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Anastasiadis et al.

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(54) **STREAMING SERVER**

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Feb. 9, 2001 (CA) 2335540

(51) **Int. Cl.**
G06F 17/30 (2006.01)

(52) **U.S. Cl.** **707/7**; 707/1

(58) **Field of Classification Search** 707/1, 707/2, 7, 10, 104.1; 709/203, 219, 221, 226, 709/231; 711/114; 714/4, 5, 11; 719/321
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,974,503 A * 10/1999 Venkatesh et al. 711/114
6,230,200 B1 * 5/2001 Forecast et al. 709/226
6,625,750 B1 * 9/2003 Duso et al. 714/11

OTHER PUBLICATIONS

Ken Rudin, Scalable Systems Architecture: Scalable I/O, Part I: Disk Striping, published in DM Review in May 1998, pp. 1–3.*

Shenoy and Vin, Failure Recovery Algorithms for Multimedia Servers, University of Texas at Austin, pp. 1–34 (undated).

Haskin and Schmuck, The Tiger Shark File System, IBM Almaden Research Center, IEEE, 1996, pp. 226–231.

Bolosky, et al., Distributed Schedule Management in the Tiger Video Fileserver, Microsoft Research, SOSP 97 (undated).

Anastasiadis, et al., Modular and Efficient Resource Management in the Exedra Media Server, University of Toronto, USfNIX Symp. On Internet Tech., San Francisco, CA Mar. 2001.

Shenoy and Vin, Efficient Striping Techniques for Multimedia File Servers, University of Texas at Austin, NOSSDAV 97, pp. 25–36 (undated).

Reddy and Wijayaratne, Techniques for improving the throughput of VBR streams, Texas A & M University, NCN 99 (undated).

Gafsi and Biersack, Data Striping and Reliability Aspects in Distributed Video Servers, Institut EURECOM, In Cluster Computing, Balzer Pub. (1998), pp. 1–27.

Özden, et al., Disk Striping in Video Server Environments, AT&T Bell Laboratories, IEEE, 1996, pp. 580–589.

(Continued)

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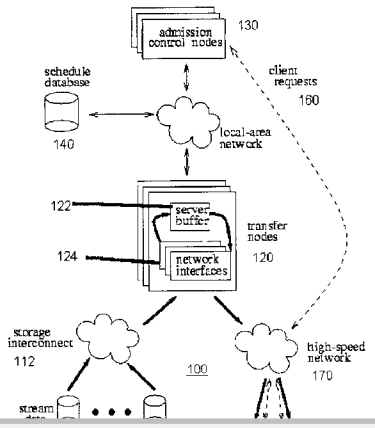
(57) **ABSTRACT**

A media server having at least one of a stride-based storage device space allocation scheme, stride-based method of striping data across multiple storage devices for continuous media streaming, server-based smoothing of variable bit-rate streams, distributed architecture, and fault tolerance.

18 Claims, 20 Drawing Sheets



OTHER PUBLICATIONS

Carbrera and Long, Swift: Using Distributed Disk Striping to Provide High I/O Data Rates, Computing Systems 4(4) (Fall 1991), pp. 405–436.

Anastasiadis, et al., Server–Based Smoothing of Variable Bit–Rate Streams, ACM Int'l Symp. On Multimedia, Oct. 2001 (Ottawa, ON Canada).

Anastasiadis, et al., Maximizing Throughput in Replicated Disk Striping of Variable Bit–Rate Streams, USfNIX Annual Tech. Conf., Monterey, CA (Jun. 2002).

Anastasiadis, et al., Disk Striping Scalability in the Exedra Media Server, University of Toronto, SPIE/ACM Multimedia Computing and Networking Conf., San Jose, CA (Jan. 2001).

McManus and Ross, A Dynamic Programming Methodology for Managing Prerecorded VBR Sources in Packet–Switched Networks, University of Pennsylvania, Jan. 1997, pp. 1–28.

Zhao and Tripathi, Banwidth–Efficient Continuous Media Streaming Through Optimal Multiplexing (undated).

Sen, et al., Proxy Prefix Caching for Multimedia Streams, IEEE, 1999, pp. 1310–1319.

Sahu, et al., On the Efficient Retrieval of VBR Video in a Multimedia Server, IEEE, 1997, pp. 46–53.

Biersack and Hamdi, Cost–optimal Data Retrieval for Video Servers with Variable Bit Rate Video Streams, NOSSDAV 98 (Cambridge, UK) (undated).

Salehi, et al., Supporting Stored Video: Reducing Rate Variability and End–to–End Resource Requirements through Optimal Smoothing, University of Massachusetts, SIGMETRICS 96, 1996, pp. 222–231.

Shenoy, et al., Symphony: An Integrated Multimedia File System, University of Texas, pp. 1–17, Tech. Report TR 97–09 (Mar. 1997).

Sen, et al., Online Smoothing of Variable–Bit–Rate Streaming Video, IEEE Transactions on Multimedia, v. 2, No. 1 (Mar. 2000).

Makaroff, et al., An Evaluation of VBR Disk Admission Algorithms for Continuous Media File Servers, ACM Multimedia (1997) pp. 145–154.

Santos and Muntz, Performance Analysis of the RIO Multimedia Storage System with Heterogeneous Disk Configurations, ACM Multimedia, 1998, pp. 1–6 and 227–238 (1998).

Gringeri, et al., Traffic Shaping, Bandwidth Allocation, and Quality Assessment for MPEG Video Distribution over Broadband Networks, IEEE Network, (Dec. 1998).

Lakshman, et al., VBR Video: Tradeoffs and Potentials, Proceedings of the IEEE, vol. 86, No. 5, May 1998, pp. 952–973.

Martin, et al., The Fellini Multimedia Storage System, Information Sciences Research Center, Journal of Digital Libraries, pp. 1–22 (1997).

Flynn and Tetzlaff, Disk Striping and Block Replication Algorithms for Video File Servers, Proceedings of Multimedia, IEEE, 1996, pp. 590–597.

Tewari, et al., High Availability in Clustered Multimedia Servers, Int'l Conf. on Data Engineering (Feb. 1996) pp. 336–342.

Ozden, et al., Fault–tolerant Architectures for Continuous Media Servers, ACM SIGMOD (Jun. 1996).

Tobagi, et al., Streaming RAID—A Disk Array Management System For Video Files, ACM Multimedia, 1993, pp. 393–400.

Mourad, Doubly–Striped Disk Mirroring: Reliable Storage for Video Servers, Multimedia Tools and Applications 2, 1996, pp. 273–297.

Berson, et al., Fault Tolerant Design of Multimedia Servers, ACM, 1995, pp. 364–375.

Gray and Shenoy, Rules of Thumb in Data Engineering, IEEE International Conference on Data Engineering, 2000.

Bolosky, et al., The Tiger Video Fileserver, NOSSDAV, (Apr. 1996).

Patterson, et al., A Case for Redundant Arrays of Inexpensive Disks (RAID), University of California (undated).

McVoy and Kleiman, Extent–like Performance from a UNIX File System, USENIX, Dallas, TX (Winter 1991), pp. 1–12.

* cited by examiner

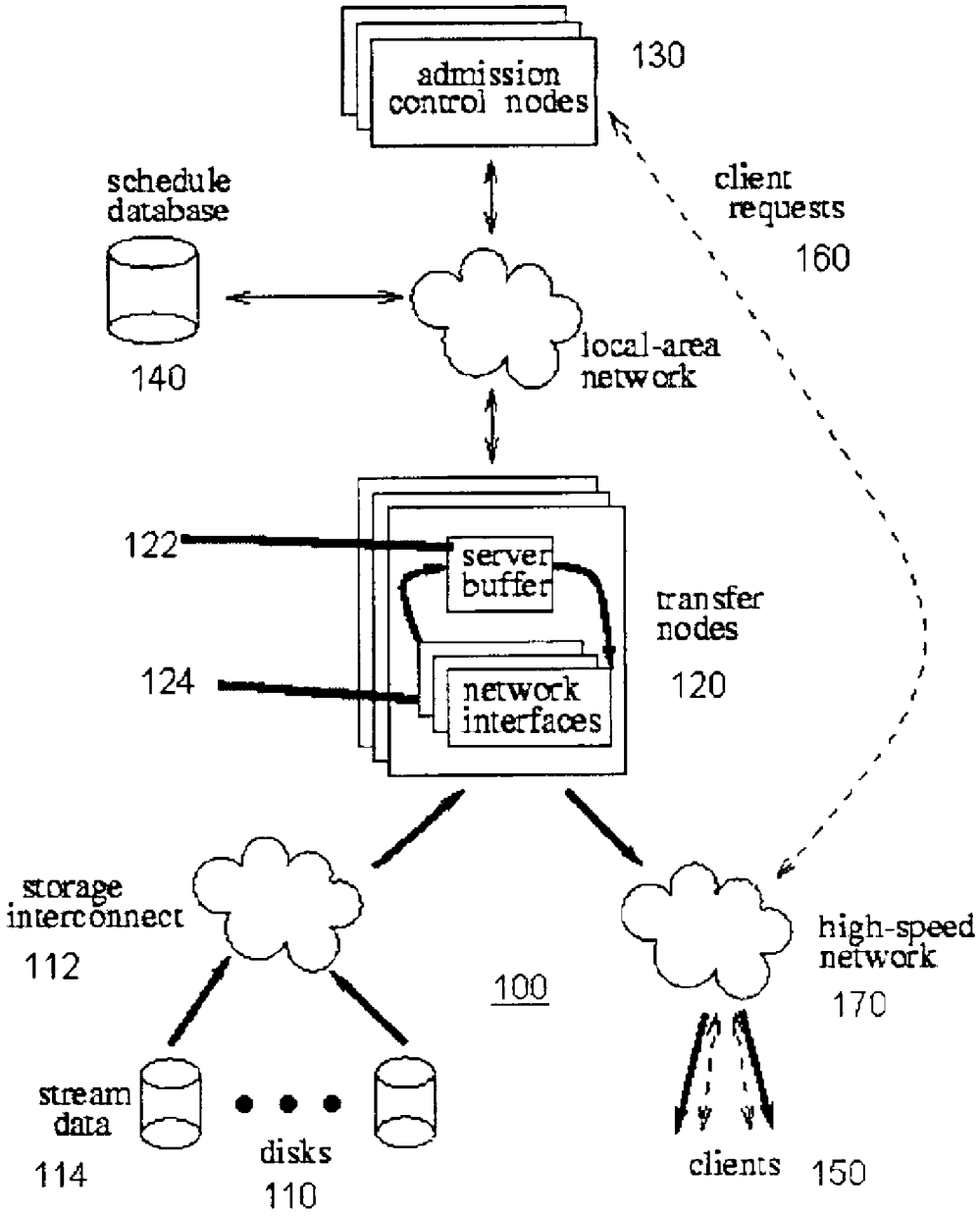


Figure 1

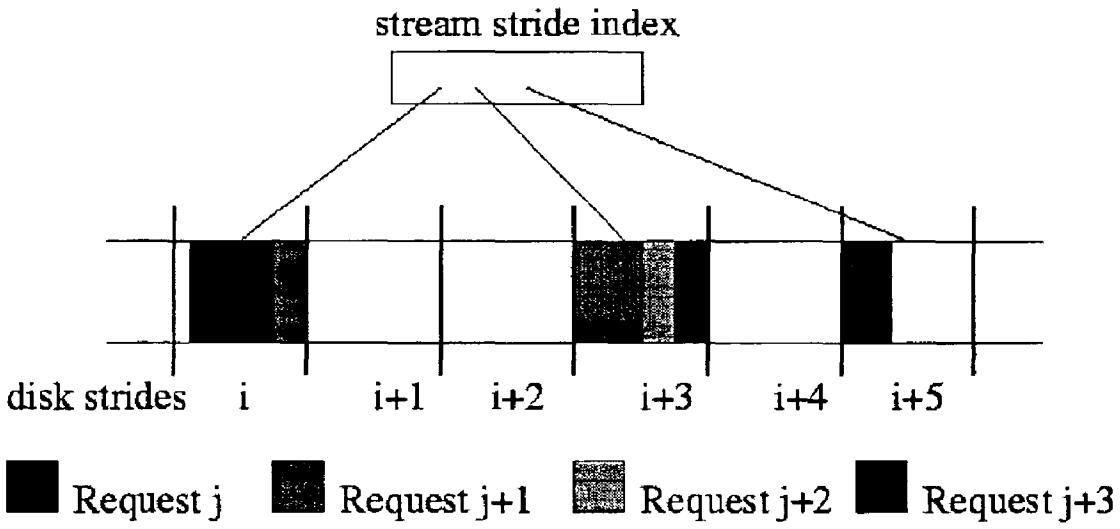


Figure 2

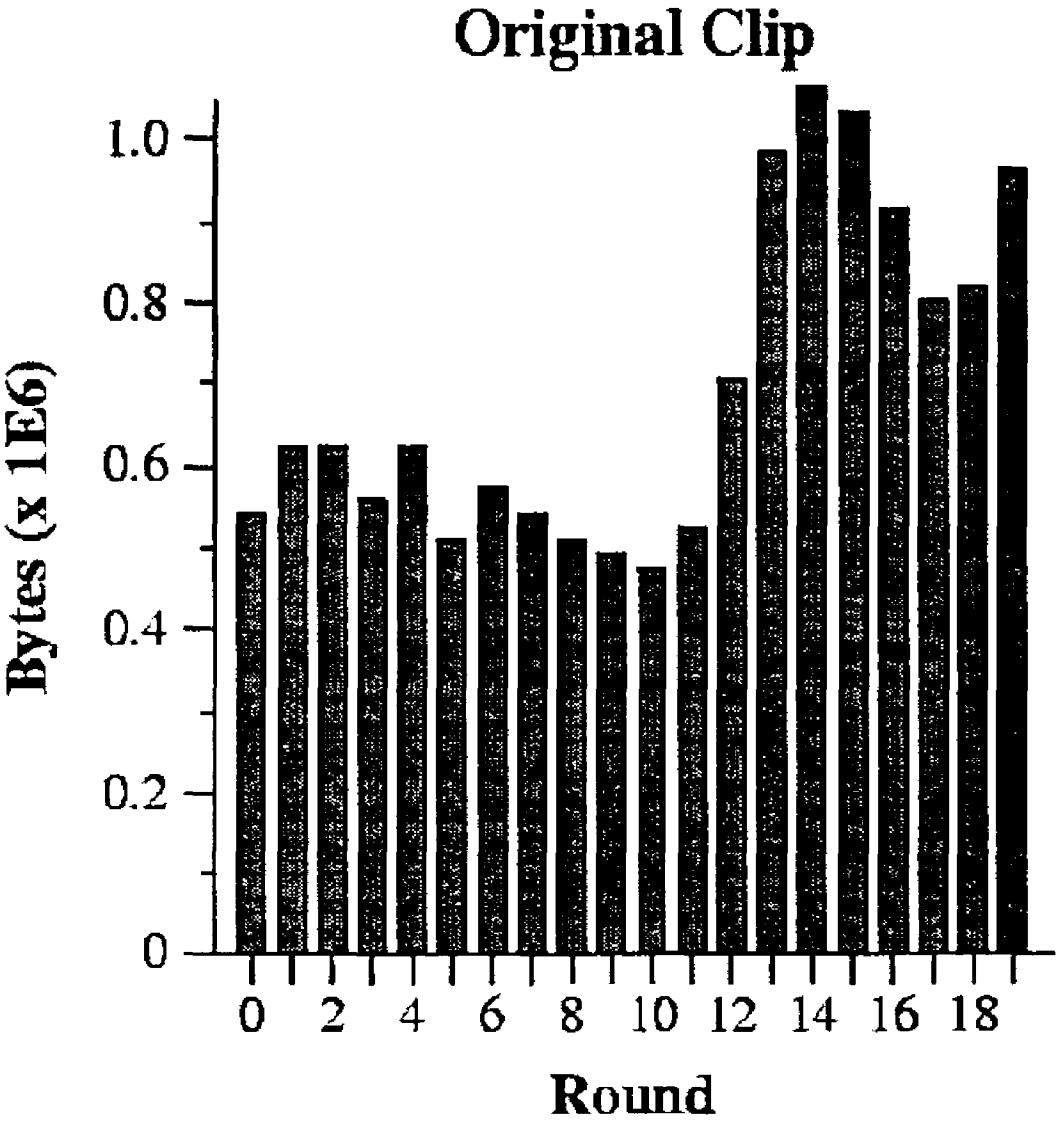


Figure 3

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