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Bhat et al.

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(54) **RESOURCE MANAGEMENT METHOD AND APPARATUS FOR MAXIMIZING MULTIMEDIA PERFORMANCE OF OPEN SYSTEMS**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(52) **U.S. Cl.** **709/226**; 709/229
(58) **Field of Search** 395/200.33, 200.47, 395/200.48, 200.49, 200.53, 200.54, 200.56, 200.31, 200.3, 821, 827, 672, 674, 675, 676, 677, 184.01; 709/203, 229, 217, 218, 219, 223, 224, 226, 201, 200, 102, 104, 105, 106, 107; 710/1, 7

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(57) **ABSTRACT**

A computer-implemented system performance model based resource management method and apparatus for dynamically guaranteeing delivery of specified constant bit rate multimedia data for a specified duration to each accepted multimedia client request, is disclosed. The method can be executed on any open system server or electronic device that selectively connects upstream multimedia information channels or storage subsystems over a data communication path to an arbitrary number of downstream NTSC ports or devices individually requiring data delivered at a specified bit rate for a specified duration. The method includes dynamically tracking the utilization and capacity of key resources of the server system as they are used by existing clients of the system, receiving and analyzing new requests for their impact if granted upon the performance of the server in servicing the existing clients, and granting the new request only if the analysis shows that such grant will guarantee that the server can simultaneously service the needs of both the new request and the existing clients. An open multimedia server system having an admission controller operating according to the described method is also disclosed.

14 Claims, 2 Drawing Sheets

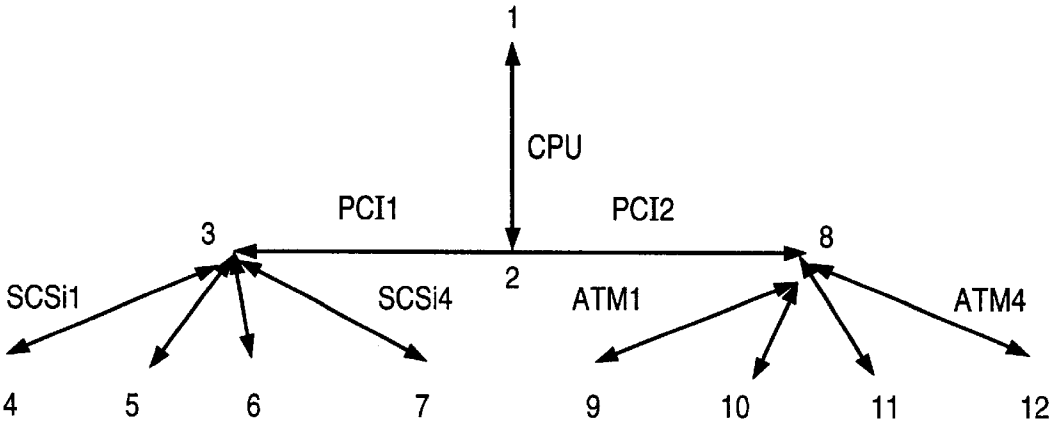

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FIG. 1

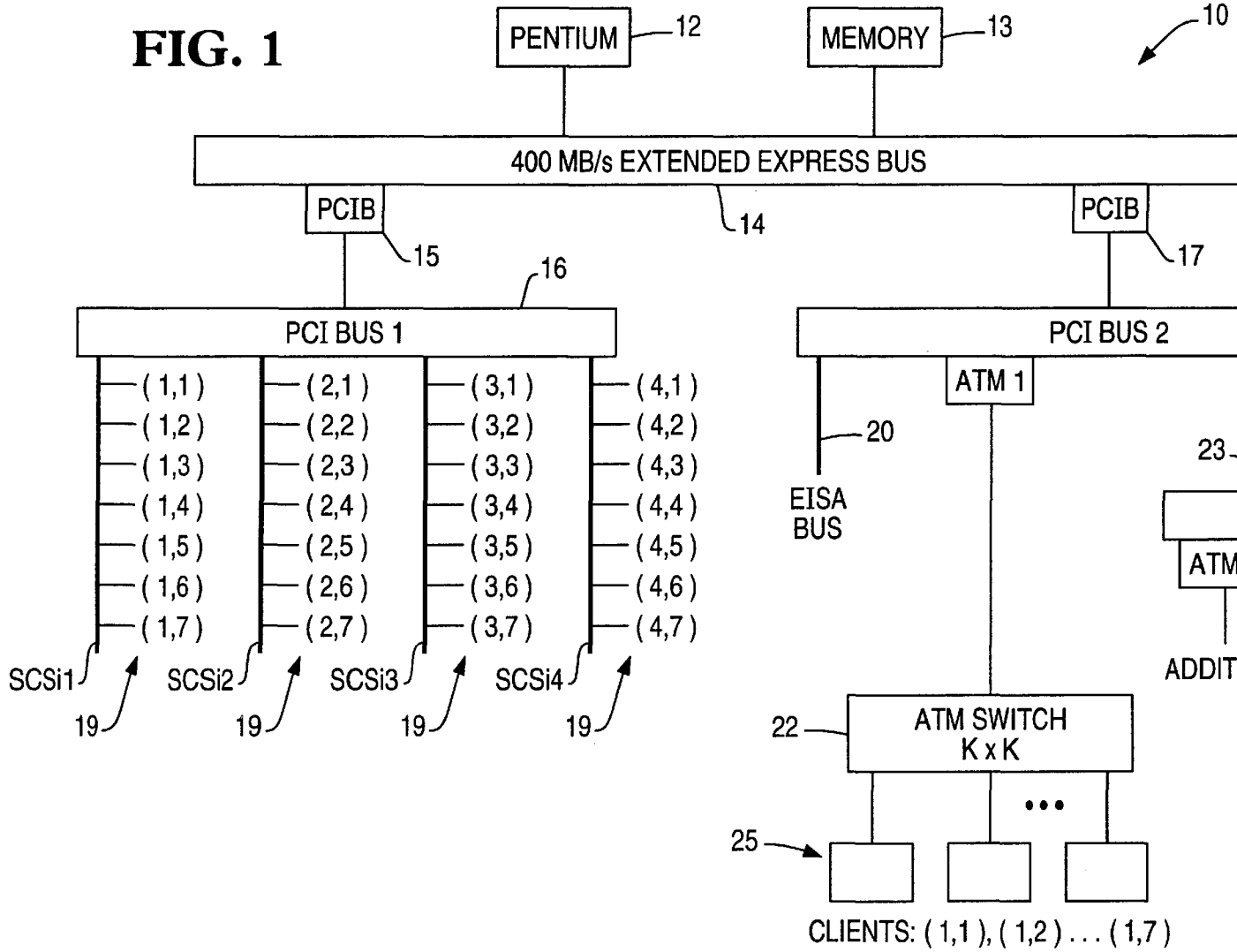
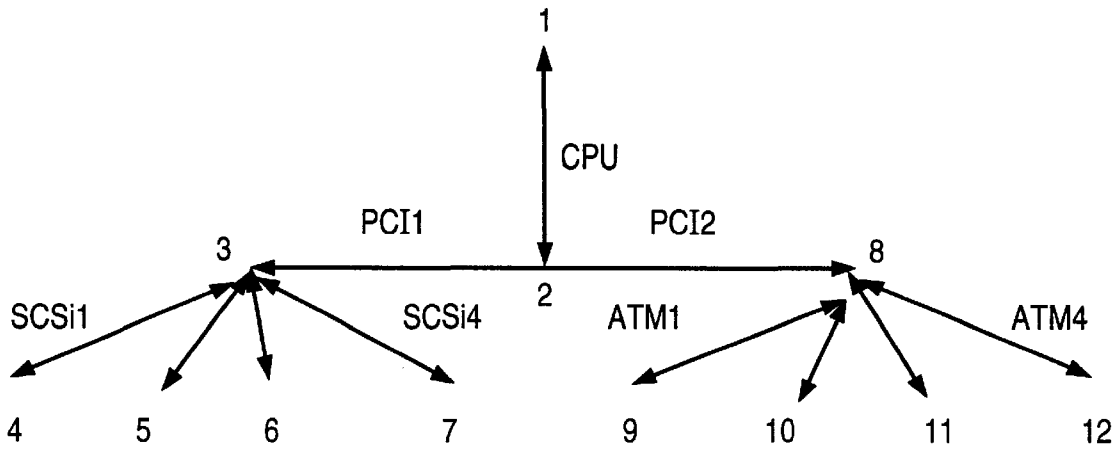


FIG. 2



RESOURCE MANAGEMENT METHOD AND APPARATUS FOR MAXIMIZING MULTIMEDIA PERFORMANCE OF OPEN SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATION

The disclosures of copending U.S. patent application Ser. No. 08/624,337, entitled "Predictable Diverse Data Delivery Enablement Method and Apparatus for ATM Based Computer System," filed on even date herewith, are herein fully incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to multimedia communication systems, and more particularly to a system performance model based resource management system for use with a multimedia server that dynamically guarantees delivery of service to accepted multimedia clients.

DESCRIPTION OF RELATED ART

Multimedia (MM) communication is a high fidelity, high productivity technological means for people to confer or to gather information wherever they are and whenever they are in need, using the media of their choice. It is a technological attempt to emulate the bandwidth, fidelity and effectiveness that are present in a face-to-face communication. The advent of high performance, low cost microprocessors, memory systems, redundant arrays of inexpensive disk storage technology and high bandwidth I/O buses, coupled with the demand for multimedia communication, is resulting in computers being an integral part of global communication systems. With the marriage of advanced technologies of computers and communication networks, people can get information they need in any form when and where they need it. These technologies facilitate activities such as watching a video of one's own choice on demand, or receiving interactive audiovisual instructions for repairing a broken machine from an expert located at a remote site.

The ability to provide a service to customers as agreed and meeting their expectations is vital for success in a competitive business such as communication and computers. In communication arena, ATM technology by design provides quality of service (QOS). QOS here is defined by guarantees on the bandwidth, loss of frames and delay to the network customers. Although considerable research has been done in specific MM areas, the issue of how to provide "guaranteed" quality of service (GQOS) in MM communication involving both computers and communication networks is not completely understood as yet. One method to achieve GQOS is to incorporate an admission control strategy where new jobs will be turned down based on some criteria.

Computers typically are configured to accurately complete specific data processing tasks within an average response time, acceptable to its customer. Understanding the application processing scenario on the system, the performance, capacity and reliability characteristics of the major system components under the processing scenario are adequate to design a good configuration meeting those needs. However, in MM computing, where certain data types such as video or audio must be delivered at the clients at a rate required by them, the traditional approaches are not adequate. In MM applications, accurate delivery of data from the computer to its client alone is not enough; it must be done at a rate needed by the client or meeting the specified deadline.

Users of MM clients (such as desk top computer or other electronic or electromechanical devices) require uninterrupted delivery of MM information to these devices from open servers at a constant bit rate for a specific duration, as needed by the clients. Current open system servers do not have the capability to dynamically guarantee MM data delivery for new service requests. This will either lead to observable failure of service to one or more MM clients of the MM server or substantial underutilization of system resources. The former results in customer dissatisfaction, and the latter in reduced performance/price ratio.

The present invention addresses the above shortcomings of prior art MM communication systems. The methodology presented by the present invention is generally applicable to different configurations of open computer systems and provides a basis for realizing GQOS in MM communication systems.

SUMMARY OF THE INVENTION

To overcome the limitations in the prior art described above, and to overcome other limitations that will become apparent upon reading and understanding the present specification, this invention discloses a computer-implemented system performance model based resource management algorithm and method that dynamically guarantees delivery of specified constant bit rate MM data for specified duration to each accepted MM client request. The system of this invention executes on any open system server (or an electronic device) that is connected to either an MM information storage subsystem (such as disks, RAIDs, optical arrays, etc.) or to an upstream MM information channel and the output channels connected to an arbitrary number of NTSC ports or other devices requiring a specified constant bit rate for a specified duration by means of a data communication path such as bus hierarchy or ATM connections. According to one aspect of the invention, the algorithm embodied in this system enables each of the NTSC ports being fed with constant bit rates of information for a specified time interval from the upstream information sources as desired by the customers. The algorithm is configured to operate in response to an MM server system performance model that predicts the number of streams that the system can dynamically support. The system of this invention enables open system MM servers to guarantee delivery of information to servers dynamically with no buffer overflows or starvation.

According to one implementation of the algorithm of the inventive system, whenever a new service request arrives at the MM server, the system recognizes the constant bit rate needs (based on the characteristics of the client) and the duration for which the client needs the guaranteed continuous service. The system maintains a table or database that dynamically keeps track of the utilization and capacity of key system resources such as the CPU(s), disks, MM data, memory, system bus and data input/output path bandwidths. According to one implementation of the algorithm of the present invention, the following steps are practiced:

(1) If the request is for terminating or cancellation of MM service, the algorithm responds to the request and updates the appropriate table entries (utilization of key resources) reflecting the release of the resources, and then continues to step (5). If it is for a new services request, then proceed to step (2).

(2) From a table look-up, the algorithm checks if key resources are available for the duration. If they are, then proceed to step (3). Otherwise, deny this request as there is no way to meet it, and proceed to step (5).

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