a Type 3 continuation chunk of chunk ID 1. The state machine refers to the states set for the audio sub-stream of chunk ID 1 and maintains those settings for the first audio sub-stream.

The scheduler then sends audio chunk 909 and header 910 across connection 900. Header 910 identifies audio chunk 909 as a Type 0 new message chunk. The state machine at receiving entity 92 resets all information in the states of the audio sub-streams and sets the new states according to header 910. The next chunk in the interleaved sequence is video chunk 911 along with header 912. Header 912 identifies video chunk 911 as a Type 3 continuation chunk of video sub-stream chunk ID 2. The state machine at receiving entity 92 accesses the states set for chunk ID 2 and keeps all of the state information in tact for video chunk 911. The next chunk sent on connection 900 is audio chunk 913 and header 914. Header 914 identifies chunk 913 as a Type 3 continuation chunk of chunk ID 3. The state machine accesses the states saved for the audio sub-stream of chunk ID 3 and maintains each state intact. The final chunk illustrated in FIG. 9 is audio chunk 915 and header 916. Header 916 identifies chunk 915 as a Type 2 chunk representing a new message having a new time delta. The state machine reads that chunk 915 is a Type 2 chunk and expects the beginning of a new audio sub-stream with only a change to one of the states for a new chunk ID 4.

As each of chunks 901, 903, 905, 907, 909, 911, 913, and 915 are received at receiving entity 92 through connection interface 97, the audio chunks are re-assembled in audio assembly 96, while the video chunks are re-assembled in video assembly 95 before being played back at receiving entity 92. The state machine at receiving entity 92 preferably reads the parameters in each of headers 902, 904, 906, 908, 910, 912, 914, and 916 controls the re-assembly of the chunks in audio assembly 96 and video assembly 95. In additional embodiments of the present invention other interleaving scheduling algorithms and/or efficiency algorithms may be implemented. The goal is to achieve an efficient mix of audio, video, and data chunks that results in a good playback that minimizes the audio or video jitter in the playback.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of

the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. A real-time priority-based communication system for communicating media streams made up of multiple media message sub-streams, said communication system comprising:
 - a chunk configurator for dividing media message sub-streams into chunks;
 - a state machine configured to utilize information regarding said media message sub-streams and said chunks and to provide state associations corresponding to said information, said state associations written into a header for each of said chunks, said state associations classifying said chunks to identify possible purposes of each chunk, wherein the possible purposes identified by said state associations consist of:
 - a new stream chunk associated with a new media message sub-stream wherein said new stream chunk includes a plurality of new parameters in a corresponding one of said headers and uses no parameters from a previous header,
 - a new media chunk associated with a new media message sub-stream wherein said new media chunk includes a plurality of new parameters in a corresponding one of said headers and uses at least one other parameter from a previous header,
 - a new time chunk associated with said new media message sub-streams wherein said new time chunk includes at least one new parameter in a corresponding one of said headers and uses a plurality of other parameters from a previous header, and
 - a continuation chunk requiring no new parameters in a corresponding one of said headers and using a plurality of parameters from a previous header;
 - a queue for holding said chunks waiting to be transmitted; and
 - a processor for executing a scheduling algorithm, wherein said scheduling algorithm determines one of said chunks in said queue to transmit next.
2. The real-time priority-based communication system of claim 1 wherein said media message sub-streams are divided into said chunks having a preset maximum payload size.
3. The real-time priority-based communication system of claim 1 wherein said chunks comprise one or more of:
 - an audio format chunk;
 - a video format chunk; and
 - a data format chunk.
4. The real-time priority-based communication system of claim 1 wherein said state machine:
 - reads said information regarding said chunks and said media message sub-streams and translates said information into said state associations.
5. The real-time priority-based communication system of claim 4 wherein said parameters comprise one or more of:

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a stream ID representing said label associated with said media message sub-streams;
 a length of said media message sub-streams;
 a media type indicator representing a type of media associated with said media message sub-streams; and
 a time delta representing a time difference between successive of said chunks;
 wherein a determination of which of said parameters are included in said state associations is determined by a value of said type indicator; and
 wherein a header length is determined by a number of said parameters included with said state associations.

6. The real-time priority-based communication system of claim 1 wherein said plurality of new parameters included in a corresponding one of said headers of said new media includes new ones of one or more of:
 a stream ID parameter;
 a length parameter;
 a media type indicator parameter; and
 a time delta parameter; and
 wherein said at least one new parameter included in a corresponding one of said headers of said new time chunk is a new time delta parameter.

7. The real-time priority-based communication system of claim 3 wherein said queue holds said chunks in sub-queues according to a format of said chunks.

8. The real-time priority-based communication system of claim 3 wherein said scheduling algorithm interleaves said audio format chunks, said video format chunks, and said data format chunks according to an efficiency algorithm.

9. The real-time priority-based communication system of claim 8 further comprising:
 a priority assigned to each of:
 said audio format chunks;
 said video format chunks; and
 said data format chunks;
 a chunk counter for counting a sub-total of chunks associated with each of said media message sub-streams sent over a preset time period, said chunk counter also counting a total number of chunks sent over said preset time period.

10. The real-time priority-based communication system of claim 9 wherein said processor further:
 totals a sub-stream priority for each of said media message sub-streams;
 totals a stream priority for said media stream;
 calculates a desired transmission percentage for each of said media message sub-streams using said sub-stream priority and said stream priority;
 calculates an actual transmission percentage for each of said media message sub-streams using said sub-total of chunks and said total number of chunks; and
 calculates a ratio between said desired transmission percentage and said actual transmission percentage.

11. The real-time priority-based communication system of claim 10 wherein said efficiency algorithm comprises:
 a selection criteria for selecting said media message sub-stream having a lowest of said ratio;
 a queue monitor for determining whether said chunk associated with said selected media message sub-stream is located in said queue; and
 a queue manager for retrieving said selected chunk from said queue for transmission.

12. A method for communicating media streams, comprised of a plurality of sub-streams, in a real-time priority-based communication protocol, said method comprising:

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dividing each one of said plurality of sub-streams into a plurality of chunks;
 assigning states to each of said plurality of chunks representative of information regarding said associated sub-streams and said associated media streams, wherein said states indicate possible purposes of a corresponding chunk, and wherein the possible purposes indicated by said states consist of:
 a new stream chunk associated with a new media message sub-stream wherein said new stream chunk includes a plurality of new parameters in a corresponding one of said headers and uses no parameters from a previous header,
 a new media chunk associated with a new media message sub-stream wherein said new media chunk includes a plurality of new parameters in a corresponding one of said headers and uses at least one other parameter from a previous header,
 a new time chunk associated with said new media message sub-streams wherein said new time chunk includes at least one new parameter in a corresponding one of said headers and uses a plurality of other parameters from a previous header, and
 a continuation chunk requiring no new parameters in a corresponding one of said headers and using a plurality of parameters from a previous header;
 writing said states into a header of each of said plurality of chunks;
 queuing said plurality of chunks for transmission; and
 transmitting ones of said plurality of chunks according to a scheduling algorithm.

13. The method of claim 12 further comprising:
 receiving said transmitted plurality of chunks;
 translating said states associated with each of said plurality of chunks into information regarding said associated sub-streams and said associated media streams; and
 re-assembling said plurality of chunks into said associated plurality of sub-streams for replay of said media streams.

14. The method of claim 12 wherein said dividing includes:
 maintaining a user-definable maximum payload size for each of said plurality of chunks.

15. The method of claim 12 wherein said assigning states includes:
 assigning a unique chunk identification parameter for associating said chunk with its sub-stream, wherein said unique chunk identification parameter is smaller than a label associated with said sub-stream.

16. The method of claim 12 wherein said parameters include one or more of:
 a stream ID parameter;
 a length parameter;
 a media type parameter; and
 a time delta parameter.

17. The method of claim 12 wherein said queuing includes:
 queuing said plurality of chunks according to a media type of said chunk, wherein said media type comprises one of:
 an audio format chunk;
 a video format chunk; and
 a data format chunk.

18. The method of claim 17 wherein said scheduling algorithm further interleaves said audio format chunks, said video format chunks, and said data format chunks according to an interleaving algorithm.

19. The method of claim 12 further comprising:
 5 assigning a priority to each sub-stream;
 totaling a priority for each media stream;
 calculating a desired transmission rate for each sub-stream using said assigned priority and said totaled priority;
 10 counting a sub-total of chunks transmitted per said sub-stream during a preset period;
 counting a total number of chunks transmitted during said preset period;
 calculating an actual transmission rate for each sub-stream using said sub-total and said total; and
 15 calculating a ratio between said desired transmission rate and said actual transmission rate.

20. The method of claim 19 wherein said scheduling algorithm includes:

20 determining a sub-stream having a lowest ratio;
 checking said queue of said plurality of chunks for a chunk associated with said determined sub-stream; and
 transmitting said chunk associated with said determined sub-stream when found in said queue.

21. A computer program product having a computer readable medium with computer program logic recorded thereon, said computer program product comprising:

code for breaking down each one of a plurality of media sub-streams making up a message stream into a plurality of associated chunks;
 30 code for implementing a state machine that processes state assignments for each of said plurality of associated chunks representative of information regarding said media sub-streams and said message streams, wherein said state assignments indicate possible purposes of a corresponding chunk, and wherein the possible purposes indicated by said state assignments consist of:

40 a new stream chunk associated with a new media message sub-stream wherein said new stream chunk includes a plurality of new parameters in a corresponding one of said headers and uses no parameters from a previous header,

45 a new media chunk associated with a new media message sub-stream wherein said new media chunk includes a plurality of new parameters in a corresponding one of said headers and uses at least one other parameter from a previous header,

50 a new time chunk associated with said new media message sub-streams wherein said new time chunk includes at least one new parameter in a corresponding one of said headers and uses a plurality of other parameters from a previous header, and

55 a continuation chunk requiring no new parameters in a corresponding one of said headers and using a plurality of parameters from a previous header;

code for writing a corresponding one of said state assignments into a header of each of said plurality of associated chunks;

60 code for building a queue for said plurality of associated chunks waiting for transmission; and

code for transmitting ones of said plurality of associated chunks according to a scheduling algorithm.

22. The computer program product of claim 21 further comprising:

code for receiving said transmitted plurality of associated chunks;

code for translating said state assignments for each of said plurality of associated chunks into information regarding said media sub-streams and said message streams; and

code for re-assembling said plurality of associated chunks into said media sub-streams for replay of said message streams.

23. The computer program product of claim 21 wherein said code for breaking down includes:

code for setting a user-definable maximum payload size for each of said plurality of associated chunks.

24. The computer program product of claim 21 wherein said code for assigning states includes:

code for assigning a chunk ID for associating said chunk with its related media sub-stream, wherein said chunk ID is smaller than an ID related to said media sub-stream.

25. The computer program product of claim 21 wherein said parameters include at least one of:

a stream ID parameter;
 a length parameter;
 a media type parameter; and a time delta parameter.

26. The computer program product of claim 21 wherein said queuing includes:

code for queuing said plurality of associated chunks according to a media type of said chunk, wherein said media type comprises one of:
 an audio format chunk;
 a video format chunk; and
 a data format chunk.

27. The computer program product of claim 21 further comprising:

code for assigning a priority to each media sub-stream;
 code for totaling a priority for each message stream;
 code for calculating a desired transmission rate for each media sub-stream using said assigned priority and said totaled priority;

code for counting a sub-total of said plurality of associated chunks transmitted per said media sub-stream during a preset period;

code for counting a total number of said plurality of associated chunks transmitted during said preset period;

code for calculating an actual transmission rate for each media sub-stream using said sub-total and said total; and

code for calculating a ratio between said desired transmission rate and said actual transmission rate.

28. The computer program product of claim 27 wherein said scheduling algorithm includes:

code for selecting said media sub-stream having a lowest of said calculated ratio;

code for searching said queue for one of said plurality of associated chunks related to said selected media sub-stream; and

60 code for transmitting said one of said plurality of associated chunks related to said determined media sub-stream.



44 (Rev. 12/07) (CAND Rev. 1/10)

CIVIL COVER SHEET

This 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the local docket sheet. (SEE INSTRUCTIONS ON PAGE TWO OF THE FORM.)

I. PLAINTIFFS
ADBE SYSTEMS, INCORPORATED, a Delaware Corporation

DEFENDANTS
WOWZA MEDIA SYSTEMS, INC., a California Corporation

(1) County of Residence of First Listed Plaintiff
Santa Clara
(4) Attorney's (Firm Name, Address, and Telephone Number)
Bob Steinberg
Latham & Watkins LLP
335 South Grand Avenue
Los Angeles, CA 90071-1560
Tel: 213.485.1234

County of Residence of First Listed Defendant Santa Clara
IN U.S. PLAINTIFF CASES ONLY
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE LAND INVOLVED.
Attorneys (If Known)
LB

II. BASIS OF JURISDICTION (Place an "X" in One Box Only)
1 U.S. Government Plaintiff
2 U.S. Government Defendant
[X] Federal Question (U.S. Government Not a Party)
4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES (Place an "X" in One Box for Plaintiff and One Box for Defendant)
Citizen of This State
Citizen of Another State
Citizen or Subject of a Foreign Country
Incorporated or Principal Place of Business in This State
Incorporated and Principal Place of Business in Another State
Foreign Nation

IV. NATURE OF SUIT (Place an "X" in One Box Only)
Table with columns: CONTRACT, REAL PROPERTY, CIVIL RIGHTS, TORTS, PRISONER PETITIONS, FORFEITURE/PENALTY, LABOR, IMMIGRATION, BANKRUPTCY, SOCIAL SECURITY, FEDERAL TAX SUITS, OTHER STATUTES.

V. ORIGIN (Place an "X" in One Box Only)
[X] Original Proceeding
2 Removed from State Court
3 Remanded from Appellate Court
4 Reinstated or Reopened
5 Transferred from another district (specify)
6 Multidistrict Litigation
17 Appeal to District Judge from Magistrate Judgment

VI. CAUSE OF ACTION
Cite the U.S. Civil Statute under which you are filing (Do not cite jurisdictional statutes unless diversity):
35 U.S.C. § 271; 15 U.S.C. § 1125(a)
Brief description of cause:
Patent Infringement; False Advertising; Unfair Competition

VII. REQUESTED IN COMPLAINT:
CHECK IF THIS IS A CLASS ACTION DEMAND \$
UNDER F.R.C.P. 23
CHECK YES only if demanded in complaint:
JURY DEMAND: [X] Yes [] No

VIII. RELATED CASE(S) IF ANY
PLEASE REFER TO CIVIL L.R. 3-12 CONCERNING REQUIREMENT TO FILE "NOTICE OF RELATED CASE".

IX. DIVISIONAL ASSIGNMENT (CIVIL L.R. 3-2) (PLACE AND "X" IN ONE BOX ONLY)
[] SAN FRANCISCO/OAKLAND [X] SAN JOSE [] EUREKA

DATE May 6, 2011
SIGNATURE OF ATTORNEY OR RECORD
Bob Steinberg

Court Name: U.S. District Court, NDCA
Division: 5
Receipt Number: 54611009626
Cashier ID: harwellt
Transaction Date: 05/06/2011
Payer Name: Specialized Legal Services I
NC

CIVIL FILING FEE

For: Adobe Systems Incorporated
Case/Party: D-CAN-4-11-CV-002243-001
Amount: \$350.00

PAPER CHECK CONVERSION

Check/Money Order Num: 43961
Amt Tendered: \$350.00

Total Due: \$350.00
Total Tendered: \$350.00
Change Amt: \$0.00

Case # 11-cv-2243-LB

Checks and drafts are accepted
subject to collections and full
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