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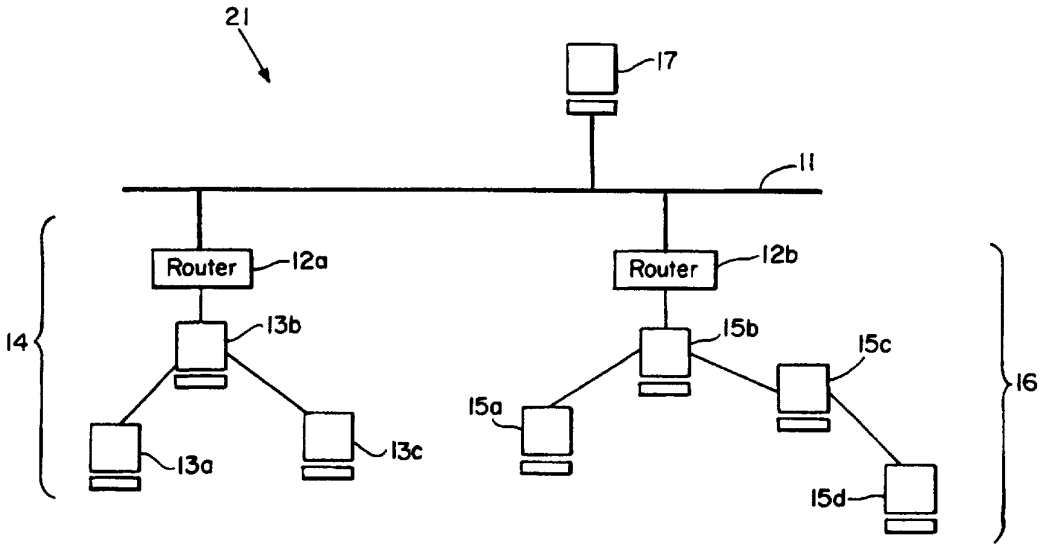

(57) Abstract

In a distributed computing environment, a data stream is formed of a sequence of requested objects. The defined order of the sequence of objects is determined from a client request for data. The order may be a default order, or, alternatively, the server may track client criteria to determine the order. For example, the server (17) may track objects previously transmitted in the stream to the client (13) such that there is no duplication of objects. In other instances, the server may select an object from a class of objects, depending upon object quality, bandwidth, client location, and other client-specific criteria. The server compiles and transmits the object data stream in real-time (on-the-fly) based on the criteria. Buffering of data with pausing to rectify buffer debt is provided by the client.

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COMPUTER METHOD AND APPARATUS FOR OBJECT STREAMING

REFERENCE TO CO-PENDING APPLICATION

This application claims the benefit of a United States Provisional Application Serial No. 60/018,256 filed May 24, 1996.

BACKGROUND

"Distributed computing" makes use of a computer network formed out of one or more computers loosely coupled together to allow processes on different computers to communicate with each other and to provide services for each other. One of the most common paradigms of distributed computing is known as the "client-server model", in which consumers of services are called "clients", and make requests of service providers, called "servers".

In object oriented distributed computing, there is a notion of computer entities called "objects". Each object comprises a particular state and a set of defined behaviors. The state is represented by data maintained by the object. The behavior is specified in terms of operations that the object can perform with the operations, typically realized by executable code. Conceptually, the data and the code are inextricably bound together in the object. Objects may be "persistent", that is, they may continue to exist even though they are inactive or the computer on which they exist has failed or has been turned off. Further, objects may issue requests for services to other objects as well as supply services.

Typically, data is held in linear files on a server. When a client requests that data or a part thereof, a connection is formed between the data source (server) and delivery (client) point.

In the prior art there are in general two different types of servers. The first, known as a web server, typically stores data files of a number of different types. Web servers typically communicate with clients over a network such as the Internet using the well known TCP/IP protocol. The second type of server, known as a streaming media server, stores and transmits media files of various types.

More particularly, the web servers presently in use typically store data files in a format known as Hyper Text Markup Language(HTML). HTML permits the web servers to handle container files which reference other files of varying formats. Using HTML, a given web document may include content information in various formats and may also refer to other files by including reference information known as a Uniform Reference Locator (URL). URL's specify the location of remote servers at which files referenced in the HTML file may be located.

Upon receipt of an HTML file from the original web server, a client then must access each document referenced from its source. Each such request typically requires a full cycle of communication with a remote server, including opening a connection socket with the remote server, requesting that the file be transferred, waiting for the file to download, closing the connection, and then, finally parsing the file. To render a given web page may therefore require many such cycles.

The other type of server, known as a streaming media server, has been developed to be particularly suited for multimedia of various types. Such servers may handle single data types, such as a RealAudio™ file, or may

include mixed media types, in formats such as NetShow™ (RealAudio™ is a trademark of Progressive Networks, Inc., and NetShow™ is a trademark of Microsoft Corporation). In any event, media files are typically laid out in a linear fashion in a single file. Thus, when the client requests a file from a streaming server, a socket is simply opened and delivery of data is begun.

The client may perform a caching or buffering operation prior to actual play back of the media file. This ensures that the media file is played back to the user of the client computer in a continuous stream. In particular, the client may calculate in advance an amount of data that it must have on hand prior to actually beginning to render the media file, so that the user has an impression of continuous delivery of the media.

In such a linear streaming server, files may be formatted in advance with a specific communication transfer bandwidth in mind. For example, a Real Audio file may have been compressed for receipt at a baud rate such as 14.4 kilo bits per second (kbps). Another file would be made available for optimum playback at 28.8 kbps. These different file formats provide for allowances in playing back data such that it is rendered in a continuous fashion at the respective rates.

In streaming media server, the connection remains open with the server during the full duration of the play back of the file. Thus, for example, even on a high speed network connection such as a T1 line, if the media file is a ten minute audio file, then the connection will remain open for ten minutes, even though the available information transfer rate on a T1 line is much greater than the audio bandwidth.

In addition, one other disadvantage of streaming media servers is that they typically implement a lossy type of compression algorithm. Thus, if network traffic increases

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