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(54) **DATA RETRIEVAL SYSTEM AND DATA RETRIEVAL METHOD**

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(57) **ABSTRACT**

A data retrieval system includes a first apparatus and a second apparatus. The first apparatus includes a distributor, a processing state receptor, and a completion determiner. The distributor distributes a query to one or more devices which can retain data. The processing state receptor receives, from the second apparatus, information indicating processing states of the devices for the query. The completion determiner determines whether the query is complete from the received processing state. The second apparatus includes a transceiver, a process manager, and a processing state transmission controller. The transceiver receives a query distributed by the first apparatus and transmits the query to the devices. The process manager manages a processing state indicating whether each device completes the query on the basis of a received processing result of the query of each device. The processing state transmission controller transmits managed processing states of the query to the first apparatus.

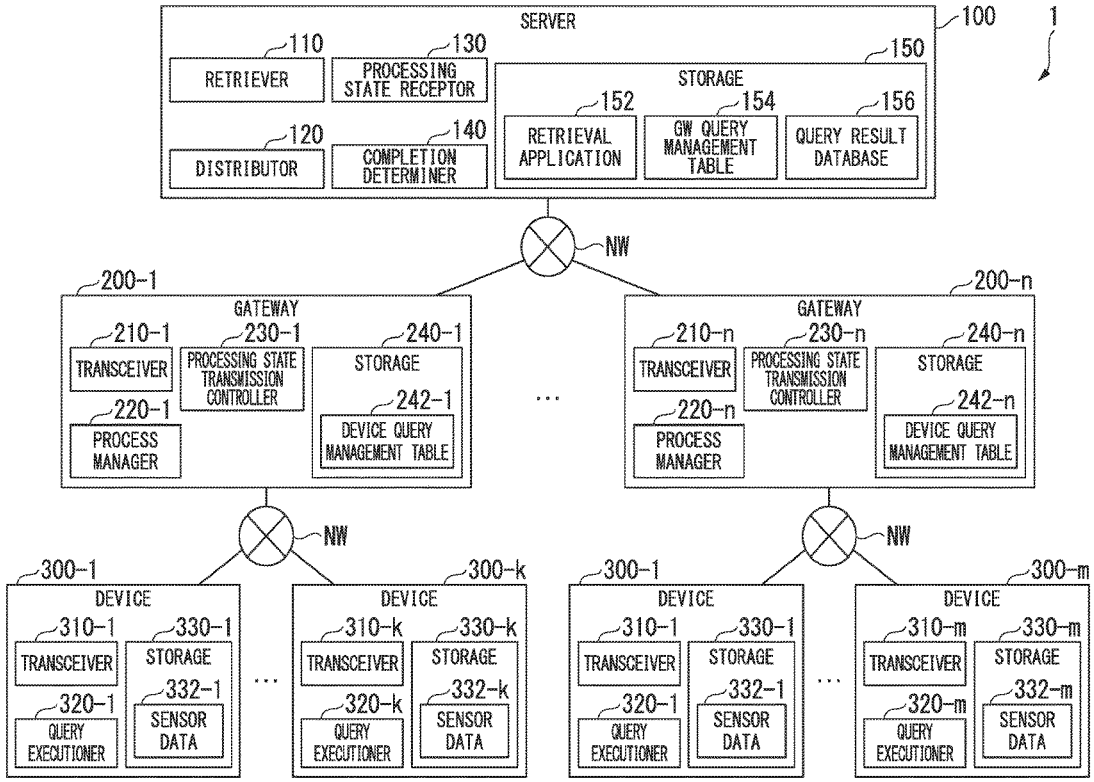


FIG. 1

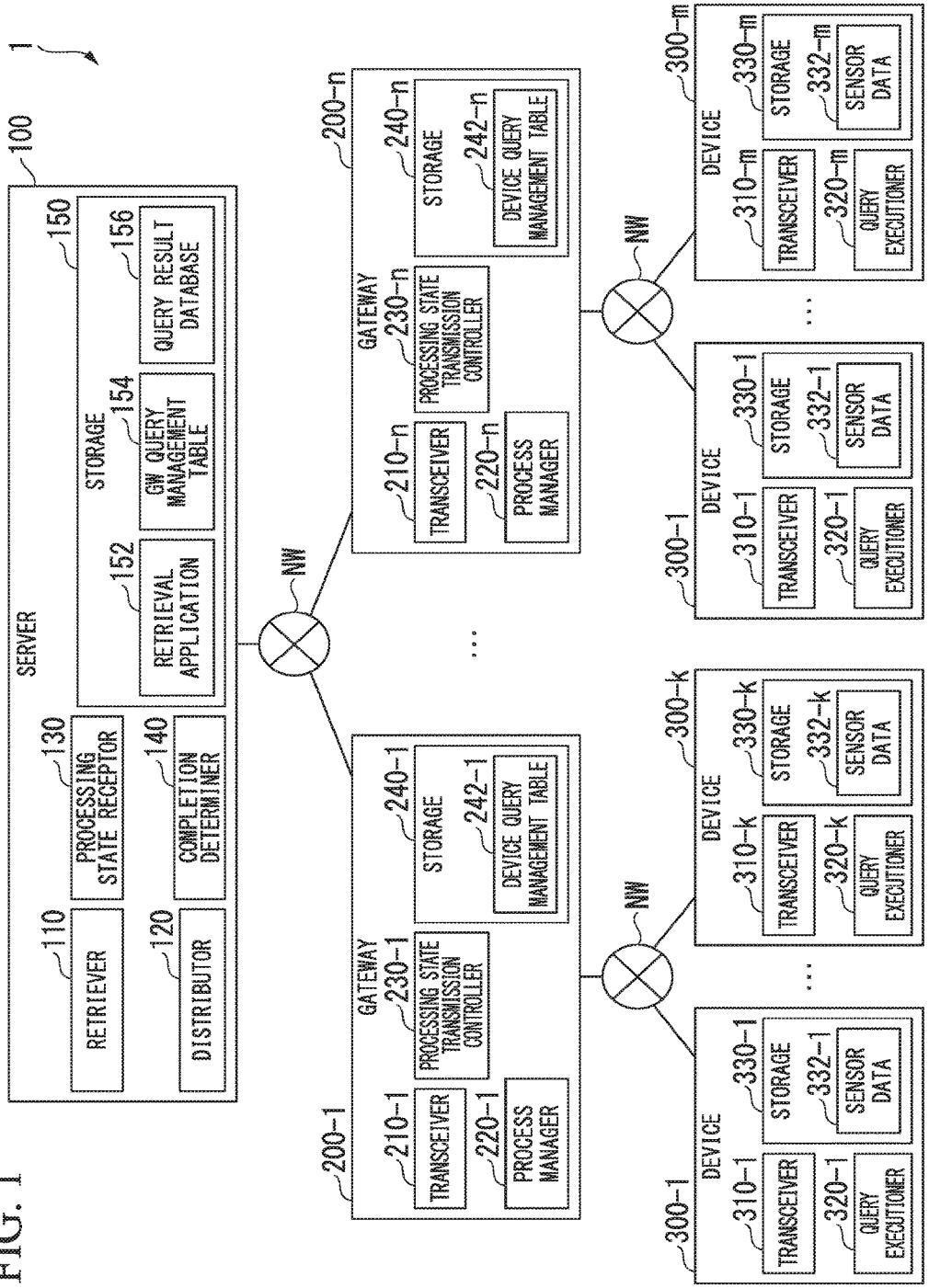

1
100
SERVER
110
RETRIEVER
130
PROCESSING STATE RECEPTOR
120
DISTRIBUTOR
140
COMPLETION DETERMINER
150
STORAGE
152
RETRIEVAL APPLICATION
154
GW QUERY MANAGEMENT TABLE
156
QUERY RESULT DATABASE
NW
200-1
GATEWAY
210-1
TRANSCEIVER
220-1
PROCESS MANAGER
230-1
PROCESSING STATE TRANSMISSION CONTROLLER
240-1
STORAGE
242-1
DEVICE QUERY MANAGEMENT TABLE
200-n
GATEWAY
210-n
TRANSCEIVER
220-n
PROCESS MANAGER
230-n
PROCESSING STATE TRANSMISSION CONTROLLER
240-n
STORAGE
242-n
DEVICE QUERY MANAGEMENT TABLE
300-1
DEVICE
310-1
TRANSCEIVER
320-1
QUERY EXECUTIONER
330-1
STORAGE
332-1
SENSOR DATA
300-k
DEVICE
310-k
TRANSCEIVER
320-k
QUERY EXECUTIONER
330-k
STORAGE
332-k
SENSOR DATA
300-m
DEVICE
310-m
TRANSCEIVER
320-m
QUERY EXECUTIONER
330-m
STORAGE
332-m
SENSOR DATA

FIG. 2

154

QUERY ID	GATEWAY ID	PROCESSING STATE	SATISFACTION LEVEL	...
query-1	GW-1	INCOMPLETE	0	...
query-1	GW-2	INCOMPLETE	0	...
query-1	GW-3	INCOMPLETE	0	...
...	...	...	...	...

FIG. 3

242

QUERY ID	DEVICE ID	PROCESSING STATE	...
query-1	device-1	INCOMPLETE	...
query-1	device-2	INCOMPLETE	...
query-1	device-3	INCOMPLETE	...
...	...	...	...

FIG. 4

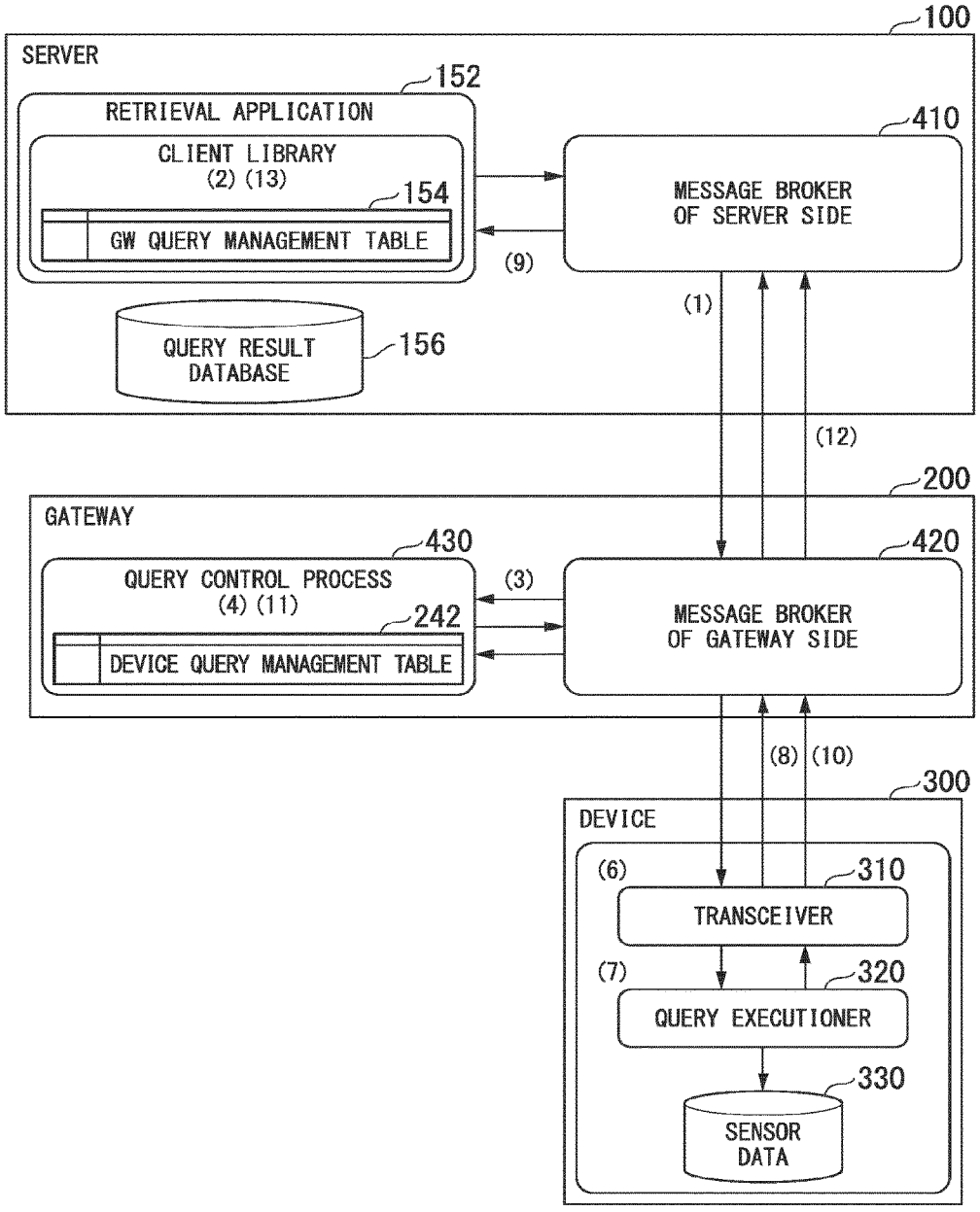

100
SERVER
152
RETRIEVAL APPLICATION
CLIENT LIBRARY
(2) (13)
154
GW QUERY MANAGEMENT TABLE
410
MESSAGE BROKER
OF SERVER SIDE
(9)
(1)
QUERY RESULT
DATABASE
156
(12)
200
GATEWAY
430
QUERY CONTROL PROCESS
(4) (11)
242
DEVICE QUERY MANAGEMENT TABLE
(3)
420
MESSAGE BROKER
OF GATEWAY SIDE
(8) (10)
300
DEVICE
(6)
310
TRANSCEIVER
(7)
320
QUERY EXECUTIONER
330
SENSOR
DATA

FIG. 5

242

QUERY ID	DEVICE ID	PROCESSING STATE
query-1	device-1	COMPLETE
query-1	device-2	COMPLETE
query-1	device-3	TIMEOUT

FIG. 6

154

QUERY ID	GATEWAY ID	PROCESSING STATE	SATISFACTION LEVEL
query-1	GW-1	COMPLETE	0.667
query-1	GW-2	COMPLETE	1
query-1	GW-3	COMPLETE	1

FIG. 7

242A

QUERY ID	DEVICE ID	DATABASE SIZE	PROCESSING STATE
query-1	device-1	50KB	COMPLETE
query-1	device-2	100KB	COMPLETE
query-1	device-3	1MB	TIMEOUT

FIG. 8

242B

QUERY ID	DEVICE ID	TABLE SIZE	PROCESSING STATE
query-1	device-1	5KB	COMPLETE
query-1	device-2	25KB	COMPLETE
query-1	device-3	500KB	TIMEOUT

FIG. 9

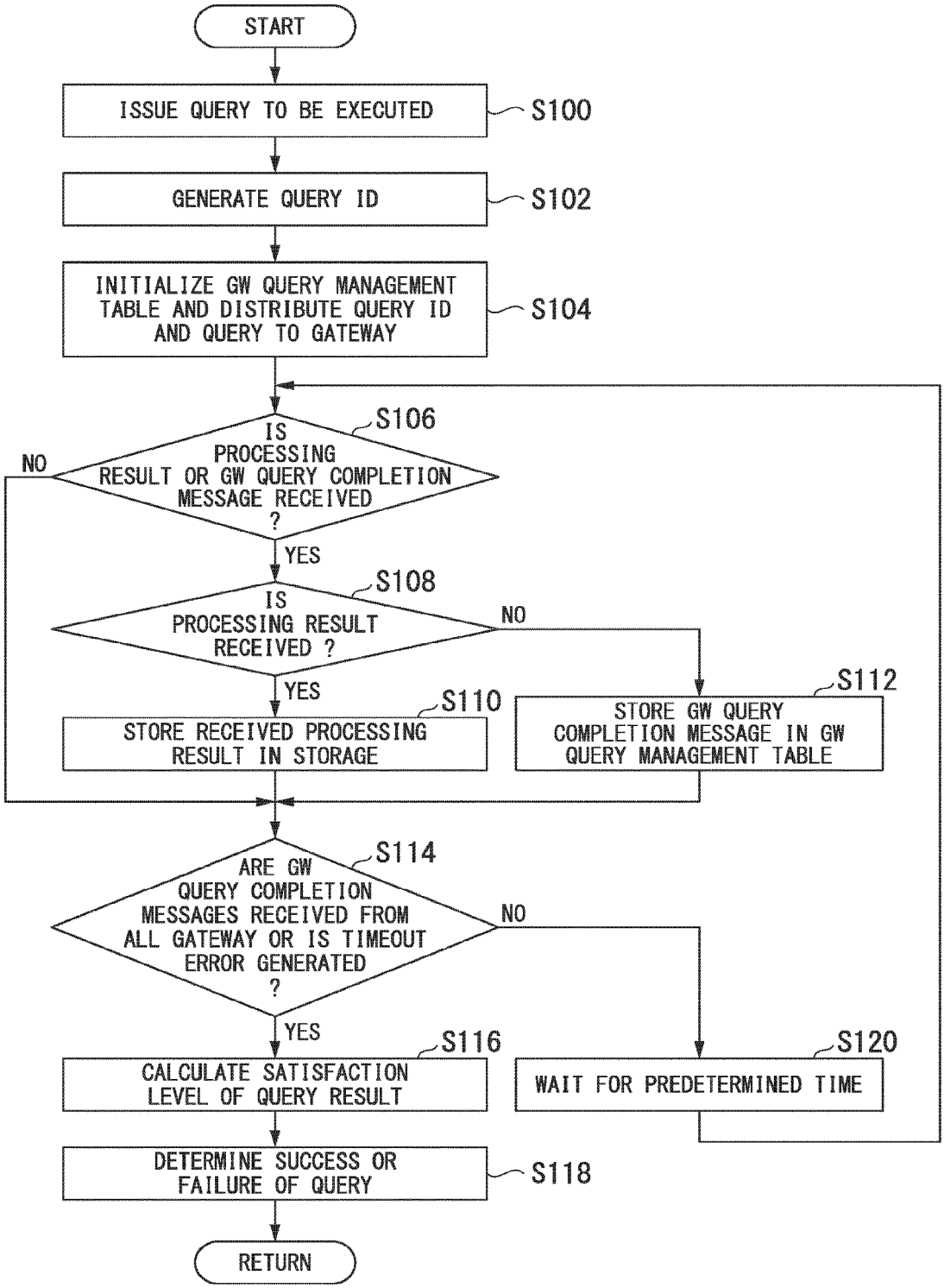

START
ISSUE QUERY TO BE EXECUTED
S100
GENERATE QUERY ID
S102
INITIALIZE GW QUERY MANAGEMENT TABLE AND DISTRIBUTE QUERY ID AND QUERY TO GATEWAY
S104
S106
IS PROCESSING RESULT OR GW QUERY COMPLETION MESSAGE RECEIVED ?
NO
YES
S108
IS PROCESSING RESULT RECEIVED ?
NO
YES
S110
STORE RECEIVED PROCESSING RESULT IN STORAGE
S112
STORE GW QUERY COMPLETION MESSAGE IN GW QUERY MANAGEMENT TABLE
S114
ARE GW QUERY COMPLETION MESSAGES RECEIVED FROM ALL GATEWAY OR IS TIMEOUT ERROR GENERATED ?
NO
YES
S116
CALCULATE SATISFACTION LEVEL OF QUERY RESULT
S120
WAIT FOR PREDETERMINED TIME
DETERMINE SUCCESS OR FAILURE OF QUERY
S118
RETURN

FIG. 10

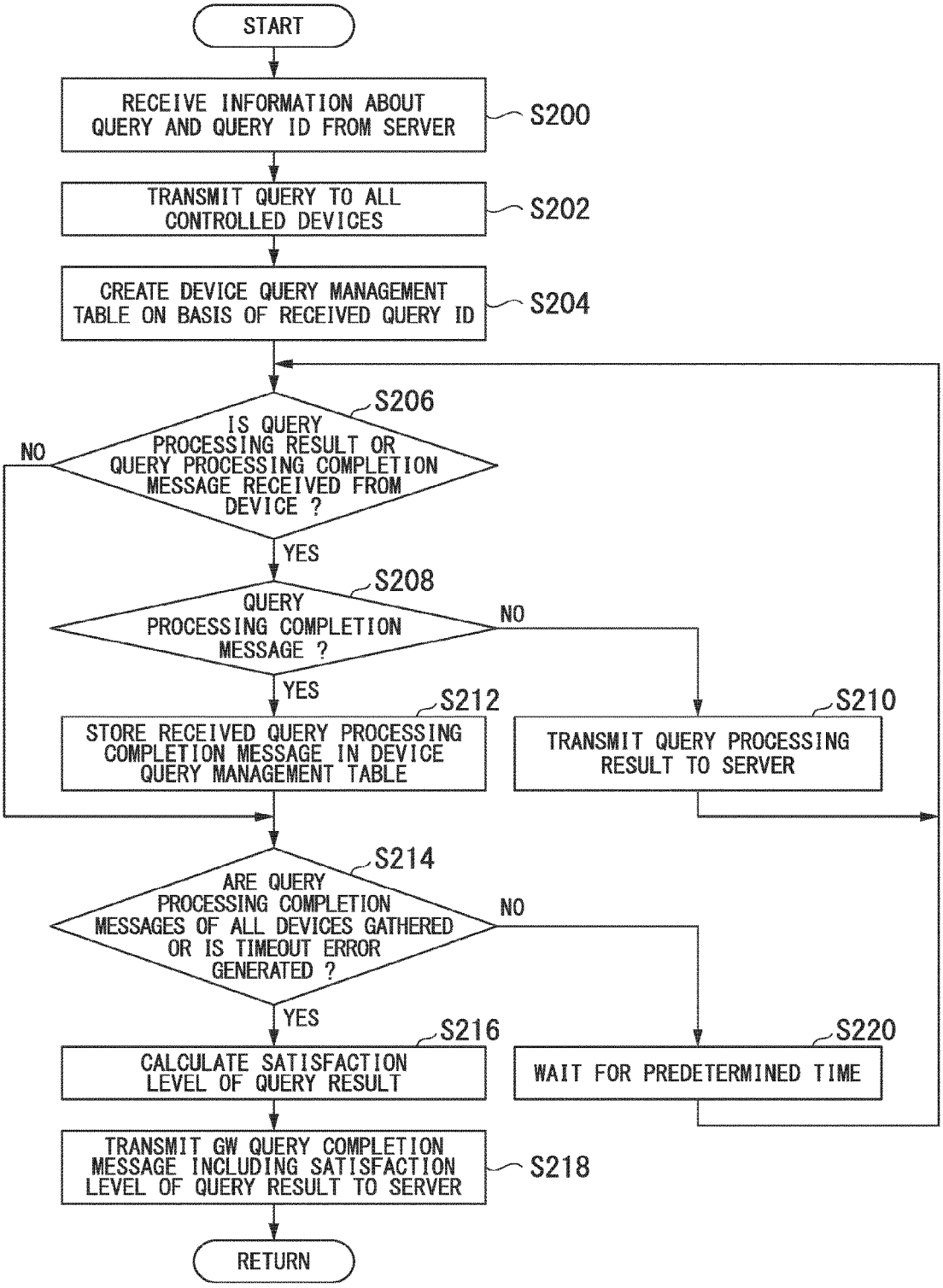
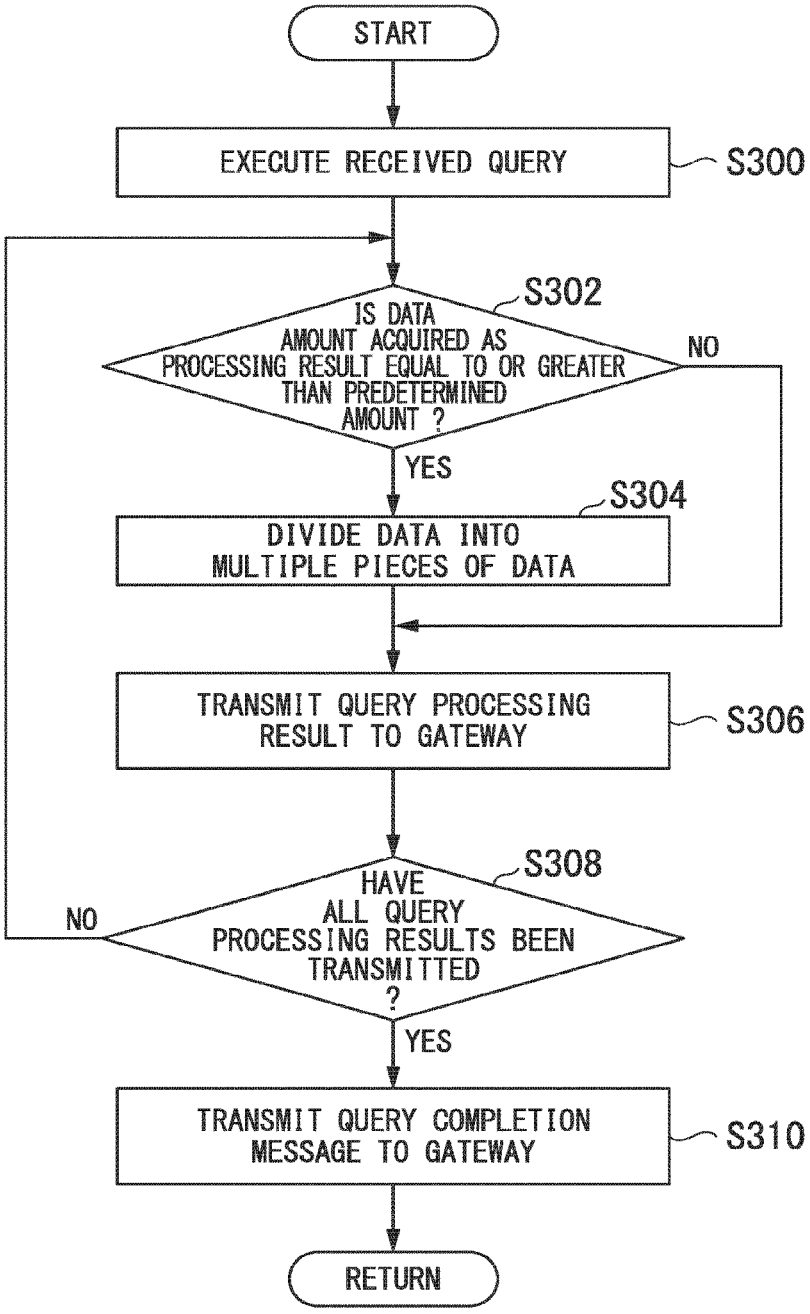

START
RECEIVE INFORMATION ABOUT QUERY AND QUERY ID FROM SERVER
S200
TRANSMIT QUERY TO ALL CONTROLLED DEVICES
S202
CREATE DEVICE QUERY MANAGEMENT TABLE ON BASIS OF RECEIVED QUERY ID
S204
S206
IS QUERY PROCESSING RESULT OR QUERY PROCESSING COMPLETION MESSAGE RECEIVED FROM DEVICE ?
NO
YES
S208
QUERY PROCESSING COMPLETION MESSAGE ?
NO
YES
S212
STORE RECEIVED QUERY PROCESSING COMPLETION MESSAGE IN DEVICE QUERY MANAGEMENT TABLE
S210
TRANSMIT QUERY PROCESSING RESULT TO SERVER
S214
ARE QUERY PROCESSING COMPLETION MESSAGES OF ALL DEVICES GATHERED OR IS TIMEOUT ERROR GENERATED ?
NO
YES
S216
CALCULATE SATISFACTION LEVEL OF QUERY RESULT
S220
WAIT FOR PREDETERMINED TIME
TRANSMIT GW QUERY COMPLETION MESSAGE INCLUDING SATISFACTION LEVEL OF QUERY RESULT TO SERVER
S218
RETURN

FIG. 11


START
EXECUTE RECEIVED QUERY
S300
S302
IS DATA AMOUNT ACQUIRED AS PROCESSING RESULT EQUAL TO OR GREATER THAN PREDETERMINED AMOUNT ?
NO
YES
S304
DIVIDE DATA INTO MULTIPLE PIECES OF DATA
TRANSMIT QUERY PROCESSING RESULT TO GATEWAY
S306
S308
HAVE ALL QUERY PROCESSING RESULTS BEEN TRANSMITTED ?
NO
YES
TRANSMIT QUERY COMPLETION MESSAGE TO GATEWAY
S310
RETURN

DATA RETRIEVAL SYSTEM AND DATA RETRIEVAL METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2016-182800, filed Sep. 20, 2016; the entire contents of which are incorporated herein by reference.

[0002] Embodiments described herein relate generally to a data retrieval system and a data retrieval method.

BACKGROUND

[0003] There is a conventional data retrieval system that retrieves data retained in each of Internet of Things (IoT) devices capable of retaining data from a server connected to a plurality of IoT devices. However, in the conventional retrieval system, when there is an IoT device for which retrieval has failed due to device failure, network failure or the like, all retrieval processes may become error control because a plurality of IoT devices are connected to the server. In addition, in the conventional retrieval system, processes are concentrated on the server and thus the processing load increases in some cases.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a diagram illustrating a functional configuration example of a data retrieval system **1** of embodiments.

[0005] FIG. **2** is a diagram illustrating content of data of a GW query management table **154**.

[0006] FIG. **3** is a diagram illustrating an example of data of a device query management table **242**.

[0007] FIG. **4** is a diagram for describing a state of query distribution from a server **100**.

[0008] FIG. **5** is a diagram illustrating an example of the device query management table **242** having processing states obtained from a controlled device **300**.

[0009] FIG. **6** is a diagram illustrating an example of the device query management table **242** having processing states obtained from a controlled gateway **200**.

[0010] FIG. **7** is a diagram illustrating an example of a device query management table **242**A including database sizes.

[0011] FIG. **8** is a diagram illustrating an example of a device query management table **242**B including table sizes.

[0012] FIG. **9** is a flowchart illustrating an example of content of a process in the server **100** of embodiments.

[0013] FIG. **10** is a flowchart illustrating an example of content of a process in the gateway **200** of the embodiments.

[0014] FIG. **11** is a flowchart illustrating an example of content of a process in the device **300** of the embodiments.

DETAILED DESCRIPTION

[0015] A data retrieval system of embodiments includes a first apparatus and a second apparatus. The first apparatus includes a distributor, a processing state receptor, and a completion determiner. The distributor distributes a query to one or more devices which are able to retain data. The processing state receptor receives, from the second apparatus, information indicating processing states of the query in the one or more devices. The completion determiner determines whether the query is completed from the processing state received by the processing state receptor. The second apparatus includes a transceiver, a process manager, and a processing state transmission controller. The transceiver receives a query distributed by the first apparatus and transmits the query to the one or more devices. The process manager manages a processing state indicating whether each of the one or more devices completes the query on the basis of a processing result of the query of each of the one or more devices received by the transceiver. The processing state transmission controller transmits processing states of the query managed by the process manager to the first apparatus using the transceiver.

[0016] A data retrieval system and a data retrieval method of embodiments will be described below with reference to the drawings.

[0017] FIG. **1** is a diagram illustrating a functional configuration example of a data retrieval system **1** of the embodiments. For example, the data retrieval system **1** illustrated in FIG. **1** includes a server (first apparatus) **100**, one or more gateways (second apparatuses) **200-1** to **200-*n***, and one or more devices **300-1** to **300-*k*** (or m). k and m are variables which may be the same number or different numbers.

[0018] The server **100**, the gateways **200** and the devices **300** communicate via networks NW including the Internet, a local area network (LAN), a wide area network (WAN) and the like. Meanwhile, in the following description, the gateways **200-1** to **200-*n*** have the same configuration, and when they are not discriminated from one another, signs after hyphens which indicate the gateways are omitted and they are referred to as "gateway **200**." In addition, the same applies to other components indicated using hyphens. Furthermore, the data retrieval system **1** of the embodiments may include a plurality of servers **100**, and the gateways **200** may be configured in a plurality of layers.

[0019] First, a functional configuration example of the server **100** will be described. For example, the server **100** includes a retriever **110**, a distributor **120**, a processing state receptor **130**, a completion determiner **140**, and a storage **150**. The retriever **110**, the processing state receptor **130** and the completion determiner **140** are realized by execution of a program (e.g., a retrieval application **152**) stored in the storage **150** by a processor such as a central processing unit (CPU). For example, the program may be downloaded from an application server (not shown) via a network NW, or a program stored in a portable storage medium such as an SD card may be installed in the server **100**. In addition, some or all of the above-described functions may be realized by hardware such as large scale integration (LSI), an application specific integrated circuit (ASIC), and a field-programmable gate array (FPGA) or realized by software and hardware in cooperation.

[0020] The retriever **110** issues a query for acquiring data retained in the one or more devices **300**. For example, the query is a command indicating a manipulation for data retained in the device **300**. For example, the query is a command described in a standard query language (SQL). For example, the query may be a command for acquiring, from the device **300**, a power consumption amount, a consumed gas amount, a tap water consumption amount, and the like from Sep. 14 to Sep. 21, 2016 in association with time information, or a command for acquiring a temperature, humidity, and the like at the present time. Furthermore, the

query may be a command for acquiring all the data retained in the device **300** regardless of the time information.

[0021] The retriever **110** outputs a query to be executed by the device **300** and a query ID for identifying the query to the distributor **120**. In addition, the retriever **110** creates a GW query management table **154** for managing a query state for each gateway **200**.

[0022] FIG. **2** is a diagram illustrating content of data of the GW query management table **154**. For example, the GW query management table **154** is information in which "processing state" and "satisfaction level" are associated with "query ID" and "gateway ID." The "query ID" is identification information of a query instructed to be executed by the retriever **110**. The gateway ID" is identification information of the gateway **200**. The "processing state" is information indicating a processing state of a query for each gateway **200**. For example, when the processing state receptor **130** has received a GW query completion message from the gateway **200**, a processing state is information indicating "complete." On the other hand, when the GW query completion message has not been received, a processing state is information indicating "incomplete."

[0023] "Satisfaction level" is a degree of satisfaction with respect to a query processing result determined by the completion determiner **140** after a processing state has been received. For example, the satisfaction level may be calculated by dividing the number of devices which have correctly completed a query by the number of devices required to process the query. The retriever **110** stores the aforementioned query ID, gateway ID, processing state and satisfaction level as a set in the GW query management table **154** when a query is distributed from the distributor **120**. Here, as initial values, "incomplete" is stored as a processing state and "0" is stored as a satisfaction level.

[0024] The distributor **120** distributes a query and a query ID acquired from the retriever **110** to the gateway **200**.

[0025] The processing state receptor **130** receives, from the gateway **200**, query processing results or processing states obtained by the one or more devices **300** after the query has been distributed by the distributor **120** to the gateway **200**. When the query processing results are received, the processing state receptor **130** stores the query processing results in a query result database **156**. The processing state receptor **130** updates processing states of the GW query management table **154** stored in the storage **150** on the basis of the received processing state of each gateway **200**.

[0026] The completion determiner **140** determines whether the query has been completed from the processing states received by the processing state receptor **130**. For example, the completion determiner **140** calculates a satisfaction level from the processing state of each gateway with reference to the GW query management table **154** stored in the storage **150**.

[0027] In addition, the completion determiner **140** determines that the executed query has succeeded when the calculated satisfaction level is equal to or greater than a predetermined threshold value (e.g., 80%). The fact that a query has succeeded means, for example, that a processing result obtained by execution of the query is determined as a valid result.

[0028] The storage **150** is realized by a random access memory (RAM), a read only memory (ROM), a hard disk drive (HDD), a flash memory or the like. For example, the storage **150** stores the retrieval application **152**, the GW query management table **154**, and information of the query result database **156**. For example, the server **100** may be a personal computer (PC) or a cloud server including a plurality of information processing apparatuses.

[0029] Next, the functional configuration of the gateway **200** will be described. For example, the gateway **200** includes a transceiver **210**, a process manager **220**, a processing state transmission controller **230**, and a storage **240**. In addition, one or both of the aforementioned process manager **220** and processing state transmission controller **230** may be realized by hardware such as an LSI, an ASIC and an FPGA or realized by software and hardware in cooperation.

[0030] The transceiver **210** receives a query distributed by the server **100**. In addition, the transceiver **210** transmits the received query to the one or more devices **300** under the control of the gateway **200**.

[0031] The process manager **220** manages a query processing result of each of the one or more devices **300** that has been received by the transceiver **210** through a device query management table **242** stored in the storage **240**.

[0032] FIG. **3** is a diagram illustrating an example of data of the device query management table **242**. For example, the device query management table **242** is information in which "processing state" is associated with "query ID" and "device ID." "Device ID" is information for identifying a device. "Processing state" is a processing state of a query for each device ID.

[0033] For example, the process manager **220** sets "incomplete" immediately after a query is distributed to each device **300** because a process for the query has not been completed. In addition, when a processing result has been received from the device **300**, the process manager **220** sets "complete" for the processing state of the target device **300**. Furthermore, when a processing result is obtained after a lapse of predetermined time after a query has been distributed to the device **300**, the process manager **220** sets information indicating a timeout error, a communication error or the like as the processing state. Meanwhile, the predetermined time may be set for each query, for example.

[0034] The processing state transmission controller **230** transmits the query processing states managed by the process manager **220** to the server **100** using the transceiver **210**.

[0035] The storage **240** is realized by a RAM, a ROM, an HDD, a flash memory or the like. For example, the storage **240** stores information of the device query management table **242**. For example, the gateway **200** may have a function of performing protocol conversion between networks.

[0036] In addition, the gateway **200** may be a relay apparatus such as a router apparatus or a hub apparatus.

[0037] Next, a functional configuration example of the device **300** will be described. For example, the device **300** includes a transceiver **310**, a query executioner **320**, and a storage **330**. The query executioner **320** may be realized by hardware such as an LSI, an ASIC and an FPGA, or realized by software and hardware in cooperation.

[0038] The transceiver **310** receives a query distributed by the gateway **200**. In addition, the transceiver **310** outputs a result of the query executed in the query executioner **320** to the gateway **200** that has distributed the query.

[0039] The query executioner **320** executes the query received by the transceiver **310**. For example, the query executioner **320** extracts data corresponding to the query among sensor data **332** stored in the storage **330**. For example, the sensor data **332** is at least one piece of data such as a temperature, humidity, power consumption, a consumed gas amount, and a tap water consumption amount which are acquired in a place where the device **300** is installed at each predetermined time intervals. The sensor data **332** may be stored together with time information.

[0040] The storage **330** is realized by a RAM, a ROM, an HDD or a flash memory. For example, the storage **330** stores information of the sensor data **332**. For example, the device **300** is an IoT device.

[0041] Various operations of a retrieval process in the server **100** will be described below. FIG. **4** is a diagram for describing a state of query distribution from the server **100**. Meanwhile, FIG. **4** shows an example in which one server **100**, one gateway **200** and one device **300** are connected for simplification of the description.

[0042] The retrieval application **152** of the server **100** causes a message broker **410** of the server side to transmit a query ID and a query to all gateways **200** ((1) in the figure). Meanwhile, the message broker **410** of the server side corresponds to the distributor **120**, for example. Furthermore, the retrieval application **152** generates the GW query management table **154** in a library thereof (client library) ((2) in the figure).

[0043] Then, when a message broker **420** of the gateway side of the gateway **200** receives the query ID and the query from the server **100**, the message broker **420** outputs the received information to a query control process **430** ((3) in the figure). For example, the message broker **420** of the gateway side corresponds to the transceiver **210**. In addition, for example, the query control process **430** corresponds to the process manager **220** and the processing state transmission controller **230**.

[0044] The query control process stores the transmitted query ID in the device query management table **242** and performs data entry ((4) in the figure). Subsequently, the message broker **420** of the gateway side transmits the query ID and the query to the device **300** ((5) in the figure).

[0045] The transceiver **310** of the device **300** receives the query ID and the query from the gateway **200** ((6) in the figure). The query executioner **320** executes the query, acquires data corresponding to the query from the sensor data **332**, and creates ResultSet of a retrieval result ((7) in the figure). ResultSet is a response of a database management system (DBMS) or the like for a query and, for example, an object including an execution result of an SQL query. As a DBMS retrieval result, for example, data indicating part of a table becomes ResultSet.

[0046] Thereafter, the query executioner **320** transmits the created ResultSet using the transceiver **310** to the server **100** via the gateway **200** ((8) in the illustration). The server **100** receives ResultSet ((9) in the illustration). Data corresponding to the received ResultSet is stored in the query result database **156**. Then, the query executioner **320** transmits a query completion message to the query control process **430** when the query is complete ((10) in the illustration).

[0047] Subsequently, the message broker **420** of the gateway side outputs the query completion message to the query control process **430**. The query control process **430** determines whether the query completion message has been received or a timeout error has been detected for all the controlled devices **300** ((11) in the illustration). In addition, the query control process **430** transmits a GW query completion message to the server **100** when the query completion message has been received or the timeout error has been detected for all the controlled devices **300** ((12) in the illustration). The GW query completion message transmitted from the query control process **430** includes information about the ratio of success or failure of the query of the controlled devices **300**.

[0048] FIG. **5** is a diagram illustrating an example of the device query management table **242** having processing states obtained from the controlled device **300**. For example, the query control process **430** has device IDs "device-1" to "device-3" of devices **300** under the control of the gateway **200**.

[0049] In this case, in the query control process **430**, processing states with respect to the device IDs "device-1" and "device-2" are set to "complete" for the query ID "query-1" and a processing state with respect to the device ID "device-3" is set to be a timeout error. In this case, since two of the three devices **300** have succeeded in the query, the query control process **430** outputs information about a ratio such as a success rate of $2/3 \approx 0.667$ to information about the GW query completion message. Meanwhile, the aforementioned information about the ratio is an example of the "satisfaction level."

[0050] Then, the retrieval application **152** receives GW query completion messages with respect to all the controlled gateways and determines success or failure in the query on the basis of the received GW query completion messages.

[0051] FIG. **6** is a diagram illustrating an example of the device query management table **242** having processing states obtained from the controlled gateway **200**. For example, the server **100** is assumed to have three gateways GW1 to GW3 under the control thereof. In addition, it is assumed that a certain gateway ID "GW-1" corresponds to a gateway which fails in query processing in one of three devices **300** under the control thereof. In this case, a satisfaction level corresponding to the gateway ID "GW-1" is 0.667. In addition, the gateways corresponding to other gateway IDs "GW-2" and "GW-3" obtain normal processing results from all the devices **300** under the control thereof. Accordingly, the satisfaction levels corresponding to the gate IDs "GW-2" and "GW-3" become 1. Accordingly, a total satisfaction level of the query results becomes $2.667/3 \approx 0.89$, which is obtained by dividing the sum of all satisfaction levels of the respective gateways **200** by the number of gateways **200**.

[0052] Here, the retrieval application **152** determines that the query has succeeded when the satisfaction level of the query is equal to or greater than a predetermined threshold value (e.g., 0.8). In this case, the aforementioned value 0.89 exceeds 0.8 and thus the retrieval application **152** determines that the query has succeeded.

[0053] Here, although the above-described process obtains a satisfaction level of a query result for each gateway **200**, embodiments of the present invention are not limited thereto. For example, the gateway **200** may obtain a satisfaction level depending on the number of devices **300** under the control thereof. In this case, the gateway **200** transmits a satisfaction level Sn of a query result and the number Nn of devices under the control thereof (e.g., n refers to n-th) to the server **100**.

[0054] The retrieval application **152** of the server **100** divides the sum of products of the satisfaction levels Sn of query results of the gateways **200** and the number Nn of devices under the control thereof by the sum of the number Nn of devices ($\Sigma(Sn \times Nn)/\Sigma Nn$), and when the divided value is equal to or greater than a threshold value, determines that the corresponding query has succeeded.

[0055] In addition, the gateway **200** may calculate a satisfaction level on the basis of a data size of the sensor data **332** retained in the device **300**. For example, the data size may be a database size or a table size. For example, when a satisfaction level is calculated on the basis of a database size, the satisfaction level is determined by a success rate for the entire database size. In this case, the gateway **200** receives a database size Dm retained in a controlled device in advance at a query issuance time. Here, the database size can be acquired by issuing a database size acquisition query at the same time when a query is issued. The acquired database size is added to each entry of the device query management table **242**.

[0056] FIG. **7** is a diagram illustrating an example of a device query management table **242**A including database sizes. The device query management table **242**A stores a database size of the sensor data **332** of the device **300** corresponding to each device ID in addition to query IDs, device IDs and processing states.

[0057] The gateway **200** transmits, to the server **100**, the sum En(=ΣDm' (m' indicates devices **300** that have succeeded)) of database sizes retained in devices **300** that have succeeded in the query and the sum Dn(=ΣDm) of database sizes retained in devices **300** required to process the query when the query is complete. The server **100** acquires a satisfaction level of a query result by calculating "ΣEn/ΣDn" on the basis of the two obtained values. Here, the aforementioned satisfaction level of the query result may be calculated in the gateway **200** and the calculated result may be transmitted to the server **100**.

[0058] Furthermore, when a satisfaction level of a query result is calculated on the basis of a table size related to a query, the gateway **200** acquires a table size Tm of a table related to the query in advance. The acquired table size is added to each entry of the device query management table **242**.

[0059] FIG. **8** is a diagram illustrating an example of a device query management table **242**B including table sizes. The device query management table **242**B stores a table size of the device **300** corresponding to each device ID in addition to query IDs, device IDs and processing states.

[0060] The gateway **200** transmits, to the server **100**, the sum Tn(=ϵTm') of table sizes related to devices **300** that have succeeded in the query and the sum Un(=ΣTm) of table sizes related to devices **300** required to process the query.

[0061] The server **100** acquires a satisfaction level of a query result by calculating "ΣTn/ΣUn" on the basis of the two obtained values. The aforementioned satisfaction level of the query result may be calculated in the gateway **200** and the calculated result may be transmitted to the server **100**. Meanwhile, in the above-described methods of calculating a satisfaction level of a query result in consideration of a database size and a table size, the aforementioned query result satisfaction level can easily be calculated in the case of a data structure having a fixed length, and the like because data sizes can be communized. Furthermore, it is possible to more appropriately determine whether the query result is successful on the basis of the aforementioned query result satisfaction level acquired using a data size.

[0062] In addition, in embodiments, it is possible to extract devices **300** from a plurality of devices **300** under the control of the gateway **200** in accordance with a predetermined group condition, form at least one group using the extracted devices, execute a query in units of formed groups, and calculate a satisfaction level or the like. For example, the predetermined group condition may be an area, or the type and numbers of devices **300**. Furthermore, in embodiments, grouping may be performed on device IDs basis or on gateway IDs basis.

[0063] For example, an administrator or the like of the server **100** sets grouping such as "all devices **300** in Kawasaki" in advance. The message broker **410** of the server side includes information for identifying a group in a query to be transmitted and transmits the query to the gateway **200**. Accordingly, the message broker **420** of the gateway side can transmit the query only to devices **300** included in the set group.

[0064] Next, content of various processes of the server **100** of the embodiments will be described in detail using a flowchart. FIG. **9** is a flowchart illustrating an example of content of a process in the server **100** of embodiments. The process illustrated in FIG. **9** is repeatedly performed whenever a query is executed.

[0065] In the example of FIG. **9**, the retriever **110** issues a query to be executed (step S**100**) and generates a query ID corresponding to the issued query (step S**102**).

[0066] Then, the distributor **120** initializes a GW query management table and distributes the query ID and the query to the gateway **200** (step S**104**). Subsequently, the processing state receptor **130** determines whether a processing result with respect to the query or a GW query completion message is received from the gateway **200** (step S**106**).

[0067] When the processing result with respect to the query (query result) or the GW query completion message is received from the gateway **200**, the processing state receptor **130** determines whether the processing result is received (step S**108**). When the processing result is received, the processing state receptor **130** stores the received processing result in the storage **150** (step S**110**). In addition, when the processing result is not received in step S**108**, the GW query completion message is received and thus the processing state receptor **130** stores the GW query completion message in the GW query management table (step S**112**). For example, the GW query completion message is a satisfaction level corresponding to the gateway **200**.

[0068] After the processes of step S**110** and step S**112**, the processing state receptor **130** determines whether GW query completion messages are received from all the gateways **200** or a timeout error is generated (step S**114**). With respect to the timeout error, for example, a time from distribution of the query to the gateways **200** until the GW query completion messages are received is set and excess of the time is determined as a timeout error.

[0069] When the GW query completion messages are received from all the gateways **200** or the timeout error is generated, the completion determiner **140** calculates a satisfaction level in the entire query (step S**116**) and determines success or failure of the query on the basis of the calculated value and a threshold value (step S**118**). For example, when the calculated satisfaction level of the query result is equal to or greater than the threshold value, it is possible to

determine that the query has succeeded. Accordingly, the process of this flowchart ends.

[0070] On the other hand, when the GW query completion messages are not received from all the gateways or the timeout error is not generated in the aforementioned process of step S**114**, the processing state receptor **130** waits for a predetermined time (step S**120**) and returns to the process of step S**106**.

[0071] Next, content of various processes of the gateway **200** of embodiments will be described in detail using a flowchart. FIG. **10** is a flowchart illustrating an example of content of a process in the gateway **200** of the embodiments. The process illustrated in FIG. **10** is repeatedly executed whenever the gateway **200** receives a query distributed from the server **100**.

[0072] In the example of FIG. **10**, the transceiver **210** receives information about a query and a query ID from the server **100** (step S**200**). Then, the process manager **220** causes the transceiver **210** to transmit the query to all the controlled devices **300** (step S**202**). Subsequently, the process manager **220** creates the device query management table **242** on the basis of the received query ID (step S**204**).

[0073] Thereafter, the process manager **220** determines whether a query processing result or a query processing completion message is received from the device **300** (step S**206**). When the query processing result or the query processing completion message is received, the process manager **220** determines whether the received information is the query processing completion message (step S**208**). If the received information is not the query processing completion message, the received information is the query processing result and thus the transceiver **210** transmits the query processing result to the server **100** (step S**210**) and returns to the process of step S**206**.

[0074] When the received information is the query processing completion message (step S**208**), the process manager **220** stores the received query processing completion message in the device query management table **242** (step S**212**).

[0075] Then, the process manager **220** determines whether query processing completion messages of all the devices **300** are gathered or a timeout error is generated (step S**214**). When the query processing completion messages of all the devices **300** are gathered or the timeout error is generated, the processing state transmission controller **230** calculates a satisfaction level with respect to query results in the controlled devices **300** (step S**216**) and causes the transceiver **210** to transmit a GW query completion message including the satisfaction level of the query results to the server **100** (step S**218**). Accordingly, the process of this flowchart ends.

[0076] Meanwhile, when the query processing completion messages from all the devices **300** are not gathered and the timeout error is not generated in the aforementioned process of step S**214**, the process manager **220** waits for a predetermined time (step S**220**) and returns to the process of step S**206**.

[0077] Next, content of various processes of the device **300** of embodiments will be described in detail using a flowchart. FIG. **11** is a flowchart illustrating an example of content of a process in the device **300** of embodiments. The process illustrated in FIG. **11** is repeatedly executed whenever the device **300** receives a query transmitted from the gateway **200**.

[0078] In the example of FIG. **11**, when a query is received from the gateway **200**, the query executioner **320** executes the received query (step S**300**). Then, the query executioner **320** determines whether a data amount acquired as a processing result of the query is equal to or greater than a predetermined amount (step S**302**). For example, the predetermined amount is a data amount standardized in transmitted messages, but the present invention is not limited thereto. When the data amount is equal to or greater than the predetermined amount, the query executioner **320** divides the data amount acquired as the processing result into a plurality of pieces of data (step S**304**).

[0079] Subsequently, the transceiver **310** transmits the query processing result to the gateway (step S**306**). In the aforementioned process of step S**304**, when the data is divided, the transceiver **310** transmits the query processing result to the gateway **200** for each piece of the divided data.

[0080] Thereafter, the query executioner **320** determines whether all query processing results are transmitted (step S**308**). When all the query processing results are not transmitted, the process returns to step S**302**. In addition, when all the query processing results are transmitted, a query completion message is transmitted to the gateway **200** (step S**310**). Accordingly, the process of this flowchart ends.

[0081] Here, for example, when a certain device **300** is down or disconnected during C transmission in the data retrieval system **1** of embodiments, the processing state receptor **130** may regard part of query results transmitted so far to be valid or invalid. In addition, the data retrieval system **1** may install a bridge process instead of the aforementioned query control process **430** illustrated in FIG. **4** in the gateway **200** and buffer query results from the device **300**. In this case, the gateway **200** temporarily retains query results according to the bridge process and, when a query processing completion message is received from the device **300**, transmits the retained query results collectively to the server **100**. Accordingly, the server **100** can acquire all query results for each device **300** and thus the accuracy of a query result satisfaction level can be improved.

[0082] For example, it is possible to perform the following determination by using the data retrieval system **1** of the above-described embodiments. For example, the retriever **110** of the server **100** causes the gateway **200** to distribute a query for acquiring a power consumption amount of the present time with respect to the device **300**. In addition, it is assumed that the server **100** has acquired 90% of devices **300** in an area to which the query has been distributed from the gateway **200**. Since 90% is equal to or greater than a preset threshold value (e.g., 80%), the completion determiner **140** of the server **100** determines that this query has succeeded.

[0083] Furthermore, when the total power consumption amount of 90% of the devices **300** is 1.2 [MWh], the completion determiner **140** estimates that the total power consumption amount of all devices **300** is $1.2 \times 10/9 \approx 1.33$ [MWh]. In addition, the completion determiner **140** compares the estimated power consumption amount with a threshold value with respect to power consumption amounts to determine whether excessive electric power is used. For example, when the estimated power consumption amount is equal to or greater than the threshold value, the completion determiner **140** determines that excessive electric power is used and may perform a process of temporarily increasing a power-saving cooperation charge, and the like. Hence,

according to the data retrieval system **1** of embodiments, since general conditions of a power consumption amount of the present time, for example, can be acquired, even if some query results are not obtained, it is possible to perform an appropriate process for the entire system by recognizing general conditions in a certain range.

[0084] Further, when query results from only 70% of the devices **300** of the area to which the query has been distributed are acquired from the gateway **200** in the above-described example, the percentage is equal to or lower than the threshold value (e.g., 80%), and thus the completion determiner **140** of the server **100** determines that this query has failed and does not perform the subsequent process. Accordingly, the data retrieval system **1** can suppress processes using unreliable data and thus the processing load of the entire system can be reduced.

[0085] According to at least one of the above-described embodiments, the data retrieval system **1** includes: the server **100**; and the gateway **200**, wherein the server **100** has the distributor **120** that distributes a query to one or more devices **300** capable of retaining data, the processing state receptor **130** that receives, from the gateway **200**, information indicating processing states of the one or more devices **300** with respect to the query, and the completion determiner **140** that determines whether the query is completed from the processing states received by the processing state receptor **130**, and the gateway **200** has the transceiver **210** that receives the query distributed by the server **100** and transmits the query to the one or more devices **300**, the process manager **220** that manages a processing state indicating whether each of the one or more devices completes the query on the basis of a query processing result of each of the one or more devices **300** that is received through the transceiver **210**, and the processing state transmission controller **230** that transmits query processing states managed by the process manager **220** to the server **100** using the transceiver **210**, and thus data distributed to the devices **300** can be retrieved with high efficiency and the processing load of the server **100** can be reduced.

[0086] Specifically, according to at least one of the embodiments, the server **100** can perform query management in the gateway **200**. In addition, according to at least one of the embodiments, it is possible to rapidly recognize whether a query has succeeded on the basis of a satisfaction degree calculated for each gateway **200**. Accordingly, the server **100** need not manage processing states of all devices **300**. Therefore, the processing load of the server **100** can be reduced.

[0087] Furthermore, according to at least one of the embodiments, it is possible to rapidly perform parallel retrieval processes for a plurality of devices **300**. In addition, according to at least one of the embodiments, it is possible to appropriately manage "quality" with respect to query results. Moreover, according to at least one of the embodiments, it is possible to manage which device completes query processing and to determine the reliability of a query result.

[0088] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

1. A data retrieval system comprising a first apparatus and a second apparatus,

wherein the first apparatus comprises:

a distributor which distributes a query to one or more devices that are able to retain data;

a processing state receptor which receives, from the second apparatus, information indicating processing states of the one or more devices for the query; and

a completion determiner which determines whether the query is complete from the processing state received by the processing state receptor, and

the second apparatus comprises:

a transceiver which receives a query distributed by the first apparatus and transmits the query to the one or more devices;

a process manager which manages a processing state indicating whether each of the one or more devices completes the query on the basis of a processing result of the query of each of the one or more devices received by the transceiver; and

a processing state transmission controller which transmits processing states of the query managed by the process manager to the first apparatus using the transceiver.

2. The data retrieval system according to claim **1**, wherein the process manager calculates a satisfaction level with respect to a result of the query on the basis of a ratio of devices which complete a process for the query from among the one or more devices to which the query has been transmitted, and

the processing state transmission controller transmits the satisfaction level to the first apparatus as the processing state using the transceiver.

3. The data retrieval system according to claim **2**, wherein the completion determiner determines whether the query has succeeded on the basis of a satisfaction degree with respect to the result of the query of the second apparatus.

4. The data retrieval system according to claim **2**, wherein the completion determiner determines that the query has succeeded when a value obtained by dividing a total sum of satisfaction degrees with respect to results of the query of each of the second apparatus by the number of second apparatuses is equal to or greater than a threshold value.

5. The data retrieval system according to claim **2**, wherein the processing state transmission controller transmits information about the number of one or more devices to which the query has been transmitted together with the satisfaction degree as the processing state to the first apparatus using the transceiver, and

the completion determiner determines that the query has succeeded when a value obtained by dividing the sum of products of satisfaction degrees of each of the second apparatus and the number of devices by the number of devices is equal to or greater than a threshold value.

6. The data retrieval system according to claim **2**, wherein the process manager calculates a satisfaction degree with respect to the result of the query on the basis of a data size of data retained in each of the one or more devices and a data size of data retained in a device which completes a process for the query.

7. The data retrieval system according to claim 1, wherein the distributor distributes the query to devices grouped in accordance with a predetermined group condition among the one or more devices that are able to retain data.

8. A data retrieval method comprising:

by a first apparatus,

distributing a query to one or more devices that are able to retain data;

receiving, from a second apparatus, information indicating processing states of the one or more devices for the query; and

determining whether the query is complete from the received processing state, and

by the second apparatus,

receiving a query distributed by the first apparatus and transmitting the query to the one or more devices;

managing a processing state indicating whether each of the one or more devices completes the query on the basis of a processing result of the query of each of the one or more devices received from the one or more devices; and

transmitting managed processing states of the query to the first apparatus.

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