United States Patent [19]

Bonomi et al.

[11] **Patent Number:** **5,864,540**

[45] **Date of Patent:** **Jan. 26, 1999**

[54] **METHOD FOR INTEGRATED TRAFFIC SHAPING IN A PACKET-SWITCHED NETWORK**

[75] Inventors: **Flavio Giovanni Bonomi**, Palo Alto, Calif.; **Albert Gordon Greenberg**, Millburn; **Jennifer Lynn Rexford**, Summit, both of N.J.

[73] Assignee: **AT&T Corp/CSI Zeinet(A Cabletron Co.)**, Middletown, N.J.

[21] Appl. No.: **825,990**

[22] Filed: **Apr. 4, 1997**

[51] **Int. Cl.^{6}** **H04J 3/14**
[52] **U.S. Cl.** **370/235**; 370/413
[58] **Field of Search** 370/229, 230, 370/231, 232, 233, 234, 235, 236, 412, 413, 414, 415, 416, 417, 418, 389, 392, 395, 428, 429, 465, 468

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,260,935	11/1993	Turner	370/418
5,268,900	12/1993	Hluchyi	370/418
5,499,238	3/1996	Shon	370/399
5,515,363	5/1996	Ben-Nun et al.	370/412
5,602,830	2/1997	Fichou et al.	370/412
5,629,937	5/1997	Hayter et al.	370/412

OTHER PUBLICATIONS

Pierre E. Boyer, Fabrice M. Buillemin, Michael J. Servel, and Jean–Pierre Courdreuse; "Spacing Cells Protects and Enhances Utilization of ATM Network Links," IEEE Network, Sep., 1992, pp. 38–49.

Eugene Wallmeir and Tom Worster; "The Spacing Policer, An Algorithm for Efficient Peak Bit Rate Control in ATM Networks," Proceedings of 14th International Switching Symposium; Oct., 1992, vol. 2, A5.5, pp. 22–26.

Jennifer L. Rexford, Albert G. Greenberg, and Flavio G. Bonomi; "Hardware–Efficient Fair Queueing Architectures for High–Speed Networks," Proceedings of IEEE Infocom '96, Mar., 1996.

Jon C. R. Bennet and Hui–Zhang, "Hierarchical Packet Fair Queueing Algorithms," Proceedings of ACM SIGCOMM, Aug., 1996, pp. 143–156.

Jennifer Rexford, Flavio Bonomi, Albert Greenberg, and Albert Wong; IEEE INFOCOM; A Scalable Architecture for Fair Leaky–Bucket Shaping, 1997.

Jennifer Rexford, Flavio Bonomi, Albert Greemberg and Alberg Wong; IEEE Journal on Selected Areas in Communications Special Issue on Advances in ATM Switching Systems; Scalable Architectures for integrated Traffic Shaping and Link Scheduling in High–Speed ATM Switches, 1997.

Primary Examiner—Huy D. Vu

[57] **ABSTRACT**

A scalable integrated traffic shaper for a use in a packet-switched network that regulates multiple connections and prevents lost data by integrating link scheduling and traffic shaping to fairly arbitrate between incoming connections.
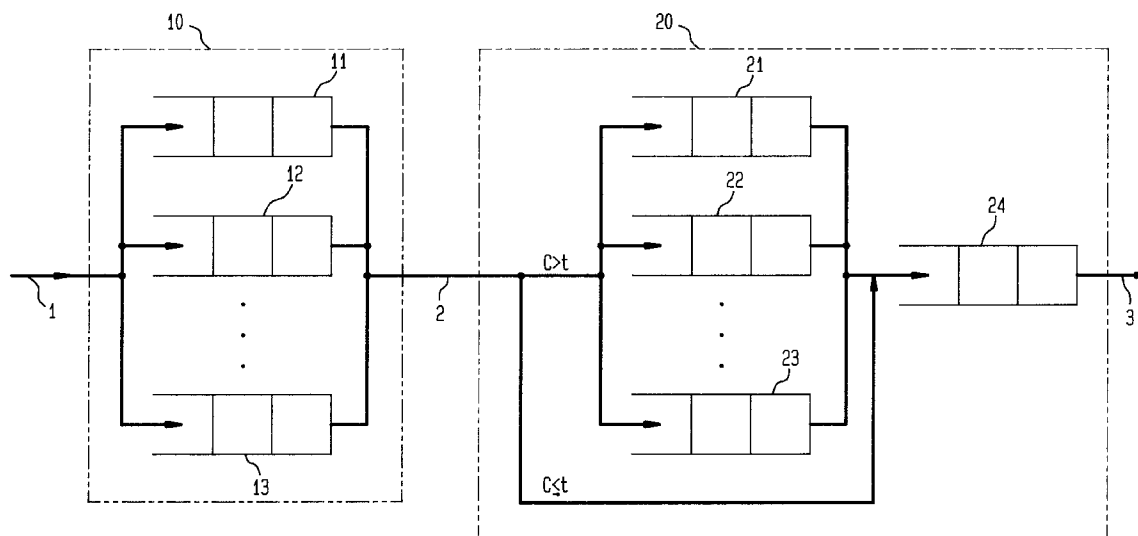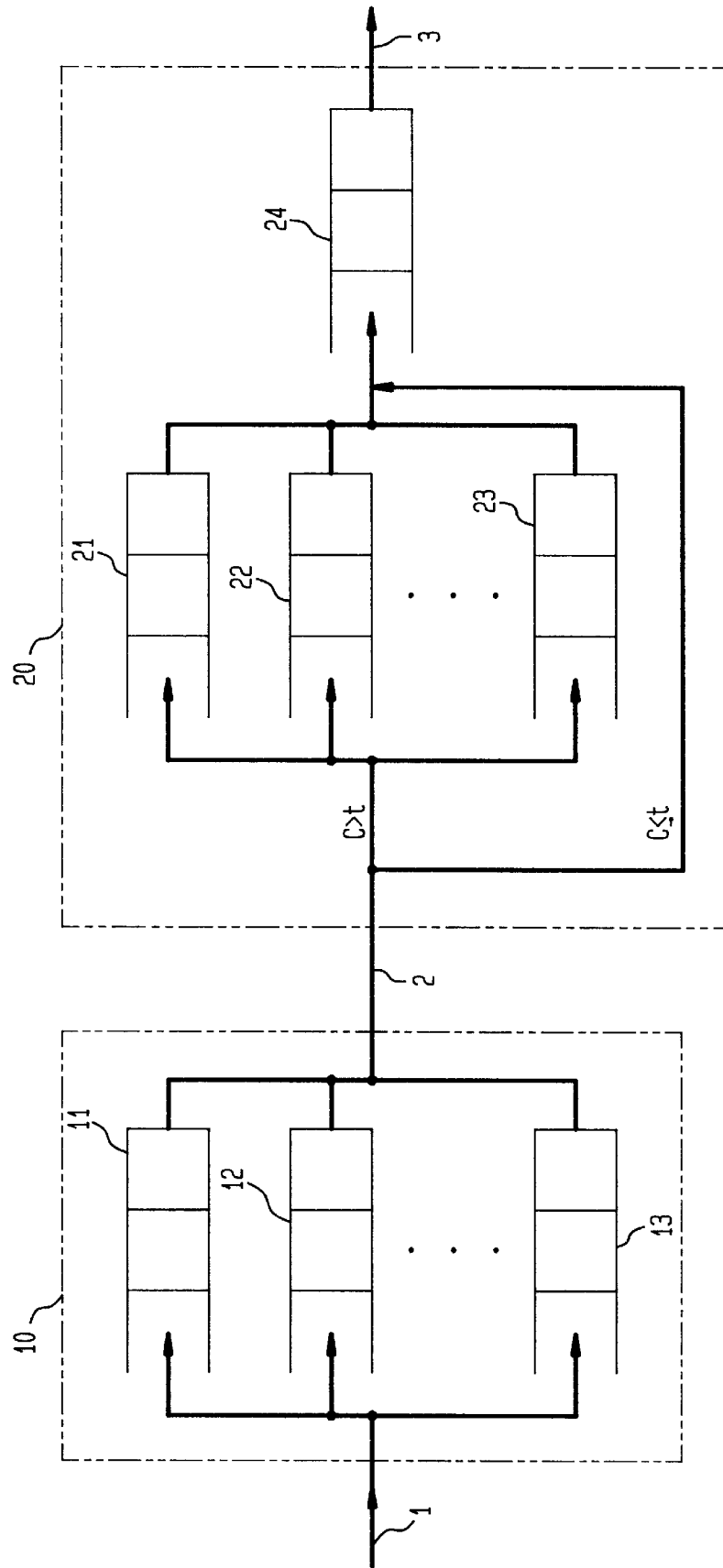
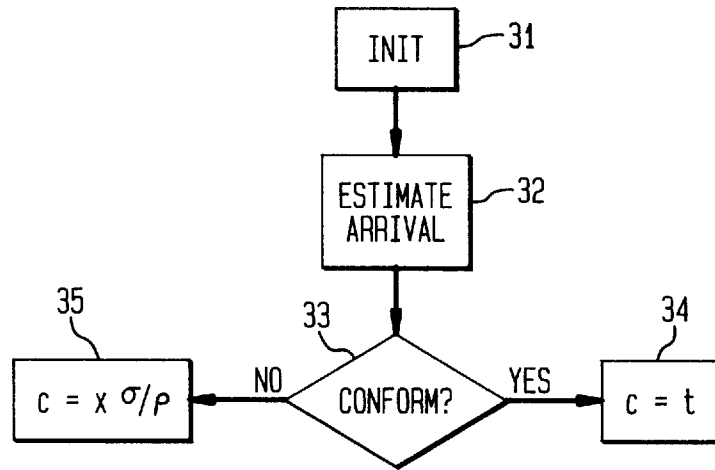**18 Claims, 5 Drawing Sheets**

FIG. 1

FIG. 2

INIT — 31

↓

ESTIMATE ARRIVAL — 32

↓

35   33   34

$c = x\, \sigma/\rho$ ← NO ← CONFORM? → YES → $c = t$

FIG. 3

COMPUTE C — 30

↓

41

IDLE CONNECTION? — NO

YES

↓

42

CONFORM? — YES → ENQUEUE IN TXFIFO — 43

NO

↓

ENQUEUE ON SORTING BIN — 44

ENQUEUE CELL ON CONNECTION FIFO — 45

FIG. 4

CELL DEPORTS ~50

CONNECTION BACKLOGGED? ~51

YES

DEQUEUE FROM CONNECTION ~52

53

CONFORM?

NO → ENQUEUE ON SORTING BIN 54

YES → ENQUEUE ON TXFIFO 55

FIG. 5

DOCKET ALARM
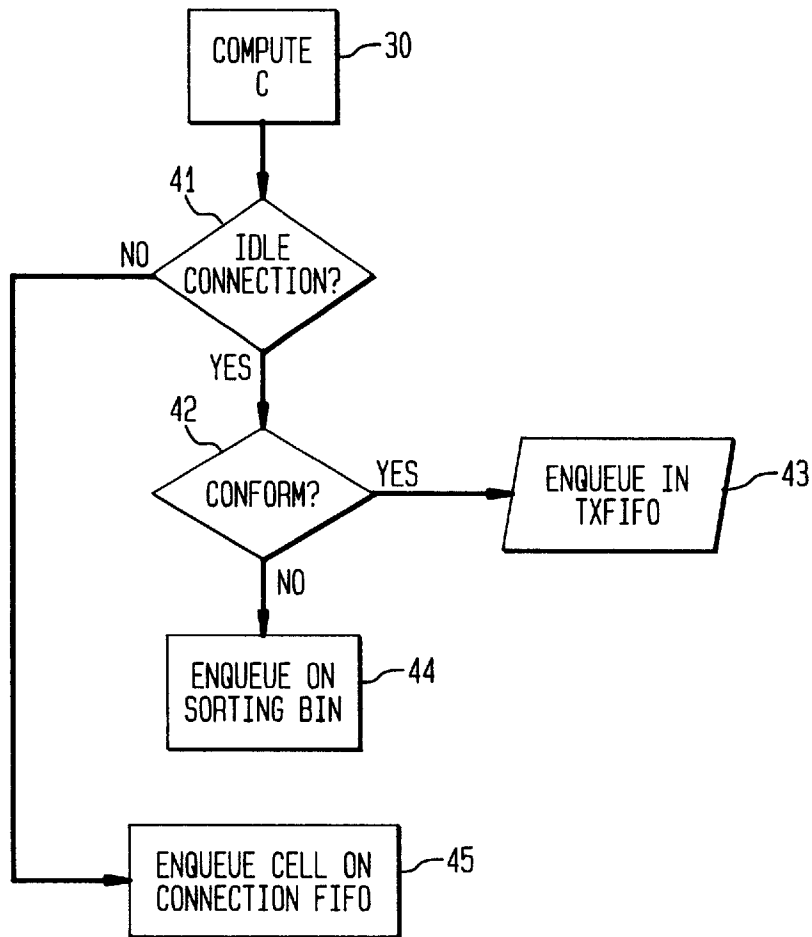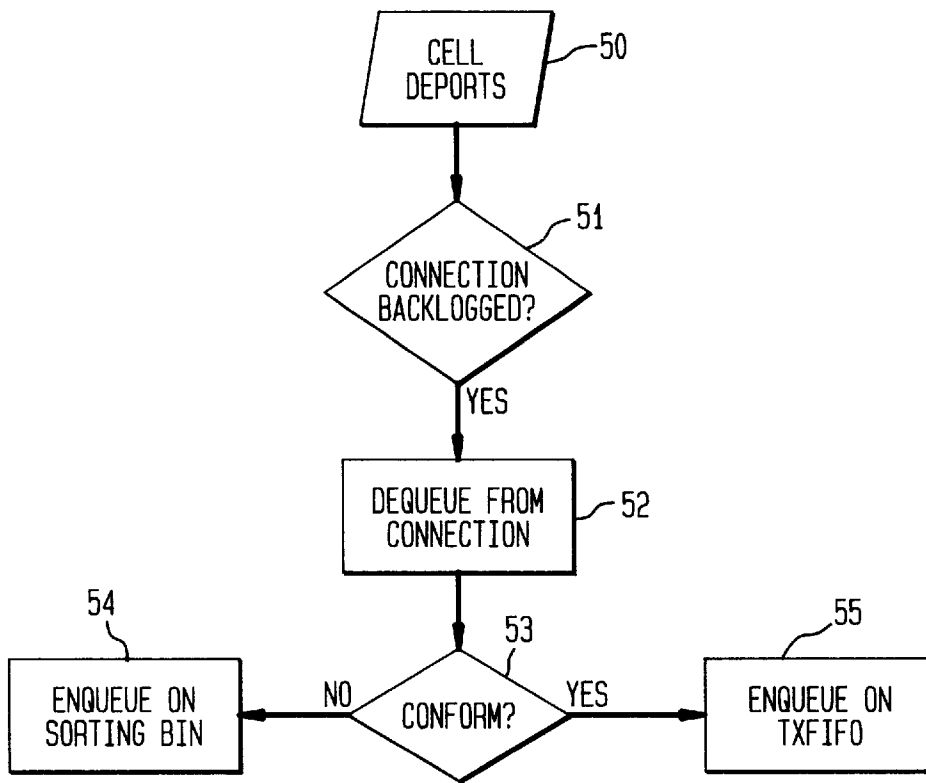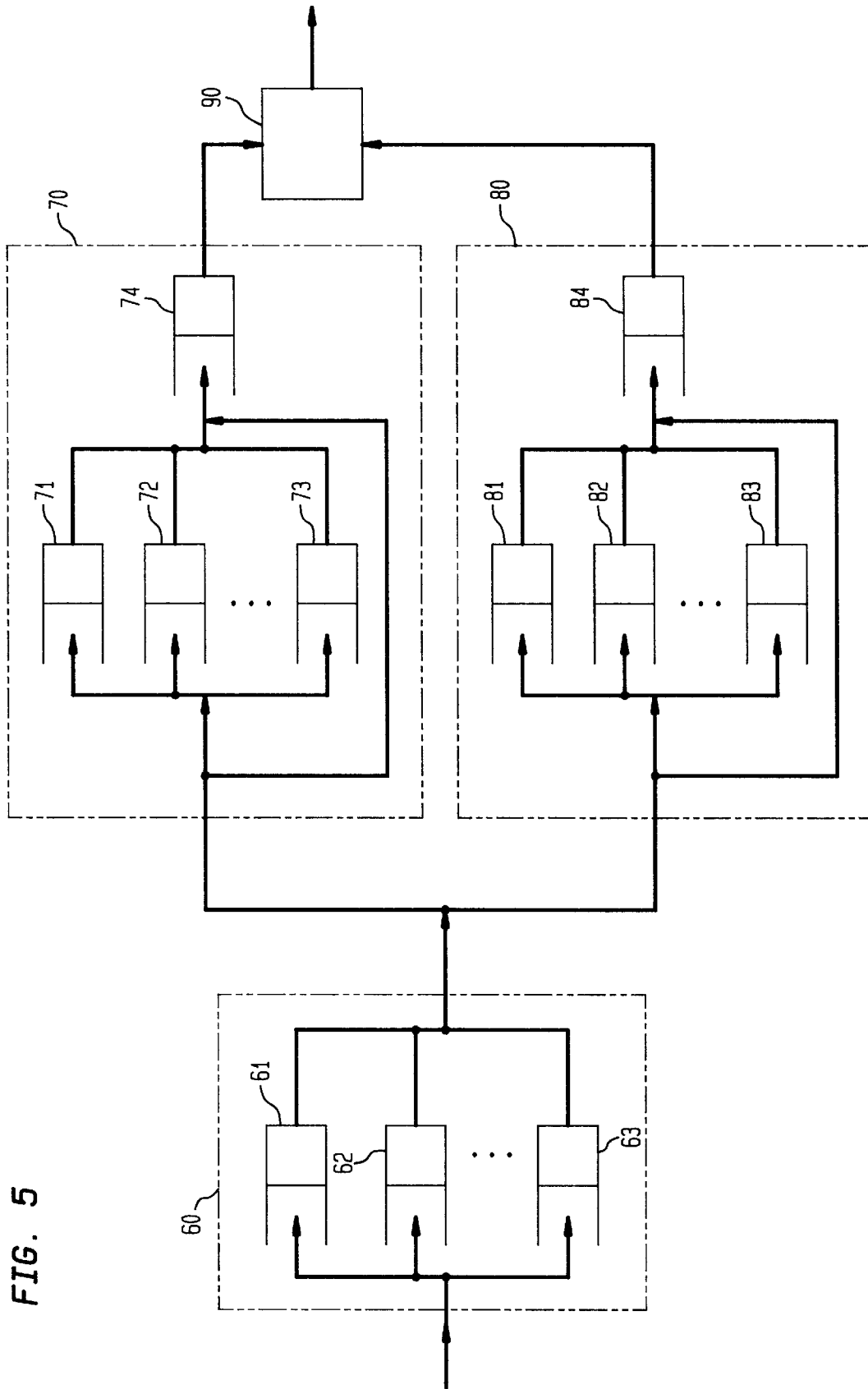
Explore Litigation Insights

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.