US 20080222301A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2008/0222301 A1

(43) Pub. Date: Sep. 11, 2008

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(54) METHOD FOR DATA DISTRIBUTION

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(21) Appl. No.: **12/068,389**

(22) Filed: **Feb. 6, 2008**

Related U.S. Application Data

(63) Continuation of application No. 11/645,069, filed on Dec. 26, 2006, now Pat. No. 7,349,986, which is a continuation of application No. 10/122,412, filed on Apr. 16, 2002, now Pat. No. 7,269,662.

(30) **Foreign Application Priority Data**

Apr. 16, 2001 (JP) 2001-116287

Publication Classification

(51) **Int. Cl.**
G06F 15/16 (2006.01)

(52) **U.S. Cl.** **709/231**

(57) **ABSTRACT**

Stream data is transmitted from a distribution server to a client without any loss of data. The capacity of a reception buffer to be prepared at the client can be made small and the network bandwidth necessary for data redistribution can be narrowed. A relay server interposed between the distribution server and client buffers stream data in an auxiliary storage device. When the relay server or client detects a loss of stream data, a redistribution request is transmitted to the distribution server or another relay server at the preceding stage.

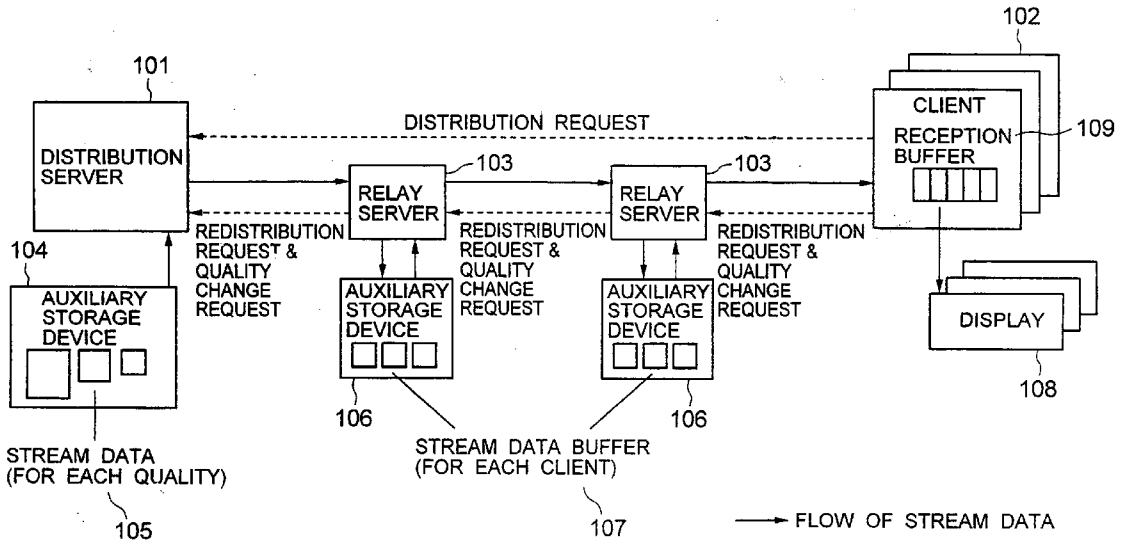


FIG. 1

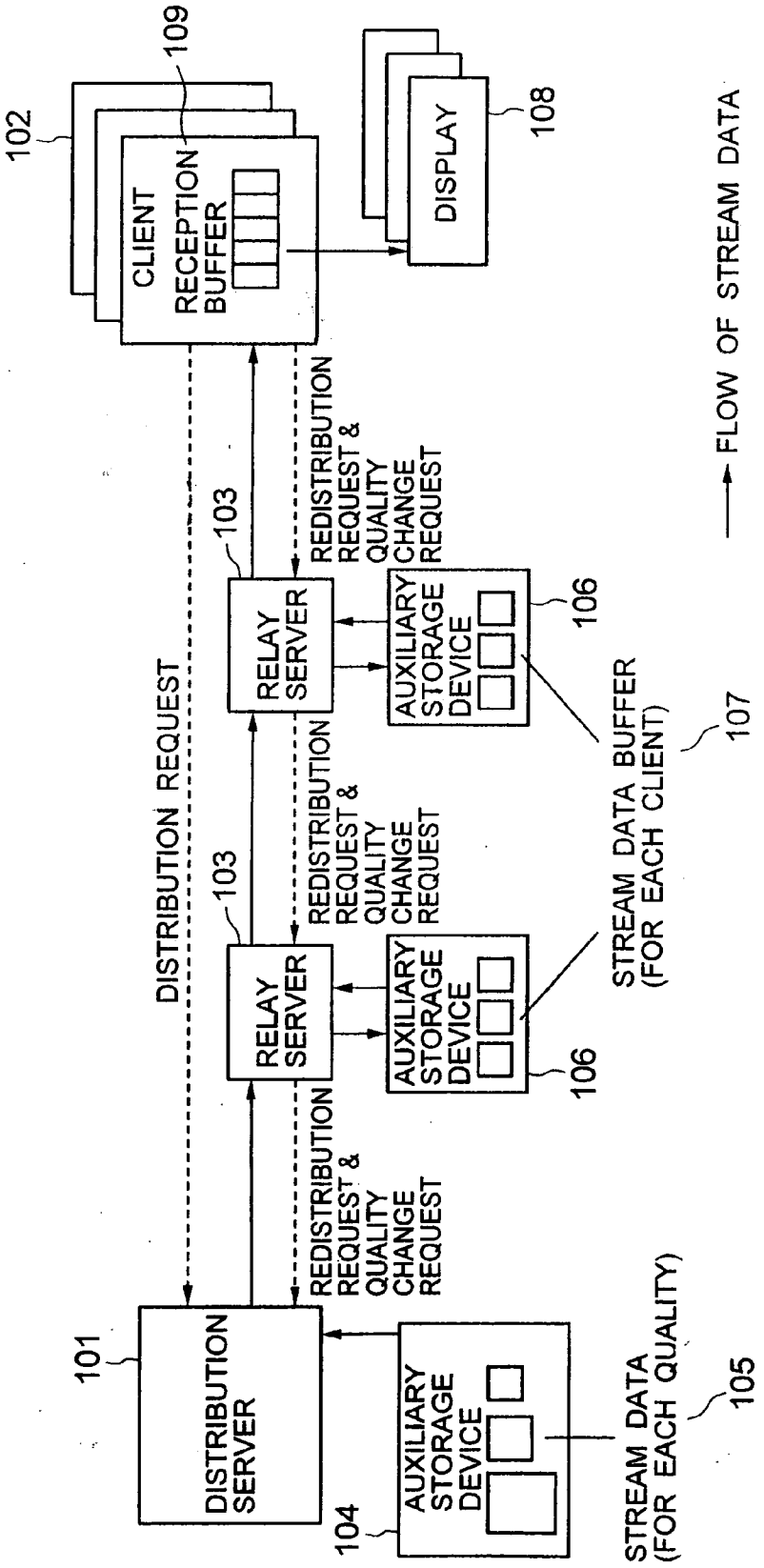

DISTRIBUTION SERVER
101
AUXILIARY STORAGE DEVICE
104
STREAM DATA (FOR EACH QUALITY)
105
RELAY SERVER
103
AUXILIARY STORAGE DEVICE
106
STREAM DATA BUFFER (FOR EACH CLIENT)
107
CLIENT RECEPTION BUFFER
109
102
DISPLAY
108
DISTRIBUTION REQUEST
REDISTRIBUTION REQUEST & QUALITY CHANGE REQUEST
FLOW OF STREAM DATA

FIG. 2 A

201

DISTRIBUTION REQUEST PACKET

COMMAND (DISTRIBUTION REQUEST)
DISTRIBUTION SERVER IP ADDRESS
CLIENT IP ADDRESS
QUALITY LEVEL

FIG. 2 B

202

STREAM DATA PACKET

COMMAND (STEAM DATA)
DISTRIBUTION SERVER IP ADDRESS
CLIENT IP ADDRESS
QUALITY LEVEL
TIME INDEX
PRECEDING STATE SERVER IP ADDRESS
DATA SIZE
DATA FIELD

FIG. 2 C

203

QUALITY CHANGE REQUEST PACKET

COMMAND (QUALITY CHANGE REQUEST)
DISTRIBUTION SERVER IP ADDRESS
CLIENT IP ADDRESS
QUALITY LEVEL

FIG. 2 D

204

COMMAND (REDISTRIBUTION REQUEST)

COMMAND (REDISTRIBUTION REQUEST)
DISTRIBUTION SERVER IP ADDRESS
CLIENT IP ADDRESS
TIME INDEX

FIG. 3

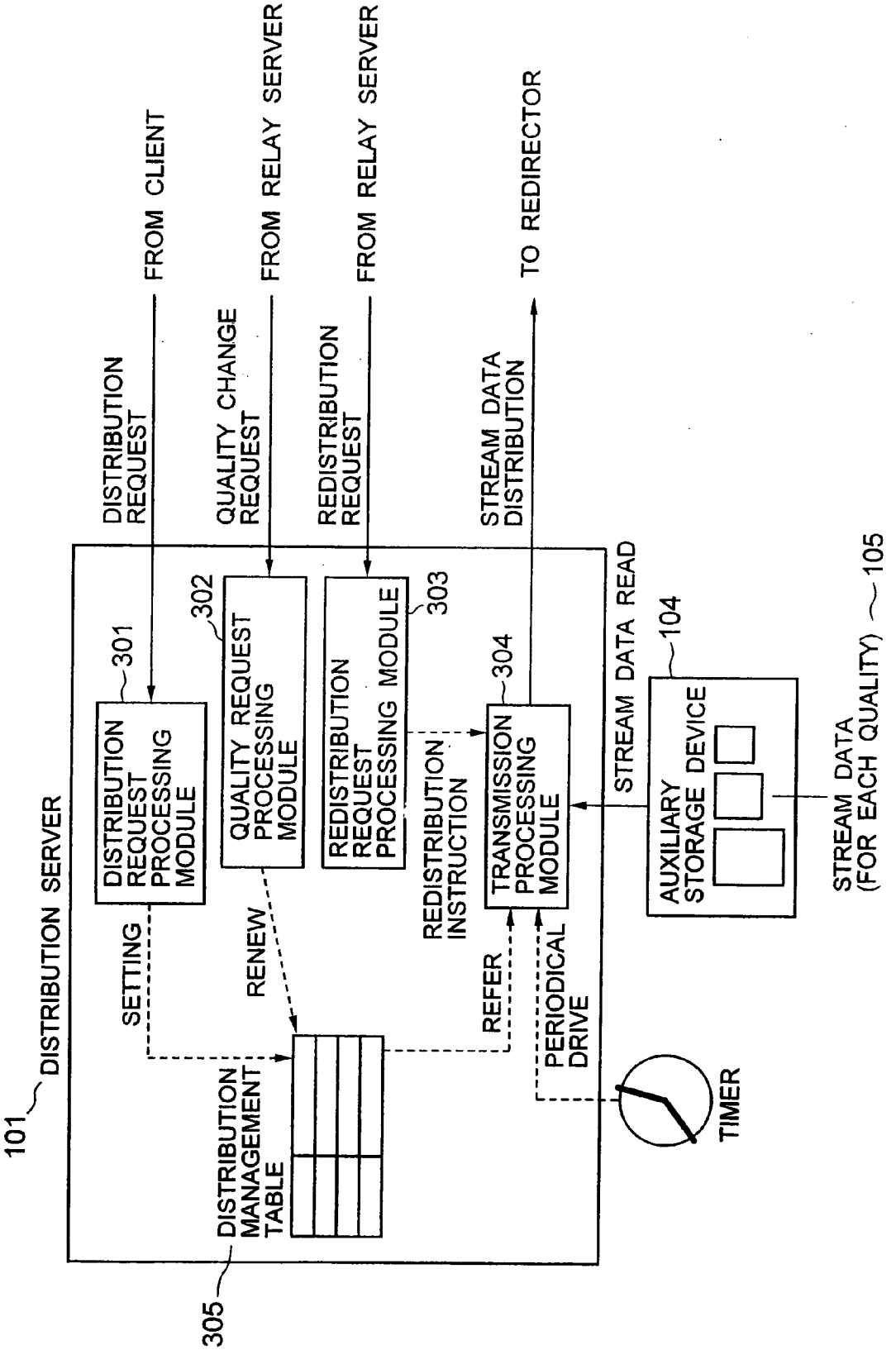

DISTRIBUTION SERVER
101
DISTRIBUTION REQUEST PROCESSING MODULE
301
QUALITY REQUEST PROCESSING MODULE
302
REDISTRIBUTION REQUEST PROCESSING MODULE
303
TRANSMISSION PROCESSING MODULE
304
DISTRIBUTION MANAGEMENT TABLE
305
AUXILIARY STORAGE DEVICE
104
STREAM DATA (FOR EACH QUALITY)
105
TIMER
FROM CLIENT
DISTRIBUTION REQUEST
FROM RELAY SERVER
QUALITY CHANGE REQUEST
FROM RELAY SERVER
REDISTRIBUTION REQUEST
TO REDIRECTOR
STREAM DATA DISTRIBUTION
STREAM DATA READ
SETTING
RENEW
REDISTRIBUTION INSTRUCTION
REFER
PERIODICAL DRIVE

FIG. 4

305

401 CLIENT IP ADDRESS	402 CURRENT QUALITY LEVEL	403 TRANSMITTED DATA TIME INDEX

FIG. 5

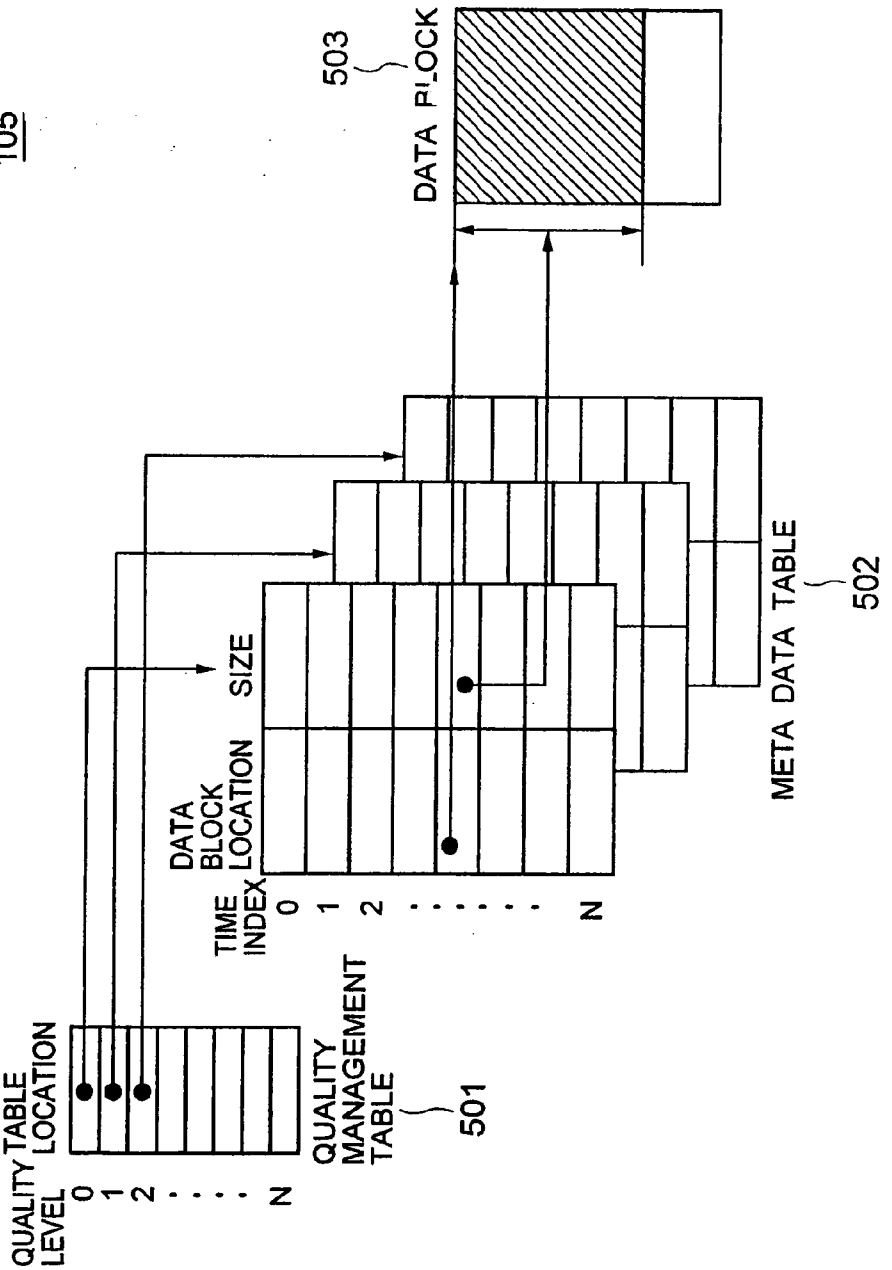

105
503
DATA BLOCK
META DATA TABLE
502
SIZE
DATA BLOCK LOCATION
TIME INDEX
0
1
2
N
META DATA TABLE LOCATION
QUALITY LEVEL
QUALITY MANAGEMENT TABLE
501

FIG. 6

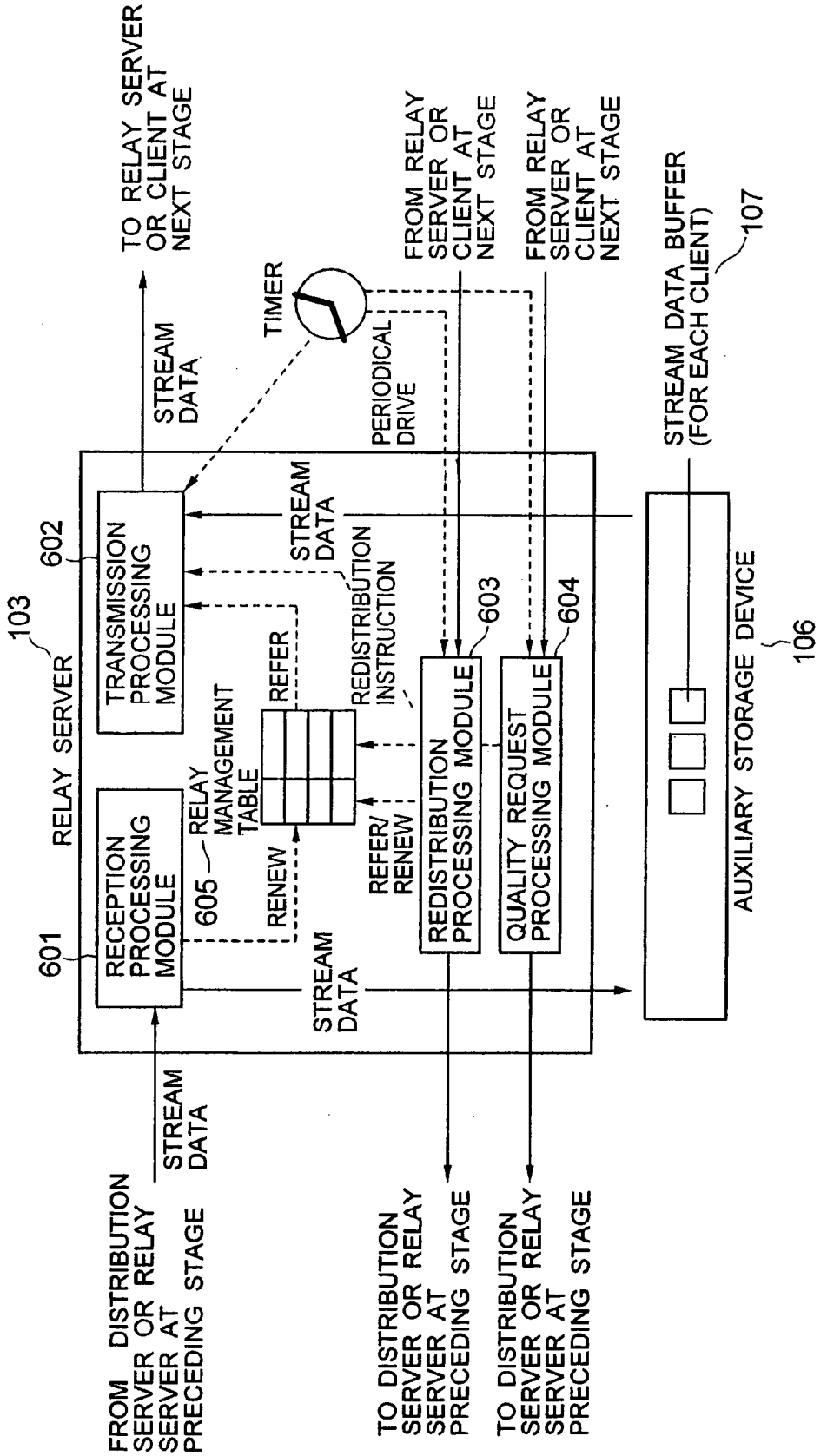

RELAY SERVER
103
601
RECEPTION PROCESSING MODULE
602
TRANSMISSION PROCESSING MODULE
603
REDISTRIBUTION PROCESSING MODULE
604
QUALITY REQUEST PROCESSING MODULE
605
RELAY MANAGEMENT TABLE
REFER
RENEW
REFER/ RENEW
REDISTRIBUTION INSTRUCTION
STREAM DATA
STREAM DATA
STREAM DATA
STREAM DATA
PERIODICAL DRIVE
TIMER
FROM DISTRIBUTION SERVER OR RELAY SERVER AT PRECEDING STAGE
TO DISTRIBUTION SERVER OR RELAY SERVER AT PRECEDING STAGE
TO DISTRIBUTION SERVER OR RELAY SERVER AT PRECEDING STAGE
TO RELAY SERVER OR CLIENT AT NEXT STAGE
FROM RELAY SERVER OR CLIENT AT NEXT STAGE
FROM RELAY SERVER OR CLIENT AT NEXT STAGE
STREAM DATA BUFFER (FOR EACH CLIENT)
107
AUXILIARY STORAGE DEVICE
106

FIG. 7

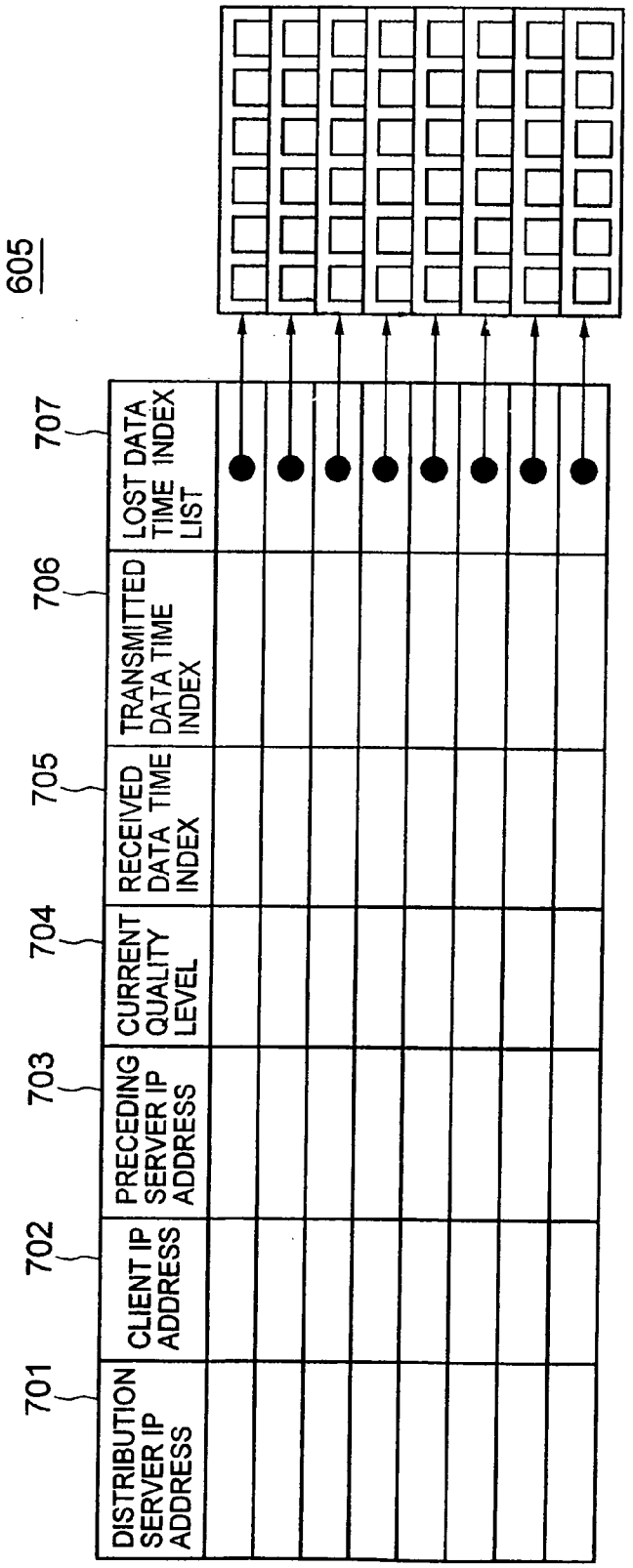

605
701
DISTRIBUTION SERVER IP ADDRESS
702
CLIENT IP ADDRESS
703
PRECEDING SERVER IP ADDRESS
704
CURRENT QUALITY LEVEL
705
RECEIVED DATA TIME INDEX
706
TRANSMITTED DATA TIME INDEX
707
LOST DATA TIME INDEX LIST

FIG. 8

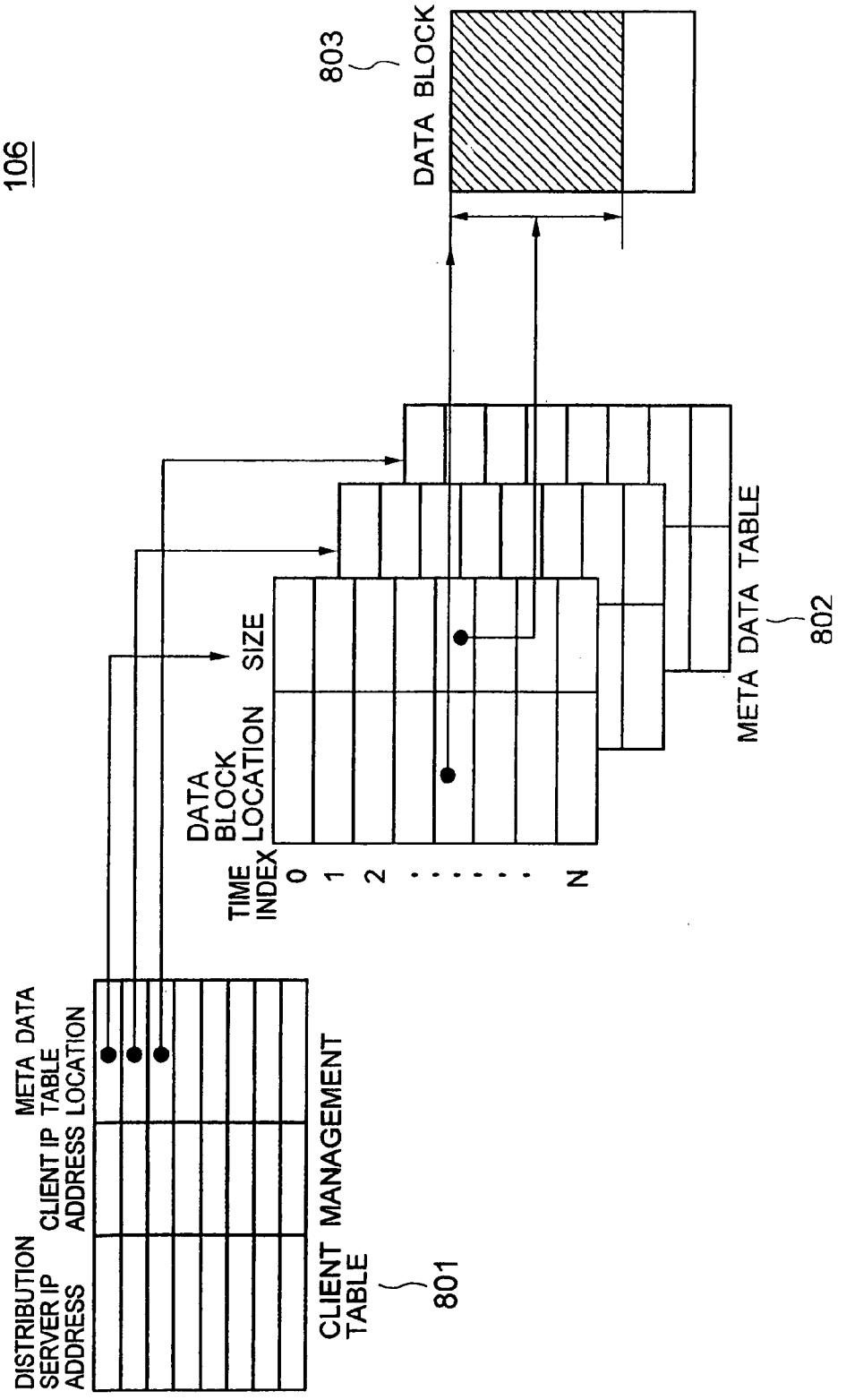

106
803
DATA BLOCK
META DATA TABLE
802
TIME INDEX
DATA BLOCK LOCATION
SIZE
0
1
2
N
DISTRIBUTION SERVER IP ADDRESS
CLIENT IP ADDRESS
META DATA TABLE LOCATION
CLIENT MANAGEMENT TABLE
801

FIG. 9

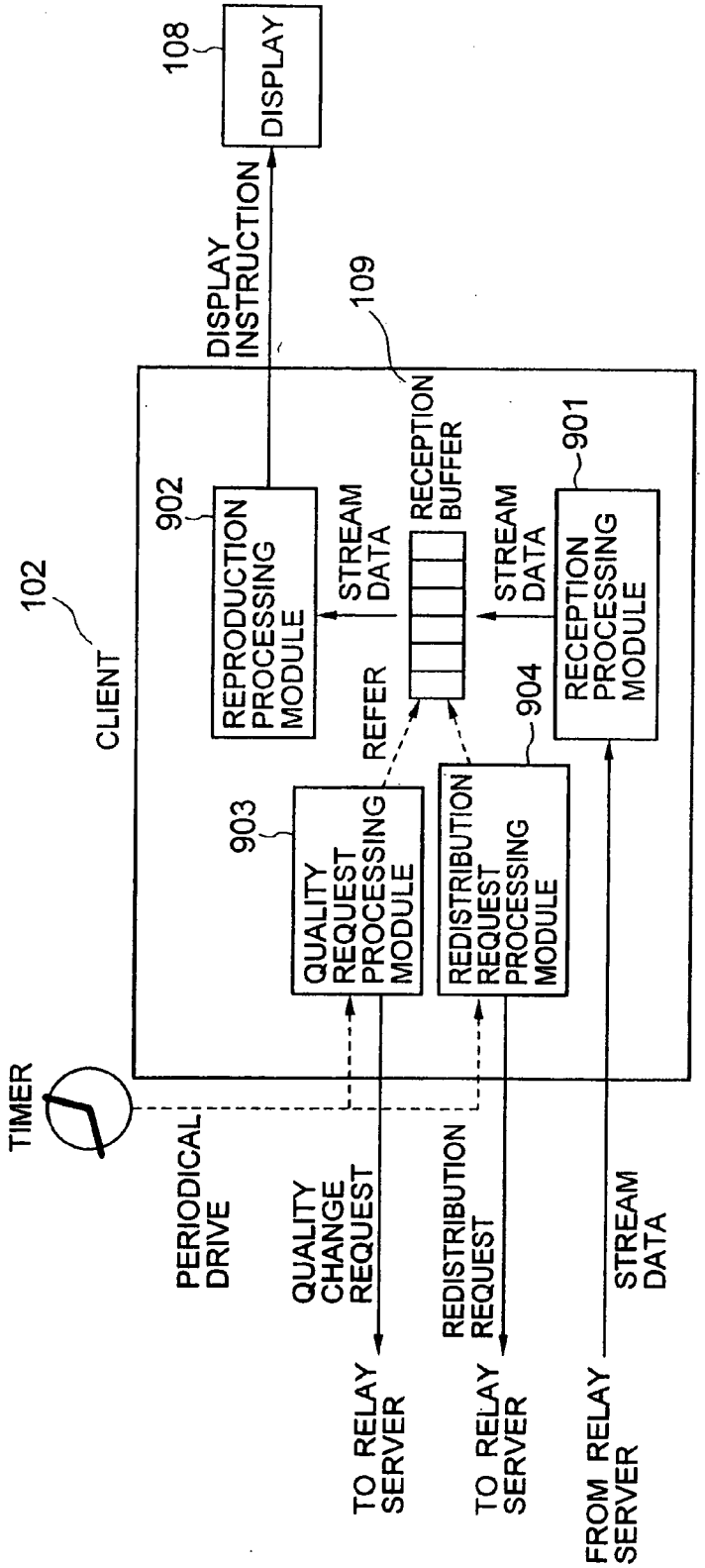

108
DISPLAY
DISPLAY INSTRUCTION
109
RECEPTION BUFFER
102
CLIENT
902
REPRODUCTION PROCESSING MODULE
STREAM DATA
STREAM DATA
901
RECEPTION PROCESSING MODULE
REFER
904
903
QUALITY REQUEST PROCESSING MODULE
REDISTRIBUTION REQUEST PROCESSING MODULE
TIMER
PERIODICAL DRIVE
QUALITY CHANGE REQUEST
REDISTRIBUTION REQUEST
STREAM DATA
TO RELAY SERVER
TO RELAY SERVER
FROM RELAY SERVER

FIG. 10

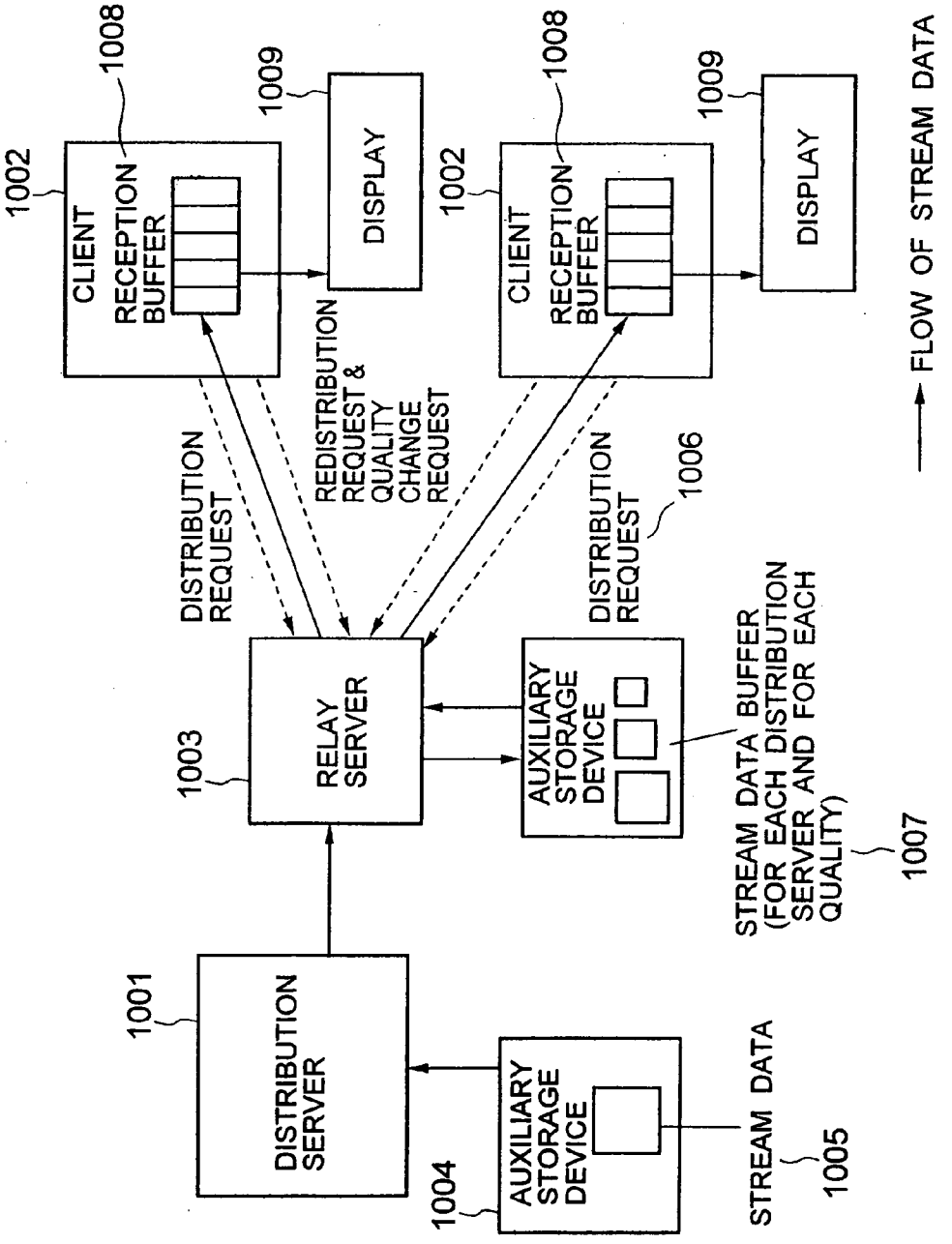

1002
1008
CLIENT
RECEPTION BUFFER
1009
DISPLAY
1002
1008
CLIENT
RECEPTION BUFFER
1009
DISPLAY
FLOW OF STREAM DATA
DISTRIBUTION REQUEST
REDISTRIBUTION REQUEST & QUALITY CHANGE REQUEST
DISTRIBUTION REQUEST
1006
1003
RELAY SERVER
AUXILIARY STORAGE DEVICE
STREAM DATA BUFFER (FOR EACH DISTRIBUTION SERVER AND FOR EACH QUALITY)
1007
1001
DISTRIBUTION SERVER
1004
AUXILIARY STORAGE DEVICE
STREAM DATA
1005

FIG. 11A

1101

DISTRIBUTION REQUEST PACKET

COMMAND (DISTRIBUTION REQUEST)
DISTRIBUTION SERVER IP ADDRESS
RELAY SERVER IP ADDRESS
CLIENT IP ADDRESS
QUALITY LEVEL

FIG. 11B

1102

STREAM DATA PACKET

COMMAND (STEAM DATA)
DISTRIBUTION SERVER IP ADDRESS
RELAY SERVER IP ADDRESS
CLIENT IP ADDRESS
QUALITY LEVEL
TIME INDEX
DATA SIZE
DATA FIELD

FIG. 11C

1103

QUALITY CHANGE REQUEST PACKET

COMMAND (QUALITY CHANGE REQUEST)
DISTRIBUTION SERVER IP ADDRESS
RELAY SERVER IP ADDRESS
CLIENT IP ADDRESS
QUALITY LEVEL

FIG. 11D

1104

COMMAND (REDISTRIBUTION REQUEST)

COMMAND (REDISTRIBUTION REQUEST)
DISTRIBUTION SERVER IP ADDRESS
RELAY SERVER IP ADDRESS
CLIENT IP ADDRESS
TIME INDEX

FIG. 12

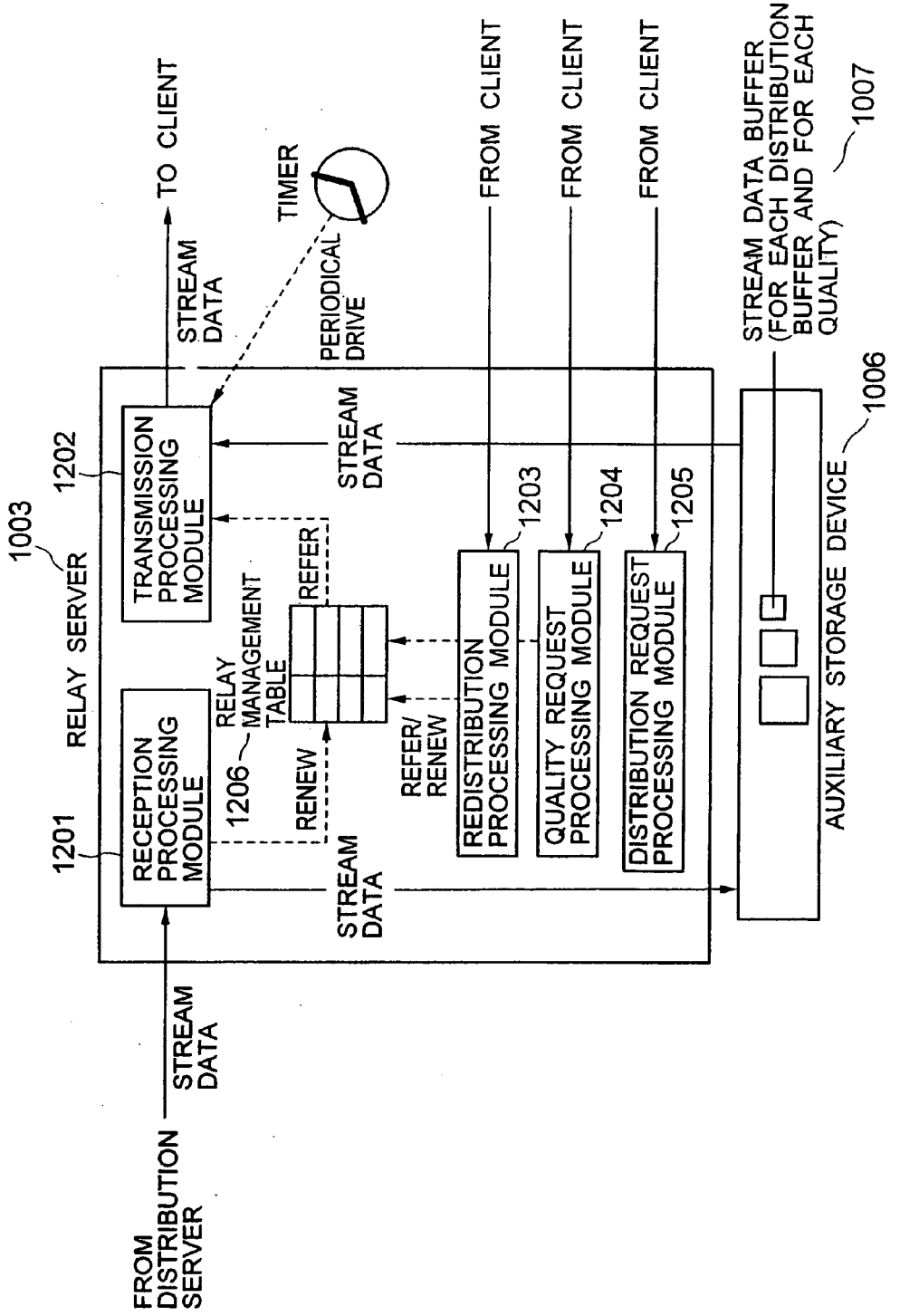

FROM DISTRIBUTION SERVER
STREAM DATA
1003
RELAY SERVER
1201
RECEPTION PROCESSING MODULE
1206
RELAY MANAGEMENT TABLE
REFER
RENEW
1202
TRANSMISSION PROCESSING MODULE
STREAM DATA
TO CLIENT
STREAM DATA
TIMER
PERIODICAL DRIVE
REFER/ RENEW
1203
REDISTRIBUTION PROCESSING MODULE
1204
QUALITY REQUEST PROCESSING MODULE
1205
DISTRIBUTION REQUEST PROCESSING MODULE
FROM CLIENT
FROM CLIENT
FROM CLIENT
STREAM DATA BUFFER (FOR EACH DISTRIBUTION BUFFER AND FOR EACH QUALITY)
1007
1006
AUXILIARY STORAGE DEVICE

FIG. 13B

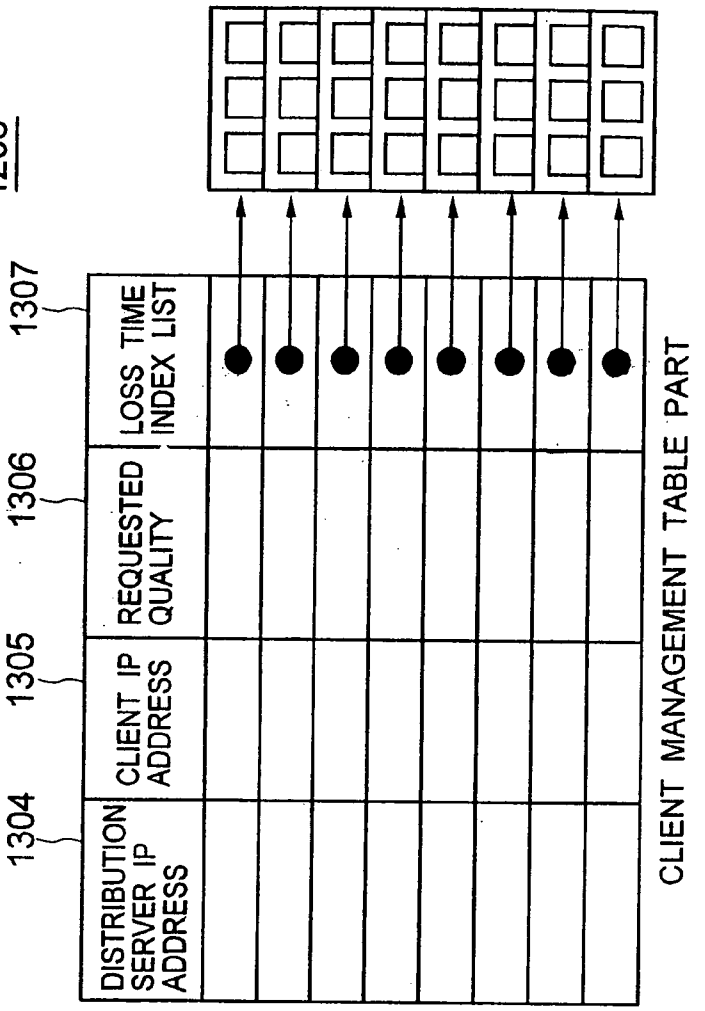
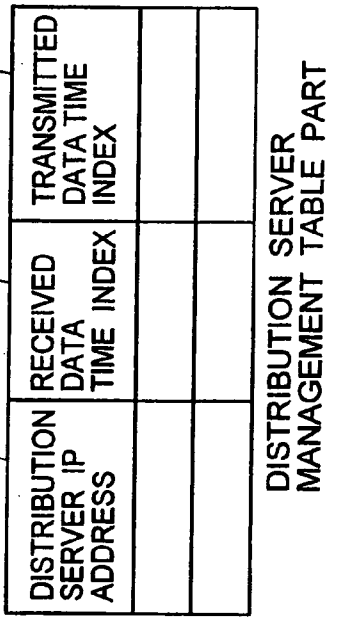


FIG. 13A



METHOD FOR DATA DISTRIBUTION

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application relates to a U.S. patent application Serial No. entitled DATA RELAY METHOD-filed by T. Takeuchi et al. on.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a data distribution method, and more particularly to a stream data distribution method of redistributing data to compensate for lost stream data and changing the quality of stream data in accordance with a network load.

[0003] A stream data distribution method of compensating for lost stream data and changing the quality of stream data is known as disclosed in JP-A-11-184780. This stream data distribution method disclosed in JP-A-11-184780 is used in a system having a distribution server and clients interconnected by a network.

[0004] The distribution server distributes stream data to a client over the network. The client loads a received stream data in a reception buffer. Stream data in the reception buffer is periodically read and displayed on a display.

[0005] The client refers to the state of the reception buffer in order to inspect whether there is stream data lost during network transfer. If there is a loss of stream data, the client transmits a redistribution request for lost stream data to the distribution server. Upon reception of the request, the distribution server executes a redistribution process for the requested stream data.

[0006] When the client refers to the state of the reception buffer, the client inspects whether the amount of stream data in the reception buffer becomes a predetermined amount or less and whether an occurrence probability of loss of stream data becomes a predetermined value or higher. If the data amount becomes the predetermined amount or less and the occurrence probability becomes the predetermined value or higher, the client transmits a quality change request to the distribution server. Upon reception of this request, the distribution server thins stream data to be transmitted thereafter in order to change the transmission rate (to lower a frame rate, i.e., time resolution).

[0007] With the method disclosed in JP-A-11-184780, the client is required to have a reception buffer of large capacity, resulting in an expensive client. Namely, according to the method disclosed in JP-A-11-184780, the client issues the redistribution request and quality change request to the redistribution server. If a network delay is large between the redistribution server and client, it takes a long time for redistributed data to arrive the client or for the rate change to be reflected, after the client transmits the redistribution request and quality change request. Therefore, unless the client prepares a reception buffer having a sufficient capacity, the reproduction process of reading the reception buffer starts or the underflow of the reception buffer occurs before arrival of redistributed data and reflection of a rate change.

[0008] With the method disclosed in JP-A-11-184780, a network bandwidth necessary for redistribution of stream data is broad. For example, in a system in which a distribution server and clients are connected via a plurality of routers, according to the method disclosed in JP-A-11-184780, even if stream data is lost in the network between intermediate routers, stream data is redistributed by using the bandwidth of the network from the distribution server to the client. The network bandwidth is consumed more than ideal redistribution of using the bandwidth of only the network between intermediate routers.

[0009] With the method disclosed in JP-A-11-184780, only the time resolution is lowered to change the quality of stream data. Even in the case that the image quality can be suppressed from being lowered if the space resolution is lowered, a degraded image quality on a display can be visually confirmed if the time resolution is lowered.

SUMMARY OF THE INVENTION

[0010] An object of the invention is to provide a stream data distribution method capable of reducing the capacity of a reception buffer to be prepared at a client, narrowing the bandwidth of a network necessary for redistribution, and changing the quality not only by lowering a time resolution but also by lowering a space resolution.

[0011] In order to achieve the above-described object, the invention provides a data distribution method which comprises the following steps. This data distribution method assumes that a distribution server reads stream data from its auxiliary storage device and transmits it to a client.

[0012] 1) A plurality of stream data sets having different qualities are stored in an auxiliary storage device readable from a distribution server, and the distribution server reads only the stream data having a certain quality and transmits it.

[0013] 2) Relay servers are provided between the distribution sever and a client, and stream data to be relayed by a relay server is once buffered in an auxiliary storage device readable from the relay server.

[0014] 3) When the relay server detects a loss of stream data, the relay server issues a redistribution of lost stream data to the distribution server or another relay server at the preceding stage.

[0015] 4) Upon reception of the redistribution request, the distribution server or relay server reads the stream data from the auxiliary storage device and redistributes it.

[0016] 5) When the amount of stream data buffered in the auxiliary storage device by the relay server becomes a predetermined amount or less, or when the occurrence probability of loss of stream data becomes a predetermined value or higher, a quality change request of stream data is transmitted to the distribution server.

[0017] 6) Upon reception of the quality change request, the distribution server change the stream data to be read from the auxiliary storage device to thereby change the quality of stream data to be transmitted.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1** is a block diagram showing the structure of a system according to a first embodiment of the invention.

[0019] FIGS. **2**A to **2**D show the formats of packets to be transferred between nodes.

[0020] FIG. **3** is a block diagram showing the overall structure of a distribution server of the embodiment.

[0021] FIG. **4** shows the structure of a distribution management table.

[0022] FIG. **5** shows the structure of stream data in an auxiliary storage device of the distribution server.

[0023] FIG. **6** shows the overall structure of a relay server.

[0024] FIG. **7** shows the structure of a relay management table.

[0025] FIG. **8** shows the structure of stream data in an auxiliary storage device of the relay server.

[0026] FIG. **9** shows the overall structure of a client.

[0027] FIG. **10** shows the structure of a system according to a second embodiment of the invention.

[0028] FIGS. **11**A to **11**D show the formats of packets to be transferred between nodes.

[0029] FIG. **12** shows the overall structure of a relay server of the second embodiment.

[0030] FIGS. **13**A and **13**B show the structure of a relay server management table.

DESCRIPTION OF THE EMBODIMENTS

[0031] A first embodiment of the invention will be described.

[0032] FIG. **1** shows the structure of a system according to the first embodiment.

[0033] In this system, a distribution server **101** reads stream data from an auxiliary storage device **104** and transmits it. A client **102** buffers the received stream data in a reception buffer **109** and displays it on a display **108**.

[0034] Stream data is transmitted in response to a distribution request from the client **102**. The distribution request contains information of the quality of stream data to be distributed. The distribution server **101** stores beforehand stream data having different qualities in the auxiliary storage device **104**, and reads only the stream data having the requested quality from the auxiliary storage device and transmits it to the client **102**.

[0035] The transmitted stream data is relayed by relay servers **103** to relay it to the client **102**. The relay server **103** has stream data buffers **107** for buffering to some degree the received stream data in an auxiliary storage device **106** at its node. The stream data buffers **107** are managed in the unit of each client. When the amount of data in the stream data buffer **107** becomes a predetermined amount or more, the stream data is sequentially read and transmitted to the client **102**. The relay server **103** and client **102** refer to the stream data buffer **106** and reception buffer **109** and inspect whether there is a loss of stream data. If there is a loss, a data redistribution request is issued to the distribution server **101** or relay server **103** at the preceding stage. The distribution server **101** or relay server **103** reads the data from the auxiliary storage device **105** or **106**.

[0036] The relay server **103** and client **102** refer to the stream data buffer **106** and reception buffer **109** and inspect whether the amount of buffered data in the buffer **106** becomes less than a predetermined amount and whether time index loss in the stream data becomes a predetermined value or higher. If the data amount is small or the occurrence probability is high, it is judged that the network is in an overload state, and a quality change request (a request of lowering the quality) is issued to the distribution server **101** or relay server **103** at the preceding stage. This request is sequentially relayed by each relay server **103** so that the request finally reaches the distribution server **101**. Thereafter, the distribution server **101** reads only the stream data having the newly requested quality from the auxiliary storage device **105** and transmits it to the client **102**.

[0037] The system having the structure shown in FIG. **1** has the following advantages:

[0038] 1) The redistribution request process is executed between the subject node and adjacent distribution server or relay server. It is therefore possible to shorten the time from issuance of the redistribution request to arrival of redistributed stream data. Although the time from the quality change request to the actual quality change is the same as that of a conventional method, the capacity of a reception buffer to be prepared at the client can be made small because not only the client but also the relay server buffers the stream data.

[0039] 2) Since the redistribution request process is executed between the subject node and adjacent distribution server or relay server, it is possible to narrow the network bandwidth to be consumed by redistribution.

[0040] 3) Since the quality of stream data is changed by changing the stream data to be read from the auxiliary storage device by the distribution server, the quality change can be performed not only by lowering the time resolution but also by lowering the space resolution.

[0041] The format of data to be transferred between nodes shown in FIG. **1** will be described first, and then the structures of the distribution server, relay server and client will be described in detail.

[0042] FIGS. **2**A to **2**D show the formats of data to be transferred between nodes shown in FIG. **1**. A format **201** of a packet storing a distribution request to be transmitted from a client to the distribution server has the following fields:

[0043] 1) A "command" field for storing data indicating that the packet is a distribution request packet.

[0044] 2) A "distribution server IP address" field for storing an IP address of the distribution server which is the transmission destination of the distribution request packet.

[0045] 3) A "client IP address" field for storing an IP address of the client which is the transmission source of the distribution request packet.

[0046] 4) A "quality level" field for storing a requested quality of stream data to be transmitted in response to the distribution request.

[0047] A format **202** of a packet storing stream data to be transmitted from the distribution server to a client has the following fields:

[0048] 1) A "command" field for storing data indicating that the packet is a stream data packet.

[0049] 2) A "distribution server IP address" field for storing an IP address of the distribution server which is the transmission source of stream data.

[0050] 3) A "client IP address" field for storing an IP address of the client which is the transmission destination of stream data.

[0051] 4) A "quality level" field for storing a quality of stream data stored in the packet.

[0052] 5) A "time index" field for storing a time index value of stream data stored in the packet. The time index value is information indicating the time required to reproduce the stream data after the start of all the stream data was reproduced.

[0053] 6) A "preceding stage server IP address" field for storing an IP address of the distribution server or relay server at the preceding stage which transmitted or relayed the stream data. When the packet is transmitted, the distribution server sets the IP address of its node to this field. When each relay server relays this packet, the relay server renews this field to the IP address of its node. Namely, each node received this

packet can recognize from this field the IP address of the distribution server or relay server at the preceding stage.

[0054] 7) A "data size" field for storing the size of the stream data stored in the packet.

[0055] 8) A "data" field for storing the stream data of the packet.

[0056] A format **203** of a packet storing a quality change request has the following fields:

[0057] 1) A "command" field for storing data indicating that the packet is a quality change request packet.

[0058] 2) A "distribution server IP address" field for storing an IP address of the distribution server which is the transmission source of stream data whose quality was requested to be changed.

[0059] 3) A "client IP address" field for storing an IP address of the client which is the transmission destination of stream data whose quality was requested to be changed.

[0060] 4) A "quality level" field for storing a newly requested quality of stream data.

[0061] A format **204** of a packet storing a redistribution request has the following fields:

[0062] 1) A "command" field for storing data indicating that the packet is a redistribution request packet.

[0063] 2) A "distribution server IP address" field for storing an IP address of the distribution server which is the transmission source of stream data which was requested to be redistributed.

[0064] 3) A "client IP address" for storing an IP address of the client which is the transmission destination of stream data which was requested to be redistributed.

[0065] 4) A "time index" field for storing a time index value of stream data which was requested to be redistributed.

[0066] The structure of the distribution server will be described with reference to FIGS. **3** to **5**.

[0067] FIG. **3** shows the overall structure of the distribution server **101**. The distribution server **101** has a distribution request processing module **301**, a transmission processing module **304**, a quality request processing module **302**, and a redistribution request processing module **303**. The structure of each module will be described.

[0068] The distribution request processing module **301** receives a distribution request packet **201** from a client and enters data in a distribution management table **305** so that the transmission processing module **304** can start transmitting stream data satisfying the transmission request.

[0069] FIG. **4** shows the structure of the distribution management table **305**. The distribution management table has the following fields:

[0070] 1) A "client IP address" field **401** for storing the IP address of a client which issued the distribution request.

[0071] 2) A "current quality level" field **402** for storing the quality level of stream data to be transmitted.

[0072] 3) A "transmitted data time index" field **403** for storing the time index value of stream data to be transmitted next.

[0073] The distribution request processing module **301** performs initial settings of the "client ID address" and "current quality level" fields of the distribution management table **305** in accordance with the "client ID address" and "current quality level" fields of the received distribution request packet **201**. The distribution request processing module **301** initializes the "transmitted data time index" field to 0.

[0074] The transmission processing module **304** is periodically driven by a timer. The transmission processing module **304** refers to the distribution management table **305** and reads stream data **105** from the auxiliary storage device **104**, the stream data **105** having the quality level **402** and time index value **403** stored in the corresponding entry of the table. The read stream data is transmitted toward the client IP address **401** stored in the entry. After the transmission is completed, the value in the transmitted time index field **403** is incremented.

[0075] FIG. **5** shows the structure of stream data in an auxiliary storage device of the distribution server.

[0076] As described above, it is necessary for the transmission processing module to read stream data having the designated quality level and time index value from the auxiliary storage device **104**. To realize this data read, the stream data is stored in the auxiliary storage device **104** in the data format shown in FIG. **5**.

[0077] The auxiliary storage device **104** has a quality management table **501** having entries for respective quality levels. Each entry of the quality management table **501** stores information representative of a location of a meta data table **502** for the stream data having the corresponding quality level.

[0078] The meta data table **502** stores meta data of stream data and has entries for respective time index values. Each entry of the meta data table stores the location information of a data block **503** of the stream data having the corresponding time index value and the effective data size information of the data block **503**.

[0079] The transmission processing module **304** performs the following operations:

[0080] 1) A meta data table corresponding to stream data having a designated quality level is searched from the quality management table **501**.

[0081] 2) A data block of the stream data having a designated time index is searched from the meta data table **502** and the stream data is read from the data block.

[0082] The transmission processing module **304** receives a redistribution request instruction from the redistribution request processing module **303**. The operation thereof will be later described together with the description of the structure of the redistribution request processing module.

[0083] The redistribution request processing module **303** is driven in response to a reception of the redistribution request packet **204** from a relay server. The redistribution processing module **303** passes the information of the "client IP address" and "time index" stored in the packet to the transmission processing module **304**. Upon reception of the information, the transmission processing module **304** immediately performs the following operations:

[0084] 1) The transmission processing module **304** refers to the distribution management table **305** and acquires the current quality level **402** of stream data to be transmitted toward the passed "client IP address" **401**.

[0085] 2) The transmission processing module **304** reads the stream data having this "quality level" and passed "time index" from the auxiliary storage device, and transmits the stream data toward the passed "client IP address".

[0086] The quality request processing module **302** is driven in response to a reception of a quality change request packet **203** from a relay server. The quality request processing module **302** immediately renews the value in the "current quality level" field **402** of the distribution management table **305** to the value designated in the "quality level" field of the packet.

[0087] The structure of the relay server will be described with reference to FIGS. **6** to **8**.

[0088] FIG. **6** shows the overall structure of the relay server **103**.

[0089] The relay server **103** has a reception processing module **601**, a redistribution request processing module **603**, a quality request processing module **604**, and a transmission processing module **602**. The structure of each module will be described.

[0090] The reception processing module **601** is driven in response to a reception of stream data from the distribution server or relay server at the preceding stage. At the same time when the reception processing module **601** stores the stream data in the auxiliary storage device **106**, a relay server management table **605** is renewed.

[0091] FIG. **7** shows the structure of the relay server management table **605**.

[0092] The relay server management table has the following fields:

[0093] 1) A "distribution server IP address" field **701** for storing an IP address of the distribution server which is the transmission source of stream data.

[0094] 2) A "client IP address" filed 702 for storing an IP address of the client which is the transmission destination of the stream data.

[0095] 3) A "preceding server IP address" field **703** for storing an IP address of the distribution server or relay server at the preceding stage.

[0096] 4) A "current quality level" field **704** for storing a current quality level of the stream data.

[0097] 5) A "received data time index" field **705** for storing a time index of the stream data expected to be received next.

[0098] 6) A "transmitted data time index" field **706** for storing a time index of the stream data to be transmitted next.

[0099] 7) A "lost data time index list" field **707** for storing a list of time index values of lost stream data.

[0100] Upon reception of the stream data, the reception processing module **601** renews the relay server management table **605** in the following operation sequence:

[0101] 1) An entry of the relay server management table **605** is searched which has the same values as those in the "distribution server IP address" and "client IP address fields of the received packet **202** storing the stream data.

[0102] 2) If the entry does not exist at 1), a new entry is formed. The "distribution server IP address" field **701**, "client IP address" field **702**, "preceding server IP address" field **703**, "current quality level" field **704** and "received data time index" field **705** of the new entry are initialized to the values in the "distribution server IP address" field, "client IP address" field, "preceding server IP address" field, "quality level" field, and "time index" field of the packet. The "transmitted data time index" field **706** of the entry is initialized to the same value as that in the "received data time index field **705**.

[0103] 3) If the entry exists at 1), the value in the "current quality level" field **704** of the entry is renewed to the value in the "quality level" field of the packet. The value in the "received data time index" field **705** of the entry is compared with the value in the "time index" field of the packet. In accordance with the comparison result, the following operations are performed:

[0104] A) If the latter (a value in the "time index" field) is larger by 1 than the former (a value in the "received data time index" field), it is judged that the stream data was received without any lost data, and the value in the "received data time index" field **705** of the entry is renewed to the value in the "time index" field of the packet.

[0105] B) If the latter is larger by 2 or more than the former, it is judged that there is lost data. The value in the "received data time index" field **705** of the entry is renewed to the vale in the "time index field" of the packet, and thereafter, the time index value of the lost data is added to the "lost time index list" field **707**.

[0106] C) If the latter is smaller than the former, it is judged that the packet stores redistributed stream data, and the value in the "time index" field of the packet is removed from the "lost time index list" field **707** of the entry.

[0107] The redistribution request processing module **603** is periodically driven by a timer. The redistribution processing module **603** issues a redistribution request for the stream data having the time index value stored in the "lost time index list" field **707** of each entry of the relay management table **605**. More specifically, a redistribution request packet **204** is formed and transmitted toward the "preceding server IP address" **703** of the entry. The values in the "distribution server IP address" and "client IP address" fields of the packet are copied from the corresponding fields of the entry. The value in the "time index" field of the packet is copied from the "lost data time index list" field **707** of the entry.

[0108] The redistribution request processing module **603** is also driven in response to a reception of a redistribution request packet **204** from the relay server or client at the next stage of the subject relay server. In this case, the information stored in the "distribution server IP address", "client IP address" and "time index" fields of the packet is passed to the transmission processing module **602**, and a redistribution instruction is issued to the transmission processing module **602**. The operation to be performed by the transmission processing module **602** in this case will be later described together with the description of the structure of the transmission processing module **602**.

[0109] The quality request processing module **604** is periodically driven by the timer to perform the following operations:

[0110] 1) It is checked for each entry of the relay server management table **605** whether the data amount in the stream data buffer **107** is a predetermined amount or less and whether an occurrence probability of loss of stream data is a predetermined value or higher. The former is checked depending upon whether a difference between values in the "received data time index" and "transmitted data time index" fields is a predetermined value or smaller. The latter is checked depending upon whether the time index value stored in the "lost data time index" field is a predetermined value or higher.

[0111] 2) If it is judged at 1) that the data amount is the predetermined amount of less or the occurrence probability is the predetermined value or higher, the quality change request packet **203** is transmitted to the distribution server or relay server at the preceding stage of its node. The values in the "distribution server IP address" and "client IP address" fields of the packet are copied from the corresponding fields of the entry. The value in the "quality level" field of the packet is set to a value in the "current quality level" field **704** of the entry subtracted by 1.

[0112] The quality request processing module **604** is also driven in response to a reception of a quality change request packet **203** from the relay server or client at the next stage of

the subject relay server. In this case, the packet is simply transferred to the distribution server or relay server at the preceding stage.

[0113] The transmission processing module **602** is periodically driven by the timer. For each entry of the relay server management server **605**, the transmission processing module **602** performs the following operations:

[0114] 1) It is judged from a difference between values in the "received data time index" and "transmitted data time index" fields of the entry whether the data amount in the stream data buffer **107** is the predetermined amount or more.

[0115] 2) Only when the data amount is the predetermined amount or more, it is judged that the stream data is transferred between the nodes designated by the values in the "distribution server IP address" field **701** and "client server IP address" field **702** of the entry. The stream data having the time index value designated in the "transmitted data time index" field **706** is read from the auxiliary storage device **106** and transmitted toward the "client IP address" **706**.

[0116] FIG. **8** shows the structure of stream data in an auxiliary storage device of the relay server.

[0117] As described above, it is necessary for the transmission processing module **602** to read stream data having the designated distribution IP address, client IP address and time index value from the auxiliary storage device **106**. To realize this data read, the stream data is stored in the auxiliary storage device **106** in the data format shown in FIG. **8**.

[0118] The auxiliary storage device **106** has a client management table **801** having entries for respective pairs of the distribution server IP address and client IP address. Each entry of the client management table **801** stores information representative of a location of a meta data table **802** for the stream data transferred between the distribution server and client. The structures of the meta data table **802** and data block **803** are similar to those shown in FIG. **5**, and the description thereof is omitted. Stream data read by the transmission processing module **602** is similar to stream data read by the transmission processing module **304** of the distribution server **101**, and the detailed description thereof is omitted.

[0119] The transmission processing module **602** is also driven in response to a reception of a redistribution instruction from the redistribution request processing module **603**. In this case, as described above, information of the "distribution server IP address", "client IP address" and "time index" is received from the redistribution request processing module **603**. The transmission processing module **602** reads the corresponding stream data from the auxiliary storage device and transmits it toward the received "client IP address".

[0120] FIG. **9** shows the structure of the client.

[0121] The client **102** has a reception processing module **901**, a reproduction processing module **902**, a quality request processing module **903** and a redistribution request processing module **904**. The structure of each module will be described.

[0122] The reception processing module **901** receives an arrival stream data packet **202** at the reception buffer **109**. In the reception buffer **109**, stream data packets **202** are sorted by the value in the "time index" field. The reproduction processing module **902** reads the stream data from the reception buffer and issues a display instruction to the display **108**.

[0123] The quality request processing module **903** is periodically driven by a timer. It is checked by referring to the state of the reception buffer whether the data amount in the reception buffer is a predetermined amount of more and whether the occurrent probability of loss of packets is a predetermined value or higher. If one of the conditions is satisfied, a quality change request packet **203** is transmitted to the relay server at the preceding stage. The values in the "distribution server IP address" and "client IP address" fields of the stream data packet **202** stored in the reception buffer are set to the "distribution server IP address" and "client IP address" fields of the packet. The value in the "quality level" field of the packet is set to a value in the "quality level" field of the stream data packet **202** at the end of the reception buffer subtracted by 1.

[0124] The redistribution request processing module **904** is also periodically driven by the timer. The values in the "time index" fields of the stream data packets **202** stored in the reception buffer are checked to judge whether there is a packet loss. If there is a packet loss, the time index value of the stream data requested to be redistributed is acquired. A redistribution request packet **204** is transmitted to the relay server at the preceding stage. The values in the "distribution server IP address" and "client IP address" fields of the stream data packet **202** stored in the reception buffer are set to the "distribution server IP address" and "client IP address" fields of the packet. The acquired time index value is stored in the "time index" field of the packet.

[0125] FIG. **10** shows the structure of a system according to a second embodiment of the invention.

[0126] In this system, a distribution server **1001** reads stream data **1005** from an auxiliary storage device **1004** and transmits it to a relay server **1003**. The relay server **1003** buffers the received stream data in a stream data buffer **1007** in an auxiliary storage device **1006**.

[0127] When each client **1002** requests for a reception of stream data, a distribution request is transmitted to the relay server **1003**. Upon reception of the distribution request, the relay server **1003** reads the stream data from the stream data buffer **1007** in the auxiliary storage device **1006**, and distributes it to the client **1002**. The distribution request contains information of a requested quality of the stream data. The relay server **1003** changes the quality of the stream data in the stream data buffer **1007** to the requested quality, and transmits it to the client **1002**. This quality change is realized by thinning the stream data received from the distribution server **1001** (by lowering a frame rate, i.e., time resolution).

[0128] The client **1002** refers to the reception buffer **1008** and inspects whether there is a loss of stream data. If there is a loss of data, a data redistribution request is issued to the relay server **1003**. Upon reception of this redistribution request, the relay server **1003** reads the data from the stream data buffer **1007** and redistributes it.

[0129] The client **1002** also refers to the reception buffer **1008** and inspects whether the amount of buffered data becomes a predetermined amount or less and whether an occurrence probability of loss of stream data becomes a predetermined value or higher. If one of the two conditions is satisfied, it is judged that the network is in an overload state, and a quality change request for lowering the quality is transmitted to the relay server **1003**. Upon reception of this request, the relay server **1003** lowers the stream data to be transmitted thereafter to the requested quality, i.e. increases a thinning rate of the stream data.

[0130] The system having the structure shown in FIG. **10** has the following advantages:

[0131] 1) The redistribution request process and quality change process are executed between the relay server and

client. It is therefore possible to shorten the time from issuance of the redistribution request to arrival of redistributed stream data. The time from issuance of the quality change request to realizing the quality change can also be shortened. It is therefore possible to reduce the capacity of the reception buffer to be prepared at the client.

[0132] 2) Similarly, since the redistribution request process is executed between the relay server and client, it is possible to narrow the network bandwidth to be consumed by redistribution.

[0133] The format of data to be transferred between nodes shown in FIG. **10** will be described first, and then the structures of the relay server will be described in detail. The structures of the distribution server and client are the same as those described earlier, and the description thereof is omitted.

[0134] FIGS. **11**A to **11**D show the formats of data to be transferred between nodes shown in FIG. **10**. These data formats are the same as those shown in FIG. **2**, excepting the following points:

[0135] 1) Each packet has a "relay server IP address" field for storing an IP address of the relay server.

[0136] 2) A stream data packet has no "preceding stage server IP address field".

[0137] The structure of the relay server will be described with reference to FIGS. **12** and **13**.

[0138] FIG. **12** shows the overall structure of the relay server **1003**.

[0139] The relay server **1003** has a reception processing module **1201**, a distribution request processing module **1205**, a redistribution request processing module **1203**, a quality request processing module **1204**, and a transmission processing module **1202**. The structure of each module will be described.

[0140] The reception processing module **1201** is driven in response to a reception of stream data from the distribution server. At the same time when the reception processing module **1201** stores the stream data in the auxiliary storage device **1006**, a relay server management table **1206** is renewed.

[0141] FIGS. **13**A and **13**B show the structure of the relay server management table **1206**. The relay server management table has a distribution server management table part and a client management table part. The distribution server management table part is used for managing a distribution server which transmits stream data to the relay server, and has entries for respective distribution servers. The client management table part is used for managing a client which receives stream data from the relay server, and has entries for respective clients.

[0142] The distribution server management table part has the following fields:

[0143] 1) A "distribution server IP address" field **1301** for storing an IP address of the distribution server which is the transmission source of stream data.

[0144] 2) A "received data time index" field **1302** for storing a time index value of stream data to be received next.

[0145] 3) A "transmitted data time index" field **1303** for storing a time index of stream data to be transmitted next.

[0146] The client management table part has the following fields:

[0147] 1) A "distribution server IP address" field **1304** for storing an IP address of the distribution server which is the transmission source of stream data.

[0148] 2) A "client IP address" field **1305** for storing an IP address of a client which is the transmission destination of the stream data.

[0149] 3) A "requested quality" field **1306** for storing the quality level of stream data to be transmitted.

[0150] 4) A "lost data time index list" field **1307** for storing a list of time index values of lost stream data.

[0151] Upon reception of the stream data, the reception processing module **1201** renews the distribution server management table part of the relay server management table **1206** and stores stream data in the auxiliary storage device **1006** in the following operation sequence:

[0152] 1) An entry of the relay server management table part of the relay server management table **1206** is searched which has the same value as that in the "distribution server IP address" field of the received packet **1102** storing the stream data.

[0153] 2) If the entry does not exist at 1), a new entry is formed. The "distribution server IP address" field **1301** of the new entry is initialized to the value in the "distribution server IP address" field of the packet. The values in the "received data time index" field **1302** and "transmitted data time index" field **1303** are initialized to the value in the "time index" field of the received data added with 1.

[0154] 3) If the entry exists at 1), the value in the "received time index" field **1302** of the entry is renewed to the value in the "time index" field of the received stream data added with 1.

[0155] 4) In addition, if the entry exists at 1, the client management table part of the relay server management table **1206** is searched to acquire a list of the "requested quality" fields **1306** corresponding to the "distribution server IP address" field **1301**. The quality of the received stream data is changed to the acquired quality levels, and the stream data is stored in the auxiliary storage device.

[0156] The distribution request processing module **1205** is driven in response to a reception of a distribution request from a client. In order to perform the transmission satisfying this distribution request, an entry of the client management table part of the relay server table **1206** is newly formed in the following manner:

[0157] 1) The values in the "distribution server IP address", "client IP address" and "distribution server IP address fields of the distribution request packet **1101** are copied to the "distribution IP address" field **1304**, "client IP address" field **1305** and "requested quality" field **1306** of the newly formed entry.

[0158] 2) The "lost data time index list" field **1307** is initialized to be empty.

[0159] The redistribution request processing module **1203** is driven in response to a reception of the redistribution request packet **1104** from a client. In this case, an entry of the client management table part of the relay server management table **1206** is searched which corresponds to the "distribution server IP address" and "client IP address" of the redistribution request packet. The value in the "time index" field of the packet is added to the "lost data time index list" field **1307** of the searched entry.

[0160] The quality request processing module **1204** is driven in response to a reception of the quality change request packet **1103** from a client. In this case, an entry of the client management table part of the relay server management table **1206** is searched which corresponds to the "distribution server IP address" and "client IP address" of the quality

change request packet. The value in the "requested quality" field **1306** of the entry is renewed to the value in the "quality level" field of the packet.

[0161] The transmission processing module **1202** is periodically driven by a timer. For each entry of the distribution server management table part of the relay server management table **1206**, the transmission processing module **1202** performs the following operations:

[0162] 1) It is judged from a difference between values in the "received data time index" and "transmitted data time index" fields of the entry whether the data amount in the stream data buffer **1007** is a predetermined amount or more.

[0163] 2) Only when the data amount is the predetermined amount or more, entries of the client management table part are acquired which correspond to the "distribution server IP address" **1301** of the subject entry. For each entry of the client management table part, the transmission processing module **1202** performs the following operations:

[0164] A) Stream data designated by the "distribution server IP address" field **1301**, "transmitted data time index" field **1302** and "requested quality" field **1306** is read from the stream data buffer **1007** in the auxiliary storage device **1006**. The value in the "transmitted data time index" field **1302** is incremented.

[0165] B) The read stream data is transmitted to the client designated by the "client IP address" field **1305**.

[0166] C) Stream data designated by the "distribution server IP address" field **1301**, each index value in the "lost data time index list" fields **1307**, and "requested quality" field **1306** is read from the stream data buffer **1007** in the auxiliary storage device **1006**. The values in the "lost data time index" fields **1307** are renewed to be empty.

[0167] D) The read stream data is transmitted to the client designated by the "client IP address" field **1305**.

[0168] As described above, it is necessary for the transmission processing module **1202** to read stream data having the designated distribution IP address, quality and time index value from the auxiliary storage device **1006**. This data read can be realized by the method described with the first embodiment, and the details thereof are omitted.

[0169] The invention provides the following advantages:

[0170] 1) The capacity of a reception buffer to be prepared at a client can be made small.

[0171] 2) The network bandwidth necessary for redistribution can be narrowed.

[0172] 3) Quality change can be made not only by lowering the time resolution but also by lowering the space resolution.

[0173] It should be further understood by those skilled in the art that the foregoing description has been made on embodiments of the invention and that various changes and modifications may be made in the invention without departing from the spirit of the invention and the scope of the appended claims.

1-10. (canceled)

11. A relay server for relaying data transmitted between a distribution server and a client apparatus via a network comprising:

a storage device that stores stream data transmitted from the distribution server to the client apparatus;

a distribution request processing module that receives a distribution request sent from the client apparatus to obtain the stream data from the distribution server, the distribution request including information of requesting the quality of the stream data to be distributed from the distribution server;

a quality request module that reads the requested quality of the stream data out of the distribution request, reads the stream data requested by the distribution request from the storage device, thins the stream data according to the requested quality to send the thinned stream data to the client apparatus;

a redistribution processing module that receives a redistribution request from the client apparatus of which includes time information indicating time to send the stream data to the client apparatus;

a transmission processing module that reads the stream data out of the storage device when time comes to time included in the data stream and distributes the stream data to the client apparatus; and

a quality request processing module that receives a quality change request sent from the client terminal and changes a thinning rate of the stream data according to the quality request.

12. The relay server according to claim **11**, wherein said quality request processing module changes a frame rate according to said quality request.

13. The relay server according to claim **11**, wherein said quality request processing module changes a frame rate of the stream data according to said quality request.

14. The relay server according to claim **11**, wherein said quality request processing module changes to increase the thinning rate of the stream data according to said quality request for lowering the quality when the network is in an overload state.

15. The relay server according to claim **11**, wherein the relay server stores IP addresses of its own server to data to be relayed;

if the relay server detects a loss of data stored in the second information storage device, it reads out an IP address of the distribution server or another relay server placed at a preceding stage stored in the data and transmits a redistribution request of data to another relay server at a preceding stage.

16. A data transmission method between a distribution server and a client apparatus via a network comprising:

storing stream data transmitted from the distribution server to the client apparatus;

receiving a distribution request sent from the client apparatus to obtain the stream data from the distribution server, the distribution request including information of requesting the quality of the stream data to be distributed from the distribution server;

reading the requested quality of the stream data out of the distribution request, reading the stream data requested by the distribution request from the storage device and thinning the stream data according to the requested quality to send the thinned stream data to the client apparatus;

receiving a redistribution request from the client apparatus of which includes time information indicating time to send the stream data to the client apparatus;

reading the stream data out of the storage device when time comes to time included in the data stream and distributing the stream data to the client apparatus; and

receiving a quality change request sent from the client terminal and changing a thinning rate of the stream data according to the quality request.

17. The data transmission method according to claim **16**, wherein said changing the thinning rate comprises changing a frame rate according to said quality request.

18. The data transmission method according to claim **16**, wherein said changing the thinning rate comprises changing a frame rate of the stream data according to said quality request.

19. The data transmission method according to claim **16**, wherein said changing the thinning rate comprises changing to increase the thinning rate of the stream data according to said quality request for lowering the quality when the network is in an overload state.

20. The data transmission method according to claim **16**, wherein the relay server stores IP addresses of its own server to data to be relayed;

if the relay server detects a loss of data stored in the second information storage device, it reads out an IP address of the distribution server or another relay server placed at a preceding stage stored in the data and transmits a redistribution request of data to another relay server at a preceding stage.

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