



US007088678B1

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

(10) **Patent No.:** **US 7,088,678 B1**
(45) **Date of Patent:** **Aug. 8, 2006**

(54) **SYSTEM AND METHOD FOR TRAFFIC SHAPING BASED ON GENERALIZED CONGESTION AND FLOW CONTROL**

5,608,446 A	3/1997	Carr et al.	348/6
5,610,910 A	3/1997	Focsaneanu et al.	370/351
5,623,542 A	4/1997	Schneider et al.	379/399
5,623,601 A	4/1997	Vu	395/187.01
5,636,211 A	6/1997	Newlin	370/465
5,675,732 A	10/1997	Majeti et al.	395/200.01

(75) Inventors: **Michael Freed**, Pleasanton, CA (US);
Satish Amara, Mt. Prospect, IL (US);
Michael Borella, Naperville, IL (US)

(Continued)

(73) Assignee: **3Com Corporation**, Marlborough, MA (US)

FOREIGN PATENT DOCUMENTS

WO WO 99/11003 3/1999

(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 968 days.

OTHER PUBLICATIONS

Droms, R., *Dynamic Host Configuration Protocol*, Request for Comments 1541, Oct. 1993, pp. 1 to 31.

(Continued)

(21) Appl. No.: **09/941,280**

(22) Filed: **Aug. 27, 2001**

(51) **Int. Cl.**
H04L 12/26 (2006.01)

(52) **U.S. Cl.** **370/230**; 370/236.1

(58) **Field of Classification Search** 370/229–236.1,
370/248, 412; 709/232–235

See application file for complete search history.

Primary Examiner—Duc Ho

Assistant Examiner—Phuongchau Ba Nguyen

(74) *Attorney, Agent, or Firm*—McDonnell Boehnen Hulbert & Berghoff

(57) **ABSTRACT**

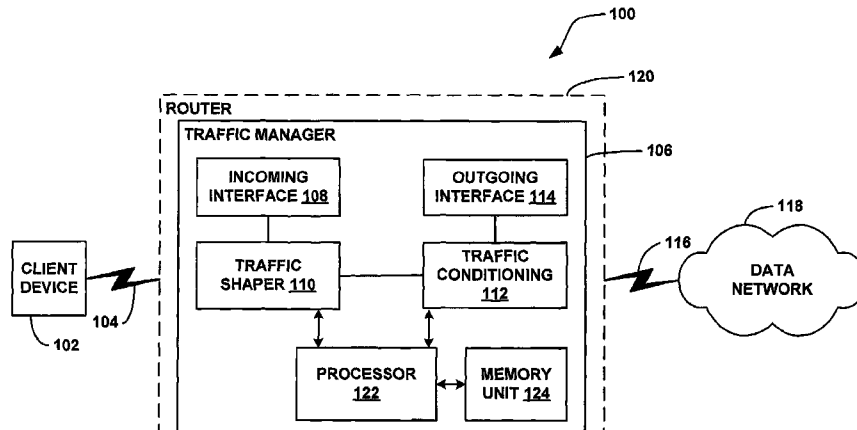
(56) **References Cited**

U.S. PATENT DOCUMENTS

4,644,533 A	2/1987	Braff et al.	370/94
4,881,263 A	11/1989	Herbison et al.	380/21
4,996,685 A	2/1991	Farese et al.	370/58.1
5,014,234 A	5/1991	Edwards, Jr.	364/900
5,138,712 A	8/1992	Corbin	395/700
5,301,273 A	4/1994	Konishi	395/200
5,347,304 A	9/1994	Moura et al.	348/12
5,430,727 A	7/1995	Callon	370/85.13
5,442,749 A	8/1995	Northcutt et al.	395/200.09
5,488,412 A	1/1996	Majeti et al.	348/10
5,489,897 A	2/1996	Inoue	340/870.39
5,528,595 A	6/1996	Walsh et al.	370/85.13
5,583,931 A	12/1996	Schneider et al.	379/399
5,586,121 A	12/1996	Moura et al.	370/404
5,598,410 A	1/1997	Stone	370/469
5,600,717 A	2/1997	Schneider et al.	379/399
5,606,606 A	2/1997	Schneider et al.	379/399

A system and methods are shown for traffic shaping and congestion avoidance in a computer network such as a data-over-cable network. A headend of the data-over-cable system includes a traffic shaper configured to calculate a packet arrival rate from a cable modem and a traffic conditioner configured to calculate an average queue size on an output interface to an external network. For example, the traffic shaper compares the packet arrival rate to three packet arrival thresholds including a committed rate threshold, a control rate threshold and a peak rate threshold. If the calculated packet arrival rate falls between the committed threshold and control rate threshold, the traffic shaper applies a link layer mechanism, such as a MAP bandwidth allocation mechanism, to lower the transmission rate from the cable modem.

35 Claims, 5 Drawing Sheets



U.S. PATENT DOCUMENTS

5,675,742 A	10/1997	Jain et al.	395/200	6,046,983 A *	4/2000	Hasegawa et al.	370/236.1
5,678,041 A	10/1997	Baker et al.	395/609	6,049,546 A	4/2000	Ramakrishnan	370/412
5,708,654 A	1/1998	Arndt et al.	370/242	6,049,825 A	4/2000	Yamamoto	709/221
5,710,885 A	1/1998	Bondi	395/200.54	6,049,826 A	4/2000	Beser	709/222
5,724,510 A	3/1998	Arndt et al.	395/200.5	6,052,724 A	4/2000	Willie et al.	709/223
5,761,602 A	6/1998	Wagner et al.	455/3.1	6,058,421 A	5/2000	Fijolek et al.	709/225
5,778,181 A	7/1998	Hidary et al.	395/200.48	6,061,349 A	5/2000	Coile et al.	370/389
5,784,597 A	7/1998	Chiu et al.	395/552	6,064,372 A	5/2000	Kahkoska	345/173
5,790,198 A	8/1998	Roop et al.	348/460	6,065,049 A	5/2000	Beser	709/218
5,790,548 A	8/1998	Sistanizadeh et al.	370/401	6,070,187 A	5/2000	Subramaniam et al.	709/220
5,790,677 A	8/1998	Fox et al.	380/24	6,070,242 A	5/2000	Wong et al.	713/201
5,790,770 A	8/1998	McClure et al.	395/200.61	6,070,246 A	5/2000	Beser	713/201
5,790,806 A	8/1998	Koperda	395/200.82	6,073,178 A	6/2000	Wong et al.	709/229
5,793,747 A	8/1998	Kline	370/230	6,075,787 A	6/2000	Bobeck et al.	370/395
5,799,086 A	8/1998	Sudia	380/23	6,091,709 A	7/2000	Harrison et al.	370/235
5,805,804 A	9/1998	Laursen et al.	395/200.02	6,094,431 A	7/2000	Yamato et al.	370/395
5,809,252 A	9/1998	Beighe et al.	395/200.57	6,104,700 A	8/2000	Haddock et al.	370/235
5,812,819 A	9/1998	Rodwin et al.	395/500	6,112,258 A	8/2000	Miller et al.	710/19
5,815,664 A	9/1998	Asano	395/200.57	6,122,254 A	9/2000	Aydemir et al.	370/235
5,818,845 A	10/1998	Moura et al.	370/449	6,128,298 A	10/2000	Wootton et al.	370/392
5,819,028 A	10/1998	Manghirmalani et al.	395/185.1	6,130,879 A	10/2000	Liu	370/230
5,819,042 A	10/1998	Hansen	395/200.52	6,130,880 A	10/2000	Naudus et al.	370/235
5,828,655 A	10/1998	Moura et al.	370/236	6,137,792 A	10/2000	Jonas et al.	370/354
5,828,666 A	10/1998	Focsaneanu et al.	370/389	6,137,793 A	10/2000	Gorman et al.	370/360
5,835,720 A	11/1998	Nelson et al.	395/200.54	6,148,410 A	11/2000	Baskey et al.	714/4
5,835,727 A	11/1998	Wong et al.	395/200.68	6,157,965 A	12/2000	Mohammed et al.	710/8
5,841,777 A	11/1998	Cohen	370/433	6,170,061 B1	1/2001	Beser	713/201
5,848,233 A	12/1998	Radia et al.	395/187.01	6,178,455 B1	1/2001	Schutte et al.	709/228
5,852,721 A	12/1998	Dillon et al.	395/200.47	6,185,624 B1	2/2001	Fijolek et al.	709/239
5,854,901 A	12/1998	Cole et al.	709/245	6,189,102 B1	2/2001	Beser	713/201
5,859,852 A	1/1999	Moura et al.	370/449	6,208,656 B1	3/2001	Hrastar et al.	370/401
5,864,679 A	1/1999	Kanai et al.	709/238	6,212,563 B1	4/2001	Beser	709/227
5,870,134 A	2/1999	Laubach et al.	348/12	6,216,171 B1	4/2001	Isono et al.	709/250
5,872,523 A	2/1999	Dellaverson et al. ..	340/825.52	6,223,222 B1	4/2001	Fijolek et al.	709/227
5,884,024 A	3/1999	Lim et al.	395/187.01	6,233,224 B1 *	5/2001	Yamashita et al.	370/231
5,892,754 A	4/1999	Kompella et al.	370/236	6,240,464 B1	5/2001	Fijolek et al.	709/250
5,894,479 A	4/1999	Mohammed	370/401	6,243,369 B1	6/2001	Grimwood et al.	370/335
5,903,558 A	5/1999	Jones et al.	370/351	6,260,072 B1	7/2001	Rodriguez-Moral	709/241
5,909,549 A	6/1999	Compliment et al.	709/223	6,269,099 B1	7/2001	Borella et al.	370/389
5,913,037 A	6/1999	Spofford et al.	395/200.56	6,272,150 B1	8/2001	Hrastar	370/486
5,915,119 A	6/1999	Cone	395/750.02	6,275,853 B1	8/2001	Beser et al.	709/223
5,922,049 A	7/1999	Radia et al.	709/220	6,289,377 B1	9/2001	Lalwaney et al.	709/222
5,922,051 A	7/1999	Sidey	709/223	6,295,554 B1	9/2001	Karadogan	709/219
5,923,659 A	7/1999	Curry et al.	370/401	6,301,223 B1	10/2001	Hrastar et al.	370/227
5,926,458 A	7/1999	Yin	370/230	6,301,618 B1	10/2001	Sitaraman et al.	709/227
5,929,850 A	7/1999	Broadwin et al.	345/327	6,308,328 B1	10/2001	Bowcutt et al.	725/111
5,941,988 A	8/1999	Bhagwat et al.	713/201	6,331,987 B1	12/2001	Beser	370/486
5,943,604 A	8/1999	Chen et al.	455/5.1	6,332,163 B1	12/2001	Bowman-Amuah	709/231
5,954,797 A	9/1999	Sidey	709/223	6,337,858 B1	1/2002	Petty et al.	370/356
5,958,007 A	9/1999	Lee et al.	709/219	6,351,773 B1	2/2002	Fijolek et al.	709/228
5,960,177 A	9/1999	Tanno	395/200.59	6,370,147 B1	4/2002	Beser	370/401
5,974,453 A	10/1999	Andersen et al.	709/220	6,393,478 B1	5/2002	Bahlmann	709/224
5,982,748 A	11/1999	Yin et al.	370/232	6,442,158 B1	8/2002	Beser	370/352
5,987,524 A	11/1999	Yoshida et al.	709/245	6,449,291 B1	9/2002	Burns et al.	370/516
5,991,292 A	11/1999	Focsaneanu et al.	370/352	6,453,472 B1	9/2002	Leano et al.	725/111
5,991,306 A	11/1999	Burns et al.	370/429	6,490,727 B1	12/2002	Nazarathy et al.	725/129
5,996,076 A	11/1999	Rowney et al.	713/201	6,510,162 B1	1/2003	Fijolek et al.	370/432
5,999,536 A	12/1999	Kawafuji et al.	370/401	6,625,118 B1 *	9/2003	Hadi Salim et al.	370/236
6,003,077 A	12/1999	Bawden et al.	709/223	6,865,185 B1 *	3/2005	Patel et al.	370/412
6,005,851 A	12/1999	Craddock et al.	370/329	6,868,063 B1 *	3/2005	De Cnodder	370/236
6,006,264 A	12/1999	Colby et al.	709/226	6,904,015 B1 *	6/2005	Chen et al.	370/235
6,009,103 A	12/1999	Woundy	370/401	6,914,883 B1 *	7/2005	Dharanikota	370/230.1
6,012,088 A	1/2000	Li et al.	709/219	2002/0122050 A1	9/2002	Sandberg	345/705
6,013,107 A	1/2000	Blackshear et al.	703/229	2002/0136165 A1	9/2002	Ady et al.	370/241
6,014,545 A	1/2000	Wu et al.	455/3.1	2002/0186660 A1 *	12/2002	Bahadiroglu	370/248
6,018,767 A	1/2000	Fijolek et al.	709/218	2003/0028891 A1	2/2003	Hardt et al.	725/107
6,031,841 A	2/2000	Woundy	370/410	2003/0097461 A1 *	5/2003	Barham et al.	709/235
6,032,019 A	2/2000	Chen et al.	455/5.1				

FOREIGN PATENT DOCUMENTS

OTHER PUBLICATIONS

- RFC 791, *Internet Protocol, DARPA Internet Program Protocol Specification*, Sep. 1981, pp. 1-37.
- Postel, J., *Internet Protocol, DARPA Internet Program Protocol Specification*, RFC 792, Sep. 1981, pp. 1-14.
- Postel, J., *User Datagram Protocol*, RFC 768, Aug. 28, 1980, pp. 1-3.
- RFC 793, *Transmission Control Protocol, DARPA Internet Program Protocol Specification*, Sep. 1981, pp. 1-68.
- Case, J. et al., *A Simple Network Management Protocol (SNMP)*, RFC 1157, May 1990, pp. 1-26.
- Sollins, K., *The TFTP Protocol (Revision 2)*, RFC 1350, Jul. 1992, pp. 1-9.
- Alexander, S., *DHCP Options and BOOTP Vendor Extensions*, RFC 2132, Mar. 1997, pp. 1-37.
- "Radio Frequency Interface Specification (Interim Specification) SP-RFIV1.1-103-991105", MCNS Holdings, L.P., 1999, pp. ii to 366.
- "Cable Modem to Customer Premise Equipment Interface Specification (Interim) SP-CMCI-I02-980317", Multimedia Cable Network Systems (MCNS) Holdings, L.P., Cable Television Laboratories, Inc., 1998, pp. ii to 40.
- "Operations Support System Interface Specification Baseline Privacy Interface MIB (Interim Specification) SP-OSSI-BPI-I01-980331", MCNS Holdings, L.P., 1997 and 1998, pp. ii to 33.
- "Cable Modem Termination System-Network Side Interface Specification (Interim Specification) SP-CMTS-NSII01-960702", MCNS Holdings, L.P., 1996, pp. ii to 13.
- "Removable Security Module Interface Specification (Interim Specification) SP-RSMI-I01-980204", MCNS Holdings, L.P., Cable Television Laboratories, Inc., 1997, pp. ii to 47.
- "Baseline Privacy Interface Specification (Interim) SP-BPI-[01-970922]", MCNS Holdings, L.P., 1997, pp. ii to 65.
- "Operations Support System Interface Specification (Interim) SP-OSSII01-970403", MCNS Holdings, L.P., 1997, pp. 1 to 30.
- "Radio Frequency Interface Specification (Interim Specification) SP-RFI-102-971008", MCNS Holdings, L.P., 1997, pp. ii to 186.
- "Cable Modem Telephony Return Interface Specification (Interim) SP-CMTRI-I01-970804", MCNS Holdings, L.P., Cable Television Laboratories, Inc., 1997, pp. ii to 73.
- "Security System Specification (Interim Specification) SP-SSI-I01-970506", MCNS Holdings, L.P., 1997, pp. ii to 103.
- "Internet Engineering Task Force", Request for Comments 2131, Dynamic Host Configuration Protocol (DHCP), Mar. 1997, pp. 1 to 42.
- S. Adiraju, J. Fijolek, IPCDN Telephony Return MIB, Internet Engineering Task Force, Internet Draft, "<draft-ietf-ipcdn-tri-mib-00.1.txt>," Mar. 1998, pp. 1 to 26.
- Kyees, P.J. et al., *ADSL: A New Twisted-Pair Access to the Information Highway*, IEEE Communications Magazine, vol. 33, Issue 4, Apr. 1995, pp. 52-60.
- Huang, Yin-Hwa et al., *Design of an MPEG-Based Set-Top Box for Video on Demand Services*, Acoustics, Speech, and Signal Processing, 1995, ICASSP-95., 1995 International Conference, vol. 4, ISBN: 0-7803-2431-5, May 9-12, 1995, pp. 2655-2658.
- "A Solution for the Priority Queue Problem of Deadline-Ordered Service Disciplines," N.R. Figueira, IEEE International Conference on Computer Communications and Networks, Sep. 22-25, 1997, pp. 320-325.
- "Radio Frequency Interface Specification (Interim Specification) SP-RFI-I04-980724", MCNS Holdings, L.P., 1997, pp. ii to 196.
- Ramakrishnan, K., *A Proposal to Add Explicit Congestion Notification (ECN) to IP*, RFC 2481, Jan. 1999, pp. 1 to 24.
- ITU-T I.732, *Functional Characteristics of ATM Equipment*, Oct. 2000.
- ITU-T I.363.3, *B-ISDN ATM Adaptation Layer Specification: Type 3/4 AAL*, Aug. 1996.
- ITU-T I.326, *Functional Architecture of Transport Networks Based on ATM*, Nov. 1995.
- "Radio Frequency Interface Specification (Interim Specification) SP-RFI-I05-991105", MCNS Holdings, L.P., 1999, pp. ii to 202.
- "Radio Frequency Interface Specification (Interim Specification) SP-RFIV1.1-I06-001215", MCNS Holdings, L.P., 2000, pp. ii to 432.
- WAP Architecture, *Wireless Application Protocol Architecture Specification*, Version 12, Jul. 12, 2001, pp. 2-24.
- www.cotse.com, *Congestion Avoidance Overview*, Oct. 30, 2000, pp. 1-8.

* cited by examiner

FIGURE 1

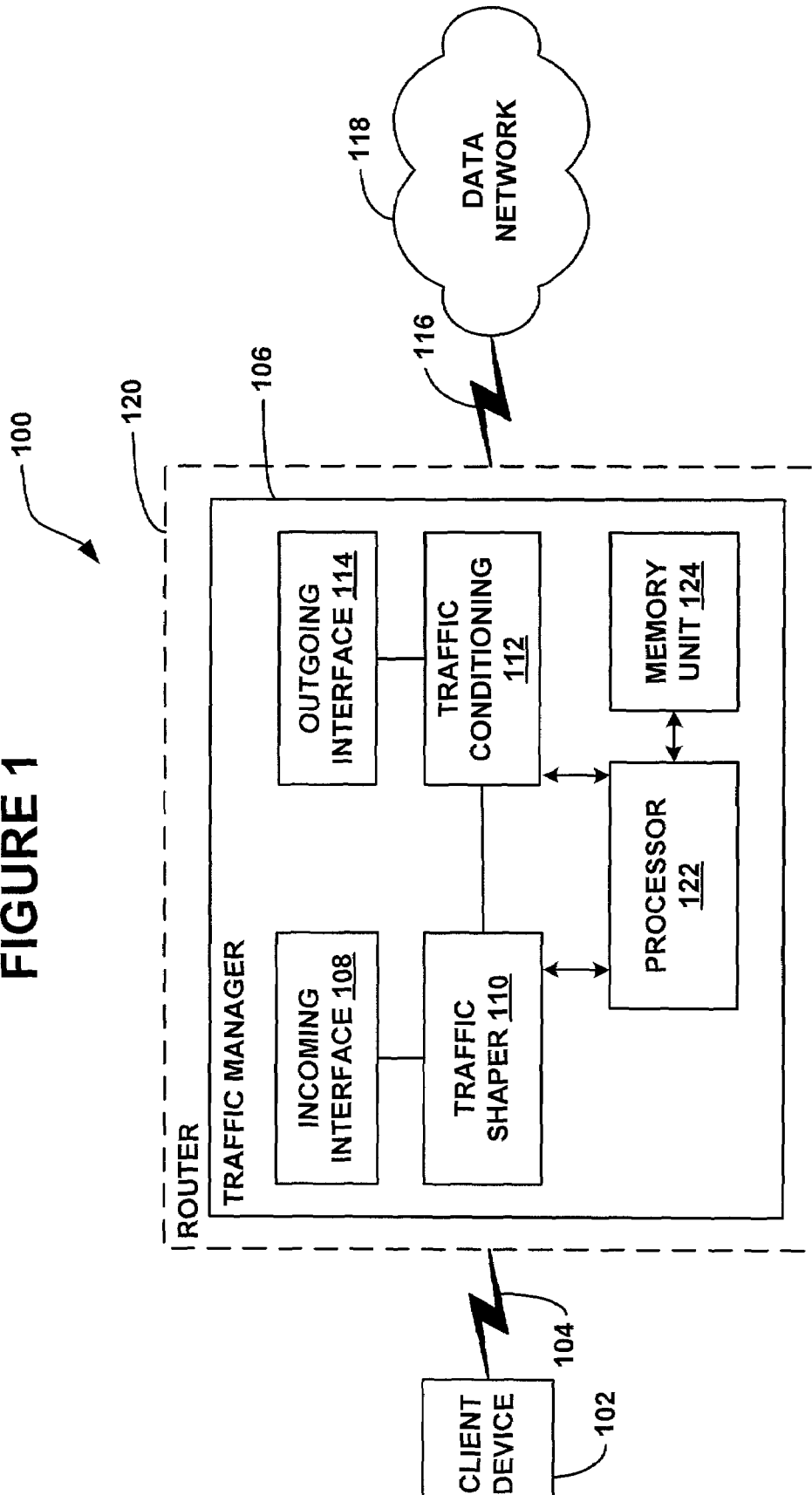
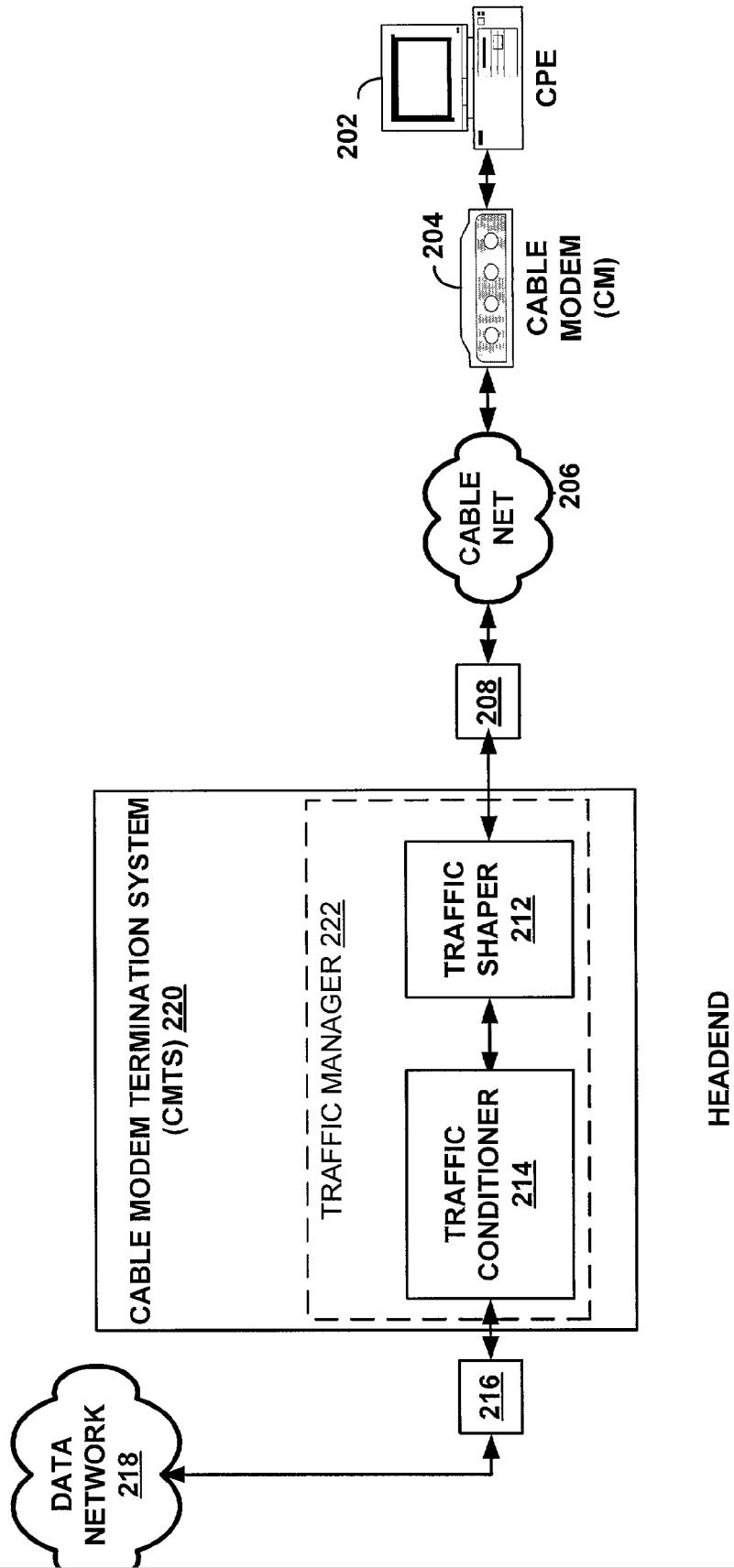


FIGURE 2

200



HEADEND

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.