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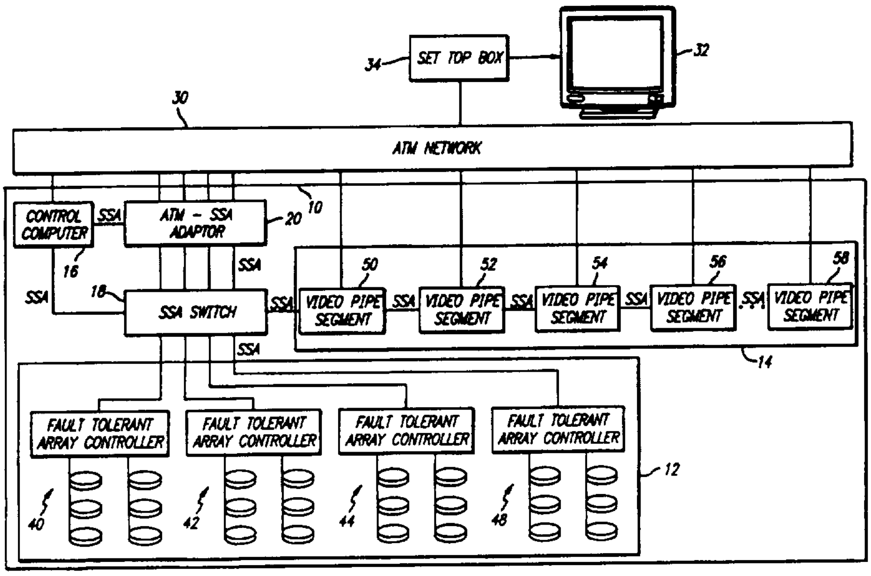

(57) Abstract

A video server (10) is described which operates to provide a plurality of video data streams to a plurality of viewers. The server includes a video pipe (14) which receives and stores one or more streams of video data from a mass storage system (12). The video pipe is composed of a plurality of interconnected pipe segments (50, 52, 54, 56, 58), each of which is further composed of a memory device (62). The pipe segments have the ability to pass a stored portion of a stored data stream to a neighboring segment for storage therein. A connection is further provided to each segment so as to route the portion stored on the segment to one of the viewers as one of the video data streams. The server is controlled via a controller (16) based on requests from the viewers.

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"VIDEO SERVER USING MEMORY PIPE SEGMENTS"

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to mass storage devices and, more specifically, to mass storage devices which deliver video-on-demand to a large number of users.

2. Description of Related Art

There is a growing market for systems which can supply numerous customers with movies to view, beginning the very moment each customer wishes to view the movie. Such systems are often referred to as "video-on-demand" systems. They are used in a variety of environments, including in hotels and motels. They are also beginning to appear in larger scale systems, such as Community Cable Television ("CATV").

One technique of supplying video-on-demand is to house and operate a large number of video cassette recorders from a central location. When a particular movie is desired to be viewed, the user communicates with the central facility and requests that the movie be played. A video cassette containing the movie is inserted into a video player to which the user is connected.

Such a system has a substantial cost per user. The equipment needed to accommodate a large number of simultaneous users also requires a large area. Reliability problems also exists because of the numerous mechanical components which move during operation.

One developing technology for reducing these problems is to utilize what is known as a "video server." The video and audio portions of the movie are digitized and stored as a stream of digital data on a mass storage system. When playback of the movie is desired, the digital data is accessed, converted back into an analog signal, and delivered to the user for viewing. Such a system is advantageous because one mass storage system can store several movies and can supply digital data representative of these several movies to several users simultaneously. This can result in a lower overall cost per user. It also can result in enhanced reliability, due to a reduction in the amount of moving mechanical parts.

These video servers, however, are often limited in the number of users which they can simultaneously service. As the number of simultaneous users grow, the needed data-delivery speed of the server must also grow. These enhanced speed requirements create additional technical problems and associated expense.

Using the Motion Picture Experts Group (MPEG) compression technique, a typical video server will have to deliver about 4 megabits per second of digital data to keep up with the movie, some applications using rates as low as 1.5 megabits per second or as high as 9 megabits per second. A "bit" is a single piece of information; a "megabit" is a million "bits." Although many of the hard disk drive storage systems which are available today can reliably transfer data at this rate, their data transferring abilities soon become saturated as the number of simultaneous users becomes very large.

More disk drives can be added to help overcome this problem. However, the cost of the system per simultaneous view remains high. For a CATV system which needs to simultaneously service a very large number of users (e.g., 100,000), moreover, the system would require a very large number of disk drives, again resulting in a system which is bulky and complicated.

SUMMARY OF THE INVENTION

One object of the present invention is to obviate these as well as other problems with prior art video-on-demand systems.

A further object of the present invention is to provide a video-on-demand system which has a low average cost per simultaneous user.

A still further object of the present invention is to provide a video-on-demand system which effectively multiplies the data transfer bandwidth of a mass storage system, thereby allowing the mass storage system to simultaneously service more users than the device could service without the invention.

A still further object of the present invention is to provide a video-on-demand system which can simultaneously service 100,000 users, which occupies relatively little space and has a minimal amount of moving mechanical parts.

These and still further objects, features and benefits of the present invention are achieved by connecting a "pipe" comprised of a plurality of interconnected memory segments to the mass storage system. Data streams representative of the most frequently used movies are loaded into the pipe. Movie stream data is delivered to users from each segment of the pipe, rather than directly from the mass storage system.

The pipe has the ability to shift data from one pipe segment to another. This allows users of the other pipe segment to receive the same data stream as was present in the previous pipe segment at a later time. The data transfer speed of each particular pipe segment is generally sufficient to allow each pipe segment to supply several movie streams to several users simultaneously. The net result is that many users can view the same movie at different times without the mass storage system having to repeatedly access the same stored movie data for every single viewer at different times.

In one embodiment of the invention, the video pipe contains enough memories having enough capacity to hold the data streams of several entire movies. Upon initialization of the system, the most popular films are advantageously loaded in the pipe before user requests are even received.

The system can be configured to cause each viewer of a frequently-viewed movie to receive the entire data stream for that movie from a single memory segment of the video pipe. Although each user could theoretically instead be switched among different memory segments to receive the sequential pieces of his requested movie stream, causing his sequential data segments to always be delivered from the same memory segment allows for a much simpler control system.

A broad variety of mass storage systems can be used to store the movies in the video server of the present invention. In one embodiment, Applicant chooses to use an array of hard disk drive arrays, advantageously employing a fault tolerant array controller to protect against discontinuities in the movie streams which are delivered.

Another feature of the present invention is to supply streams of movies which are not frequently viewed directly from the mass storage system itself. This avoids unnecessary use of the video pipe and an associated increase in the size of the pipe which otherwise might be needed.

IBM's serial storage architecture (SSA) may advantageously be used to connect many components of the video server, including connections between the video pipe and the mass storage system and the individual memory segments in the video pipe. Using SSA connections, the first segment of movie stream data coming from the mass storage system can advantageously begin to be stored in any one of the memory segments in the video pipe.

A broad variety of techniques can be used to effectuate the control necessary for causing the desired movement of movie stream segments through the video server. In one embodiment, the pipe segments themself include a control that determines when the pipe segment should shift the movie stream data contained therein to a neighboring segment. In this way, portions of the control system are distributed, thereby reducing control traffic and complexity.

The present invention is well suited to a variety of communication networks, including the Asynchronous Transfer Mode (ATM) network developed by telecommunication companies.

Through the use of the present invention, a very large number of viewers (e.g., 100,000) can view videos-on-demand at a fraction of the cost per viewer than otherwise would be possible.

These and still further objects, features and benefits of the present invention will now become clear from an examination of the drawings, taken in conjunction with the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of one embodiment of the video server of the present invention, shown connected to an ATM network.

Fig. 2 is a block diagram of one embodiment of the video pipe segments shown in Fig. 1.

Fig. 3 is a block diagram of an alternate network distribution configuration which may advantageously be used in conjunction with the video server of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a block diagram of one embodiment of the video server of the present invention, shown connected to an ATM network.

As shown in Fig. 1, a video server 10 made in accordance with the present invention includes a mass storage system 12, a video pipe 14, a control computer 16, an SSA switch 18 and an ATM-SSA adaptor 20.

The video server 10 may advantageously be connected to an ATM network 30. Also connected to the ATM network 30 are a plurality of TVs and associated Set Top Boxes, such as TV 32 and Set Top Box 34.

As is well known in the art, the Set Top Box 34 receives digital data from the ATM network 30, extracts the data stream representative of the movie to be shown on the TV 32 from that digital data, and converts that digital data to the analog signal which the TV 32 requires for viewing of the movie.

In some configurations, the Set Top Box 34 may also request the movie stream which the user desires to view from the ATM network 30. In other configurations, the request for the movie may be made by the user through means not shown in Fig. 1, such as a telephone call to the user's cable company.

When the Set Top Box 34 is used to request a movie stream, it may or may not continue to participate in the request process by requesting specific segments of the movie stream to be viewed. The choice as to whether the Set Top Box 34 communicates requests for movie streams and whether it will communicate the request only initially or for the various segments of the movie stream is a design choice. All such configurations are contemplated to be used in connection with the present invention.

In a typical video server, the movie data will be stored in the mass storage system 12 in a compressed format. One popular compression scheme which may be used in connection with the present invention is what is known as the Motion Picture Experts Group (MPEG) compression scheme. To reduce the bandwidth requirements of the ATM network 30, the digital data would normally not be decompressed until it reaches the Set Top Box 34. Thus, decompression of the digital data will also typically be the responsibility of the Set Top Box 34. Again, of course, this is by no means a requirement for use of the present invention.

The Set Top Box 34 can be connected to the ATM network 30 using a vast array of techniques, typically a coaxial or fiberoptic cable. Wireless techniques, of course, would also be within the scope of the present invention.

The ATM network 30 shown in Fig. 1 is a type of network used by telecommunication companies. The switches used in this network can be purchased from Siemans AG, located in Munich, Germany, among other companies. Interface chips to the network can also be purchased from a variety of companies, including Fore Systems, located in Pissburgh, Pennsylvania. Although an ATM network has been selected for the illustration of the present invention shown in Fig. 1, the invention is also well suited to being used in a broad variety of other types of networks or using other types of connection techniques. Other interfaces which might be used include SCSI and IPI Fiber Channel Structured Architecture Loop.

The invention is well suited for being used in connection with a broad variety of mass storage systems, including optical drives, tape drives, etc. However, Applicant believes that hard disk drives currently provide the best compromise between price, storage capacity, reliability and speed.

In the embodiment shown in Fig. 1, the mass storage system 12 consists of a plurality of disk drive arrays 40, 42, 44 and 46. Each array, in turn, consists of a plurality of hard disk drives connected to a fault tolerant array controller.

There are, of course, a broad variety of disk drive arrays which could be used in connection with the present invention. Considerations of capacity, speed, cost and reliability will determine the actual choice.

A typical movie lasts for 100 minutes or 6,000 seconds. Using MPEG compression techniques, 4 megabits of data will be required for each second of the movie. Thus, the mass storage system 12 will need to have a storage capacity of about 3 gigabytes for each movie. A "byte" is a set of "bits" and, in this case, 8 "bits." A "gigabyte" is 1000 "megabytes."

Speed is also a very important factor. One function of the mass storage system 12 is to deliver movie streams to the video pipe 14 so that each movie stream can simultaneously be viewed by a plurality of users. Typically, only movies which are being frequently requested would be delivered to the pipe.

For those movies which are not frequently requested, it is usually not efficient to also deliver them to the pipe 14. Instead, these movie streams are delivered to single users through the SSA switch 18 and the ATM-SSA adaptor 20.

Thus, the mass storage system 12 is capable of simultaneously delivering frequently-viewed movie streams to the video pipe 14, as well as infrequently-viewed movie streams directly to the ATM network 30.

Applicant estimates that 75% of the users will request the top ten movies during peak hours of demand from 7:00 p.m. to 1:00 a.m. The delivery of these top ten movies to the pipe 14 may therefore require 40 megabits to be delivered per second by the mass storage device 12 (4 megabits per second times ten). An additional 4 megabits per second will be required for each additional stream which the mass storage system 12 is required to provide to viewers of infrequently watched movies, i.e., movie streams which are not loaded into the pipe 14.

There are a variety of techniques to increase the effective speed (i.e., to enhance the bandwidth) of the individual disk drives which make up the mass storage system 12. These techniques include using a Redundant Array of Inexpensive Drives (RAID), such as is described in U.S. Patent No. 4,870,643, entitled "Parallel Disk Array Storage System," and Applicant's U.S. Patent No. 5,191,584, entitled

"Mass Storage Array With Efficient Parity Calculation." Both of these patents are assigned to the Micropolis Corporation of Chatsworth, California, the assignee of the present invention. Striping techniques can also be utilized in recording the movie data on the drive arrays to increase speed. Fault tolerant controllers can also be used to reduce or eliminate discontinuities in the movie stream data caused by errors, such as described in Applicant's co-pending U.S. patent application, entitled "Disk Drive Array For Multi-User Audio/Video Data Server Using Pipelined, Fault Tolerant Data Retrieval Method," serial No. 08/210,899.

The mass storage system 12, of course, requires appropriate circuitry to interface with the SSA connection to the SSA switch 18. SSA is a technology designed by IBM. An SSA protocol hardware chip can advantageously be used to accomplish this interface. Such chips are available from NCR in Colorado Springs, Colorado, Adaptek in Milpitas, California, LSI in Milpitas, California and IBM.

As previously noted, Applicant estimates that 75% of the total demand during peak hours will be for the ten most popular movies. One technique which Applicant originally considered for meeting this demand was to store the video streams for these ten movies in a single large memory (typically 30 gigabytes) connected to a telecommunications interface. However, that would require a bus operating at 37.5 gigabytes per second, a system which would require a large supercomputer, costing many millions of dollars.

Instead, Applicant has conceived of the idea of using a video pipe, such as the video pipe 14 shown in Fig. 1. This pipe includes a plurality of video pipe segments, such as segments 50, 52, 54, 56 and 58.

The first video pipe segment 50 is connected through the SSA switch 18 to the mass storage device 12 using an SSA connection. Each successive video pipe segment is also connected to the previous video pipe segment using an SSA connection. Although five video pipe segments have been drawn in Fig. 1, this is for illustration purposes only. The actual number is likely to be much larger. Yet, any number greater than one is considered to be within the scope of the present invention.

Fig. 2 illustrates one embodiment of the video pipe segments shown in Fig. 1. As shown in Fig. 2, each video pipe segment 60 includes a memory 62, SSA interface devices 64 and 66, an ATM interface device 68, and a control 70. Different types of interface devices would, of course, be used if different types of connections were made. As shown in Fig. 1, each of the video pipe segments is interconnected, an SSA interconnection being chosen for the implementation shown in Fig. 1.

One good specification for the ATM connection is SONET level OC-3. OC-3 can handle 150 megabits per second. Each movie stream requires about 4 megabits per second. Adding needed overhead, OC-3 can therefore support about 25 movie data streams per ATM connection. To satisfy 75,000 users at 25 streams per ATM connection, therefore, 3,000 video pipe segments are needed. For 3,000 video pipe segments to store 30 gigabytes of movie stream data, in turn, each memory 62 would need to store 10 megabytes. Thus, 10 megabyte DRAMs (dynamic random access memory) are used in the embodiment shown in Fig. 1. Obviously, a different number of segments and/or a different size or type of memory could also advantageously be used.

Each video pipe segment used in the video pipe 14 should have the capability of transferring the data stored in its memory to its neighboring video pipe segment. Although transfers of data from one video pipe segment to either (or even both) of its neighbors are considered to be within the scope of the present invention, the embodiment shown in Fig. 1 only allows transfers of data from one video pipe segment to its right neighboring video pipe segment.

As should be obvious from the discussion above, the SSA switch 18 facilitates routing of data from the mass storage system 12 to the video pipe 14 or to the ATM-SSA adaptor 20. Similarly, the ATM-SSA adaptor 20 facilitates routing of data between the ATM network 30, the SSA switch 18 and the control computer 16.

It should now be obvious to a person of ordinary skill in the art that these configurations effectively multiply the bandwidth delivery capabilities of the mass storage system 12, thereby simultaneously servicing more users than the mass storage system 12 could otherwise independently service. As should also now be apparent to a person of ordinary skill in the art, a broad variety of data routing algorithms can be applied to facilitate this bandwidth multiplication, all of which are within the scope of the subject invention. What will now be discussed are but a few examples.

One approach is to load the ten top movies in the video pipe 14 before any request for movies are received. Initial requests for movies may then advantageously be serviced directly from the mass storage system 12 by having the requested movie streams delivered through the SSA switch 18 to the ATM-SSA adaptor 20 and out onto the ATM network 30.

When the number of requests for a particular movie reach a threshold level, the video pipe 14 would be used to provide the various time-shifted streams for that movie. Up to 25 simultaneous viewers of that movie who are viewing the portion of the movie stored in a particular video pipe segment would be assigned to receive their movie stream from that video pipe segment through the ATM connection to that segment. As additional users subsequently request that movie stream, they would be assigned to receive that movie stream from successive video pipe segments. The data in the previous video pipe segment would be shifted to the successive video pipe segments for viewing by the new group of viewers, while the previous video pipe segment would receive the next segment of the video movie stream from its predecessor video pipe segment. In this manner, a single movie stream originating from the mass storage system 12 can be viewed by numerous viewers at different points in time, without having to again access the entire stream from the mass storage system 12. This effectively multiplies the data delivery bandwidth of the mass storage system 12.

Using this configuration, it should be realized that numerous conditions can occur which would require a change in the delivery approach. For example, the number of viewers wishing to simultaneously view the movie segment stored within a particular video pipe segment may exceed the 25 stream bandwidth of that video segment. If this occurs, several alternatives may be implemented. One alternative is to make the new viewer wait until the beginning of the movie appears in a video pipe segment which is not being used to capacity and to then assign that new viewer to that video pipe segment. Another alternative is to load an additional copy of the movie stream from the mass storage system 12 into the video pipe 14, starting with a video pipe segment which has already emptied its movie stream data. Using the SSA connection technology described above, it is possible to accomplish this by having the movie stream data segment that is delivered to the first video pipe segment 50 of the video pipe 14 passed through each video pipe segment until it reaches the desired new video pipe segment. This pass through can occur without the data stream being stored in the intervening video pipe segments and without altering the data which is stored in the intervening video pipe segments.

Another routing option is to circulate shifted movie stream segments from the last video pipe segment which holds a particular movie stream into the first video pipe segment which held that movie stream, rather than having earlier video pipe segments become empty after the last portion of the movie stream passes through them. This approach would be advantageous in systems where the video pipe is essentially dedicated to storing just the top ten movie streams. With this configuration, it is not necessary to re-access the mass storage system 12 for replacement movie streams for the pipe 14.

The system may also be initialized with no movie streams being stored in the video pipe 14. In this case, when the requests for a particular movie become numerous enough, the SSA switch 18 would route the next stream of that movie data to the video pipe 14, rather than directly to the ATM network 30 through the ATM-SSA adaptor 20. Subsequent viewers of that movie would then be assigned to the appropriate video pipe segment to receive their stream of that movie.

The point at which the video server 10 causes the supply of popular movie streams to switch from the mass storage system 12 to the pipe 14 typically depends upon the bandwidth capacity of the mass storage system. The switch over might be set to occur when the mass storage system 12 reaches a significant percentage of its data stream delivery limit.

During streaming of a particular movie's data into the video pipe 14 from the mass storage system 12, of course, a second and different movie may begin to be requested at a high rate. At such time, the next stream of the second movie could similarly be channeled by the SSA switch 18 into the video pipe 14 for viewing by subsequent users. But in this case, the video segment which actually stores the first segment of this second movie stream might not be the first video pipe segment 50, as the video pipe segment 50 might still be busy handling the first movie stream. Instead, the first segment of the second movie stream might be stored in the first video pipe segment of the video pipe 14 which is empty and not needed for storage of the first movie. As noted above, the SSA connections used in the video pipe 14 can advantageously pass data presented to the first video pipe segment 50 to a subsequent video pipe segment, without significant delay and without requiring that data to first be stored in the intervening video pipe segments.

The distribution sequences thus-far described result in each video pipe segment being dedicated to the storage of a particular movie stream. However, this is not an intrinsic limitation of the invention. Theoretically, portions of streams from different movies may be stored in and distributed by each video pipe segment. Such an alternate approach, however, would probably require a much higher degree of control and associated overhead.

As should also now be obvious to those skilled in the art, the system includes apparatus to implement the stream distribution algorithms which ultimately are selected. This includes controls which read movie stream data from the mass storage system 12, controls which route video data using the SSA switch 18 and the ATM-SSA adaptor 20, and controls which signal when and where data is to be shifted from one video pipe segment to another. Such controls also associate each user with the correct ATM connection(s) so that he can receive the uninterrupted movie stream which he has requested.

To those skilled in this art, it should be obvious that a vast array of known techniques can advantageously be employed to implement these controls. The implementation may use hardware, software or a combination of both.

In Fig. 1, control computer 16 is a master controller, and preferably a personal computer ("PC"). Whether the control is actually given to this device and the exact nature and degree of the responsibilities of this device, in large part, depend upon the specific design of the system, both in terms of hardware, software, and the data distribution algorithms which are to be followed. In one embodiment, for example, the control computer 16 maintains awareness of each current user, the movie stream he has requested, the ATM connection(s) which has (have) been assigned to deliver that movie stream, and the status of that delivery. Based on this information, as well as a knowledge of the algorithms to be implemented, the control computer 16 controls the ATM-SSA adaptor 20, the SSA switch 18, the mass storage system 12, and the video pipe 14. Although direct connections between the control computer 16 and the mass storage system 12 and video pipe 14 are not shown in Fig. 1, it should be understood that the SSA connection technology being utilized nevertheless facilitates transfer of control information from the control computer 16 to these other devices. The net result is that each user receives a steady stream of digital data representative of the movie he has asked to view.

To reduce the amount of traffic caused by control signals emanating from the control computer 16, it is advantageous to distribute all or portions of some control functions to other devices in the system. For example, each video pipe segment in the video pipe 14 may advantageously include its own control system, shown as a control 70 in the video pipe segment shown in Fig. 2. Such an internal control, for example, might itself determine when data in the memory 62 of the video pipe segment should be shifted to a successive video pipe segment.

Although certain embodiments have now been discussed, it should be understood that the present invention is applicable to a far broader array of embodiments, using different structures and still different data distribution and control techniques.

For example, it is by no means required that the pipe 14 contain a quantity of memory sufficient to store the data streams of several entire films or, for that matter, even the data stream of a single entire film. A smaller number of video pipe segments and/or a smaller size of DRAM memory could also advantageously be used. As the size of the video pipe decreases, however, it is expected that the number of users who can simultaneously be serviced by the pipe would also decrease.

It is also by no means necessary for the system to include connections that would allow less frequently used movies to be supplied directly by the mass storage system 12 to the ATM network 30. All movie streams could be required to be channeled into the pipe 14 and all users could be required to be assigned to one of the video pipe segments. Such a configuration might be advantageous, for example, in situations where only a small number of movies are to be stored in the mass storage system 12 and where all of these stored movies are expected to be quite popular.

Although the set top boxes, such as Set Top Box 34, have been described as servicing but a single TV, such as TV 32, it is also contemplated that the video server 10 of the present invention could be used in a system in which a single decoder, comparable to the Set Top Box 34, services several TVs at once. The non-server portion of this embodiment is illustrated in Fig. 3. Although only three decoders are illustrated, it should of course be understood that several more may be attached to the network. Similarly, although only three TVs are illustrated as being connected to each decoder, it should of course be understood that several more might be connected to each decoder.

Although the present invention has thus-far been described as useful in the storage and simultaneous delivery of digital data representative of movies, the present invention is by no means limited to this application. The present invention is equally useful in connection with the storage and simultaneous delivery of digitized voices or music, as well as any type of lenthy digital data stream which is frequently accessed in the same order by a number of users at different times. Films and videos other than motion pictures, of course, could also advantageously be distributed by the present invention.

In short, the present invention is of far broader scope than what has thus-far been described and is limited only by the following claims.

CLAIMS

1. A video server for delivering a plurality of streams of video data on request, each stream representative of a movie, comprising:

A. A mass storage system for storing and delivering one or more streams of digital data, each stream representative of a movie;

B. A video pipe connected to said mass storage system for receiving one or more streams of digital data from said mass storage system and for storing the streams, said video pipe including a plurality of video pipe segments, each segment including a memory device for storing a portion of a movie stream, said segments being interconnected so that each segment may pass the stored portion to a neighboring video pipe segment for storage in said neighboring pipe segment;

C. A connection to each of said video pipe segments, each connection for routing the data stream segment stored in said video pipe segment to at least one viewer; and

D. A control for controlling said mass storage system and said video pipe and for causing a series of stored segments to be delivered from a segment of said video pipe to a viewer, said series of stored segments being representative of a movie.

2. The video server of claim 1 wherein the combined size of the memories in said video pipe is large enough to hold digital data representative of a plurality of entire movies.

3. The video server of claim 1 wherein said control causes a plurality of streams of digital data, each representative of a movie, to be loaded in said video pipe upon initialization of the system.

4. The video server of claim 1 wherein said control causes the source of stored segments which a particular viewer receives to all originate from a single video pipe segment.

5. The video server of claim 1 wherein the connection between each video pipe segment permits digital data coming from said mass storage device to be initially loaded in any one of said video pipe segments.

6. The video server of claim 5 wherein said connection is an SSA connections.

7. The video server of claim 1 wherein said control is in part included within each of said video pipe segments and wherein said included control part determines if and when each video pipe segment passes the digital data stored therein to a neighboring video pipe segment for storage in said neighboring video pipe segment.

8. The video server of claim 1 wherein said control includes a computer.

9. The video server of claim 1 further including additional connections which permit one or more streams of digital data, each stream representative of a movie, to be delivered directly from said mass storage system to viewers of those streams.

10. The video server of claim 9 wherein said additional connections include an SSA switch connected to said mass storage system.

11. The video server of claim 10 wherein said additional connections further include an ATM-SSA adaptor connected to said SSA switch.

12. The video server of claim 1 wherein each of said connections includes an interface for routing the stored segments into an ATM network.

13. The video server of claim 1 wherein said mass storage system includes one or more RAIDs controlled by a fault tolerant array controller.

14. A pipe for connecting to and multiplying the effective bandwidth of a mass storage system comprising:

A. A plurality of video pipe segments, each segment including a memory device for storing a portion of a digital data stream coming from a mass storage system, said video pipe segments being interconnected so that each segment may pass the stored portion to a neighboring video pipe segment for storage in said neighboring video pipe segment; and

B. A connection to each of said video pipe segments, each connection for routing the data stream segment stored in said video pipe segment to at least one user of that data stream.

15. The pipe of claim 14 wherein the combined size of the memories in said video pipe is large enough to hold digital data representative of a plurality of entire movies.

16. The pipe of claim 14 wherein the connection between each video pipe segment permits digital data coming from a mass storage system to be initially loaded in any one of said video pipe segments.

17. The pipe of claim 14 wherein each of said connections includes an interface for routing the stored stream segments into an ATM network.

18. A video server for delivering a plurality of streams of video data on request, each stream representative of a movie, comprising:

A. A mass storage system for storing and delivering one or more streams of digital data, each stream representative of a movie;

B. A video pipe connected to said mass storage device for receiving one or more streams of digital data from said mass storage device and for storing the streams; and

C. A switch connected to said mass storage device and to said video pipe for routing streams of data originating from said mass storage device to either the video pipe or directly to a data communication network.

19. The video server of claim 18 wherein said switch is an SSA switch.

20. The video server of claim 19 further including an ATM-SSA adaptor connected to said SSA switch for routing digital data streams directly from said mass storage system into an ATM network.

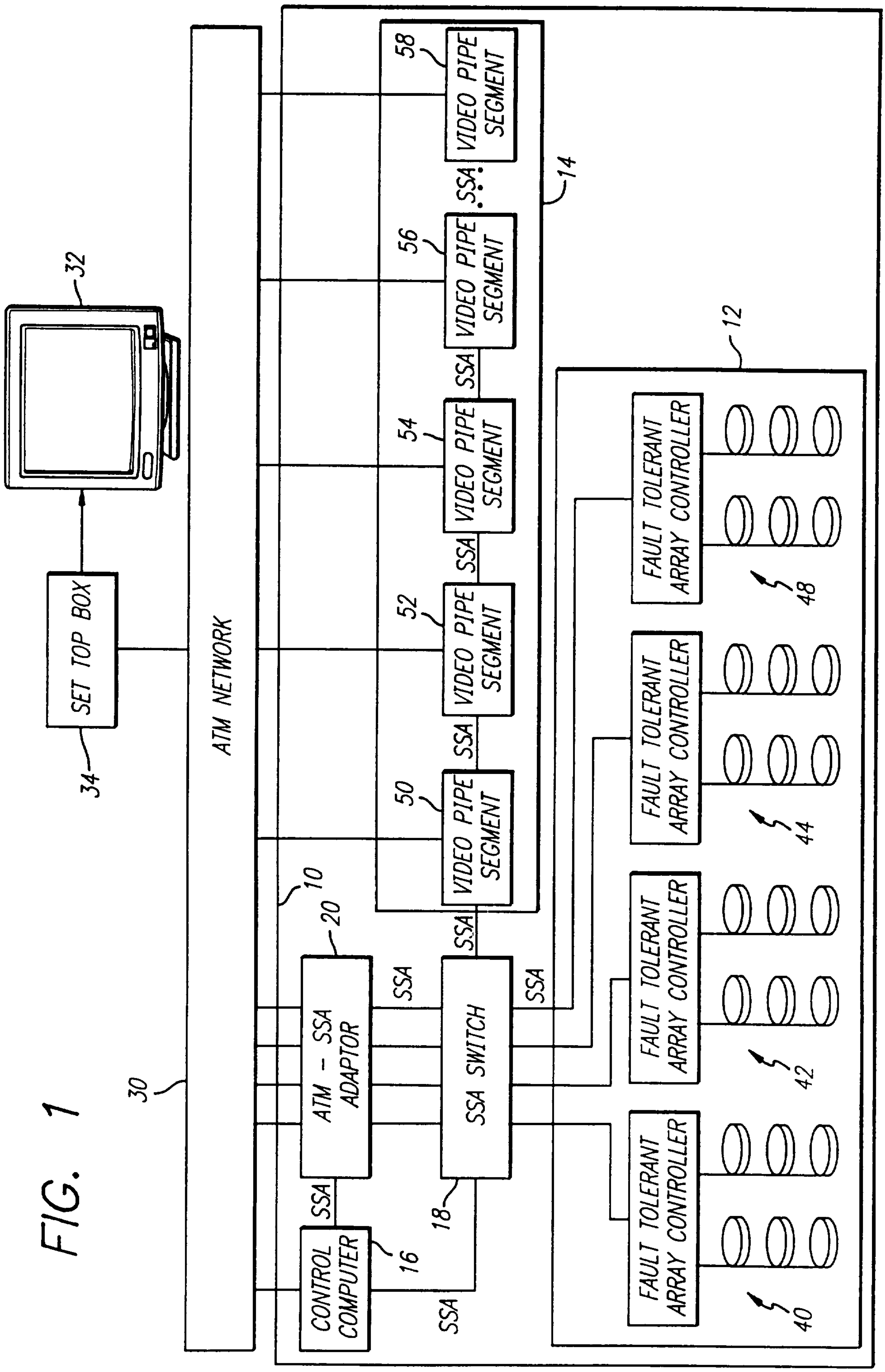
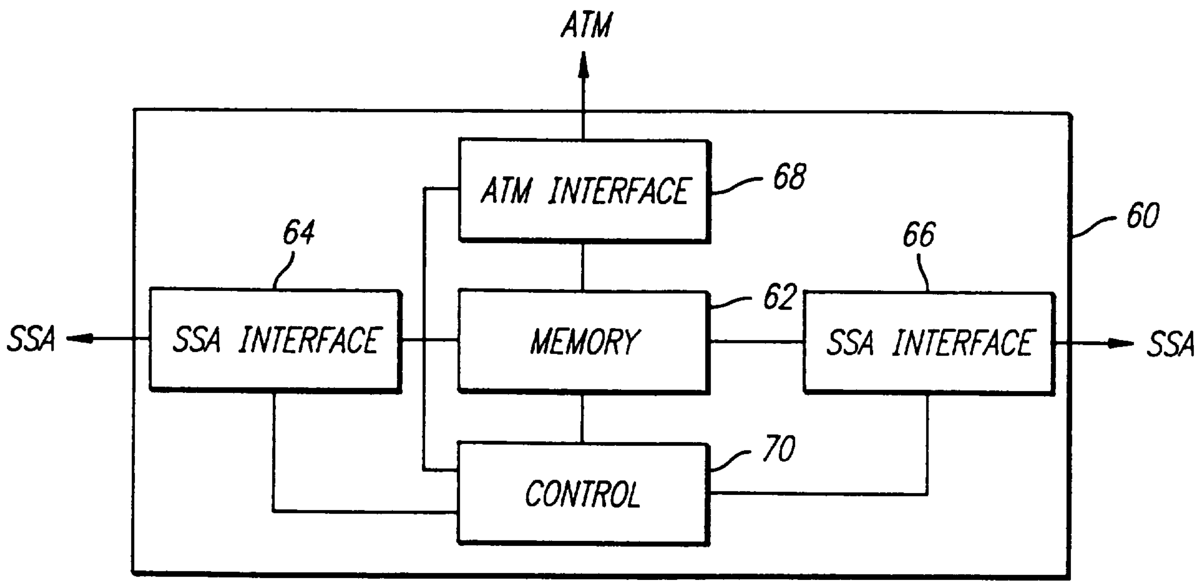

SET TOP BOX
34
32
ATM NETWORK
30
10
CONTROL COMPUTER
16
SSA
ATM - SSA ADAPTOR
20
SSA SWITCH
18
SSA
VIDEO PIPE SEGMENT
50
52
54
56
58
14
FAULT TOLERANT ARRAY CONTROLLER
40
42
44
48
12

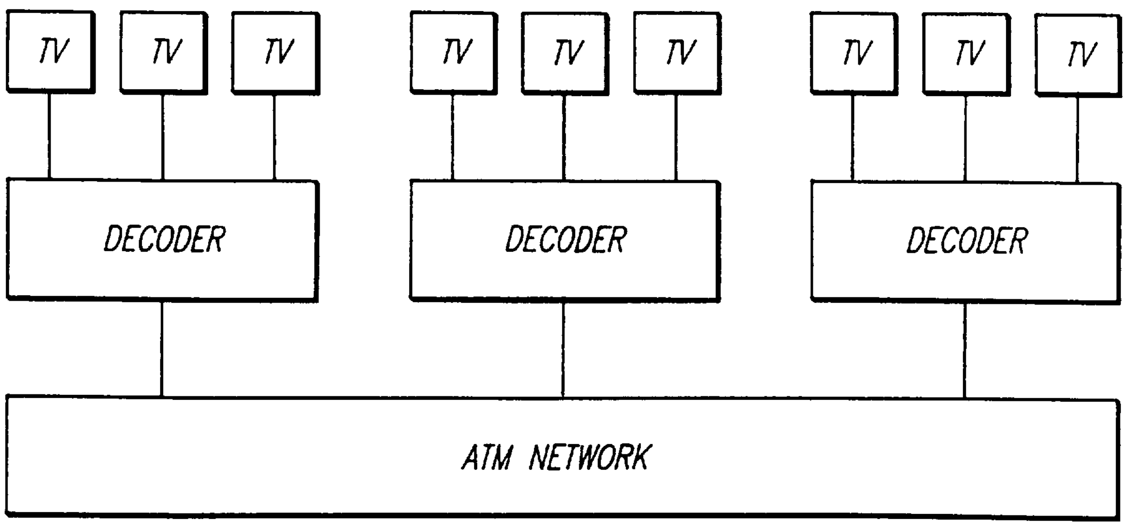
FIG. 1

FIG. 2



VIDEO PIPE SEGMENT

FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/10303

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04N 7/173
US CL : 348/7
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/7, 6, 8, 12, 13, 715; 455/3.1, 3.2, 4.1, 4.2, 5.1; 358/86, 335; 370/42, 60, 60.1, 73; H04N 5/907, 7/14, 7/173

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	W.D. Sincoskie, "System architecture for a large scale video on demand service", Computer Networks and ISDN Systems, No. 22, published in 1991 by North-Holland, see pages 155-162.	1-20
Y	JP, A, 59-122192 (MATSUSHITA DENKI SANGYO K.K.) 14 July 1984, see entire document.	1-20
Y	JP, A, 1-205691 (FUJITSU LTD) 18 August 1989, see entire document.	1-20
Y, E	US, A, 5,442,390 (HOOPER ET AL.) 15 August 1995, see entire document.	1-20
A, P	EP, A, 0,637,890 (TRW INC.) 08 February 1995, see entire document.	1-20

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 SEPTEMBER 1995	27 NOV 1995

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/10303

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, A, 63-151240 (FUJITSU LTD) 23 June 1988, see entire document.	1-20