US 20140250061A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2014/0250061 A1
Zoltan et al. (43) Pub. Date: Sep. 4, 2014

(54) SYSTEM AND METHOD FOR ACCESSING INFORMATION IN A REPLICATED DATABASE

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(21) Appl. No.: **14/181,288**

(22) Filed: **Feb. 14, 2014**

Related U.S. Application Data

(63) Continuation of application No. 11/211,320, filed on Aug. 25, 2005, now Pat. No. 8,682,847, which is a continuation of application No. 10/042,034, filed on Oct. 19, 2001, now Pat. No. 6,938,031.

Publication Classification

(51) **Int. Cl.**
G06F 17/30 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 17/30575*** (2013.01); ***G06F 17/30864*** (2013.01)
USPC **707/615**

(57) **ABSTRACT**

A method for accessing information in a replicated database may include receiving a request for information in a database. The request may be associated with a table in the database. The table may include a plurality of identifiers each identifying a portion of the information in the table. The method may also include executing a logical structure associated with the table to produce a logical view of the table. The logical view may contain at least a portion of the information from the table, without containing the identifiers. The method may further include identifying the requested information in the logical view, and communicating the identified requested information in the logical view.

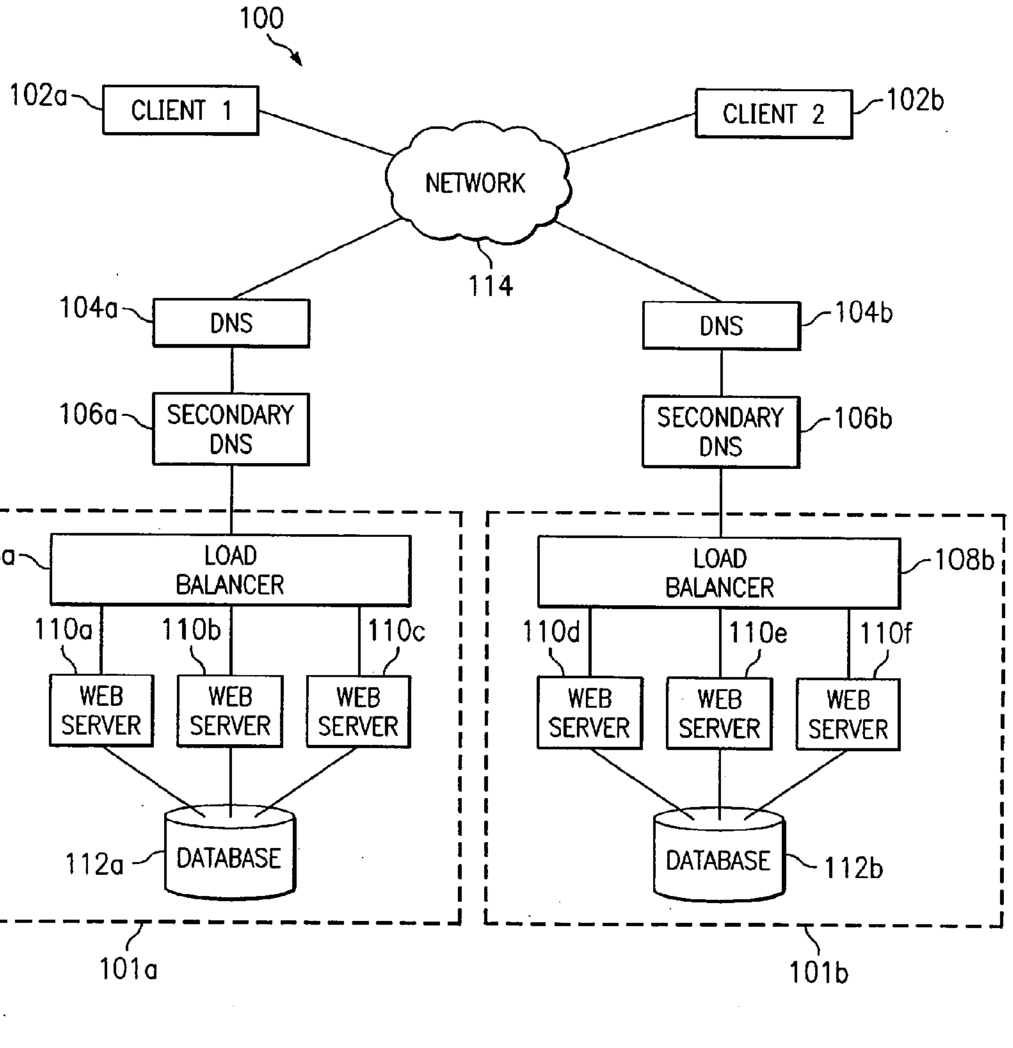


FIG. 1

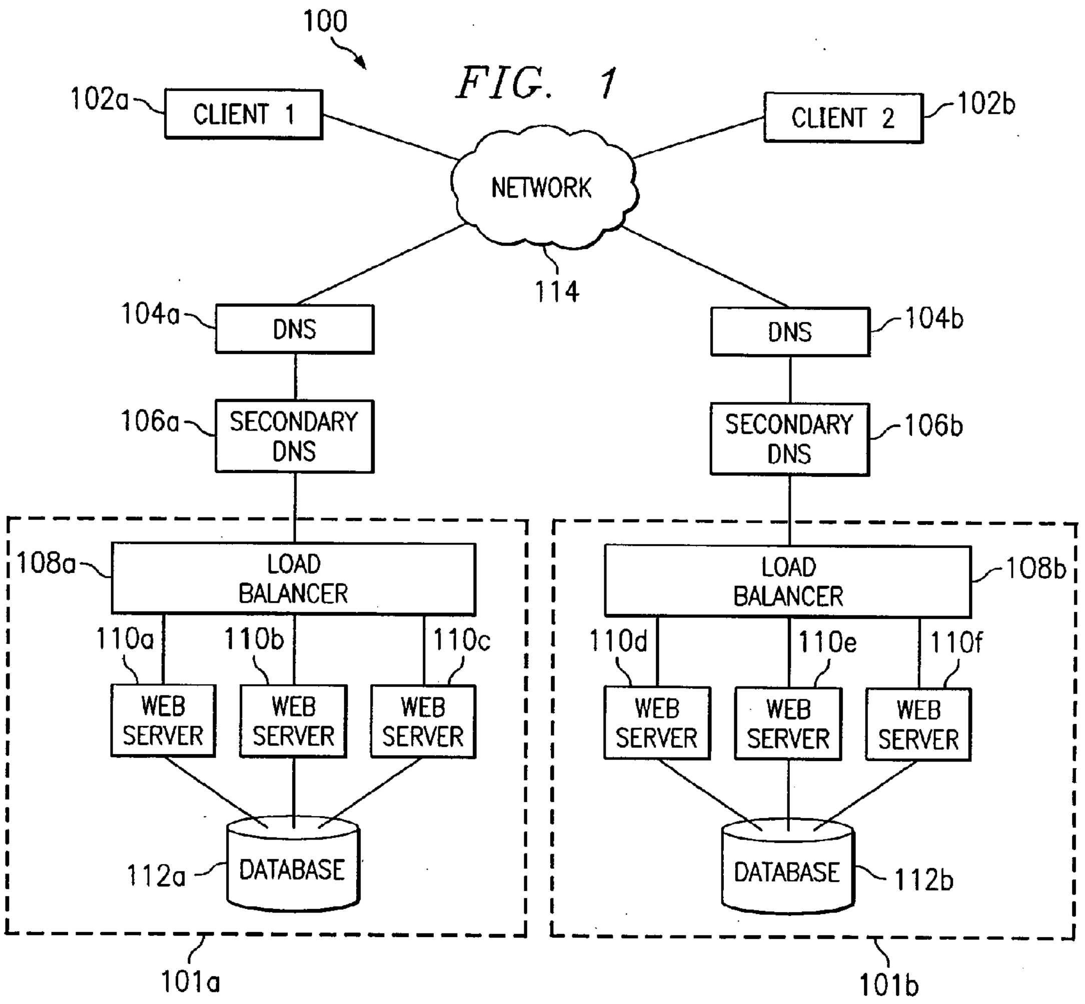


FIG. 7

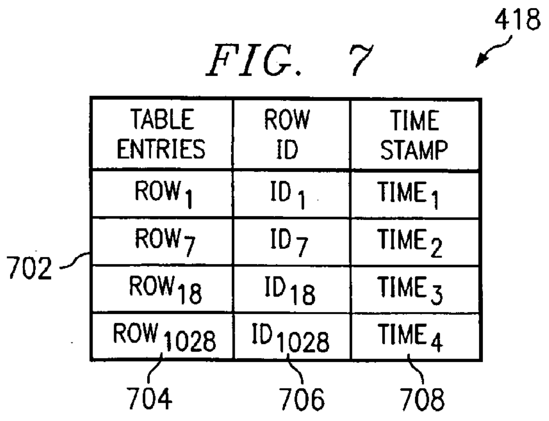

418
702
704
706
708

TABLE ENTRIES	ROW ID	TIME STAMP
ROW_1	ID_1	$TIME_1$
ROW_7	ID_7	$TIME_2$
ROW_{18}	ID_{18}	$TIME_3$
ROW_{1028}	ID_{1028}	$TIME_4$

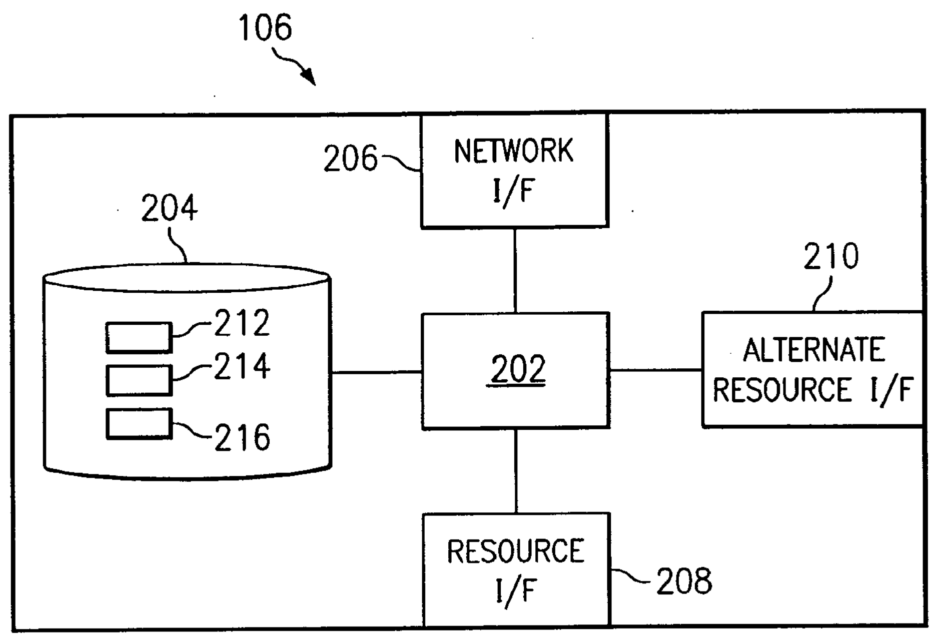

106
206
NETWORK I/F
204
212
214
216
202
210
ALTERNATE RESOURCE I/F
RESOURCE I/F
208

FIG. 2

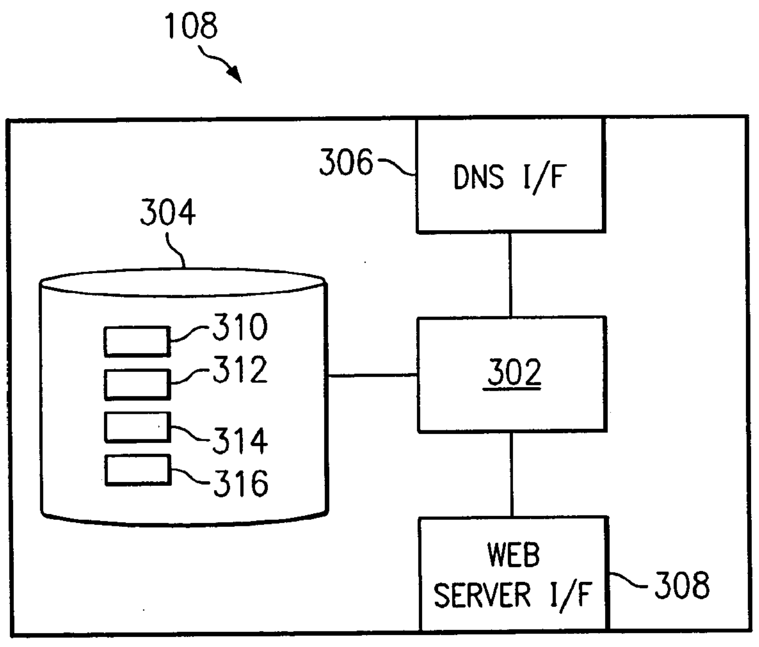

108
306
DNS I/F
304
310
312
314
316
302
WEB SERVER I/F
308

FIG. 3

FIG. 4

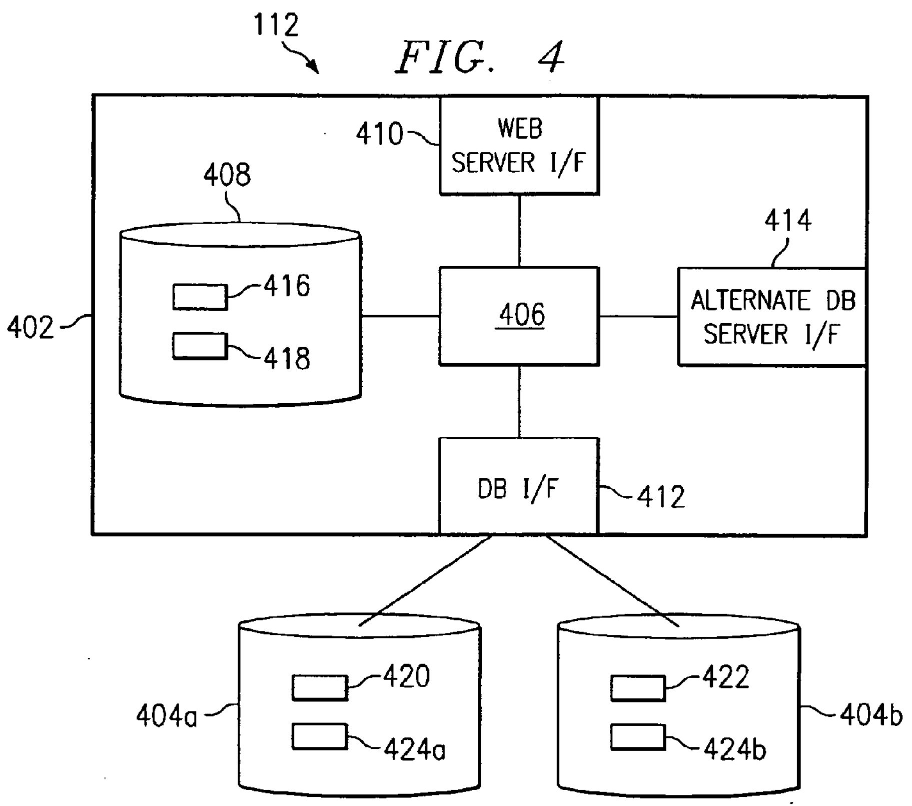


FIG. 5

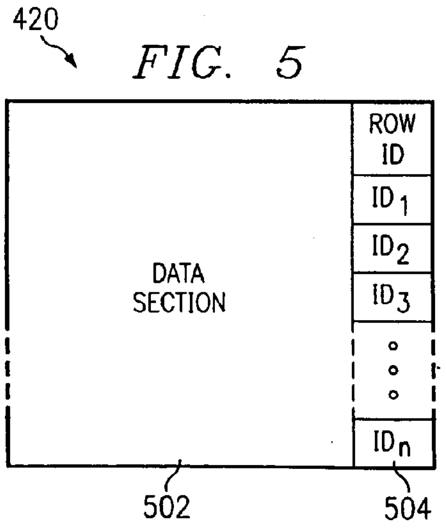
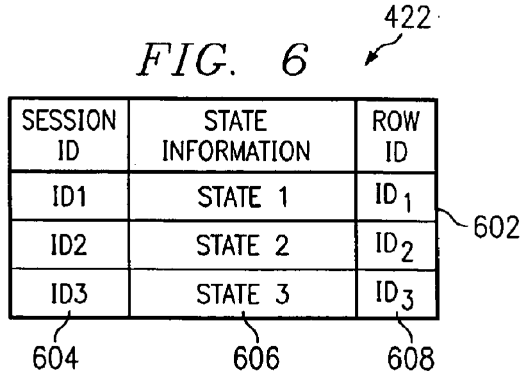


FIG. 6


422
602
604
606
608

SESSION ID	STATE INFORMATION	ROW ID
ID1	STATE 1	ID_1
ID2	STATE 2	ID_2
ID3	STATE 3	ID_3

FIG. 9

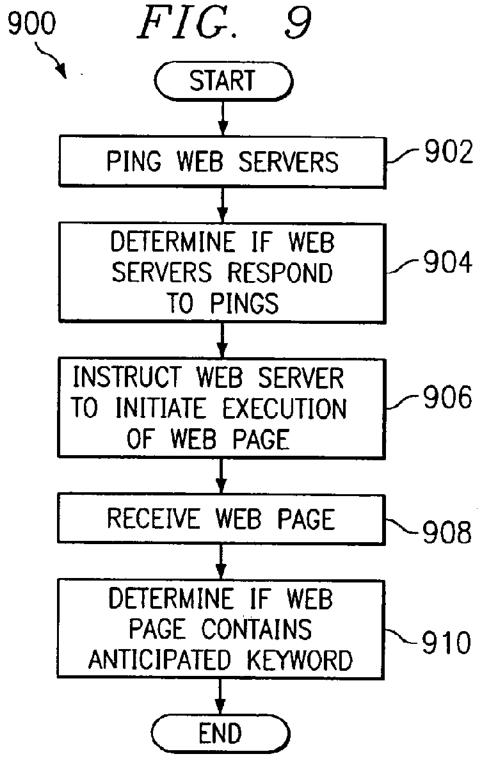

900
START
PING WEB SERVERS
902
DETERMINE IF WEB SERVERS RESPOND TO PINGS
904
INSTRUCT WEB SERVER TO INITIATE EXECUTION OF WEB PAGE
906
RECEIVE WEB PAGE
908
DETERMINE IF WEB PAGE CONTAINS ANTICIPATED KEYWORD
910
END

FIG. 8

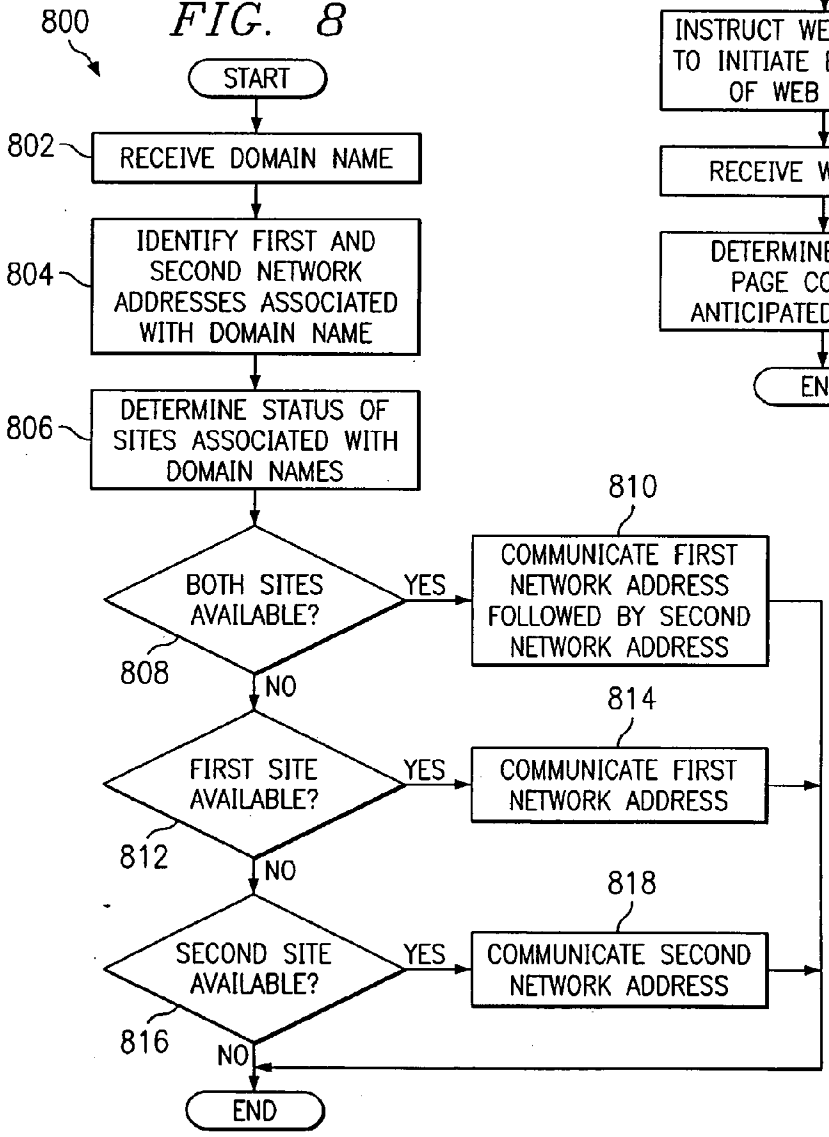

800
START
802
RECEIVE DOMAIN NAME
804
IDENTIFY FIRST AND SECOND NETWORK ADDRESSES ASSOCIATED WITH DOMAIN NAME
806
DETERMINE STATUS OF SITES ASSOCIATED WITH DOMAIN NAMES
BOTH SITES AVAILABLE?
808
YES
NO
810
COMMUNICATE FIRST NETWORK ADDRESS FOLLOWED BY SECOND NETWORK ADDRESS
FIRST SITE AVAILABLE?
812
YES
NO
814
COMMUNICATE FIRST NETWORK ADDRESS
SECOND SITE AVAILABLE?
816
YES
NO
818
COMMUNICATE SECOND NETWORK ADDRESS
END

FIG. 10

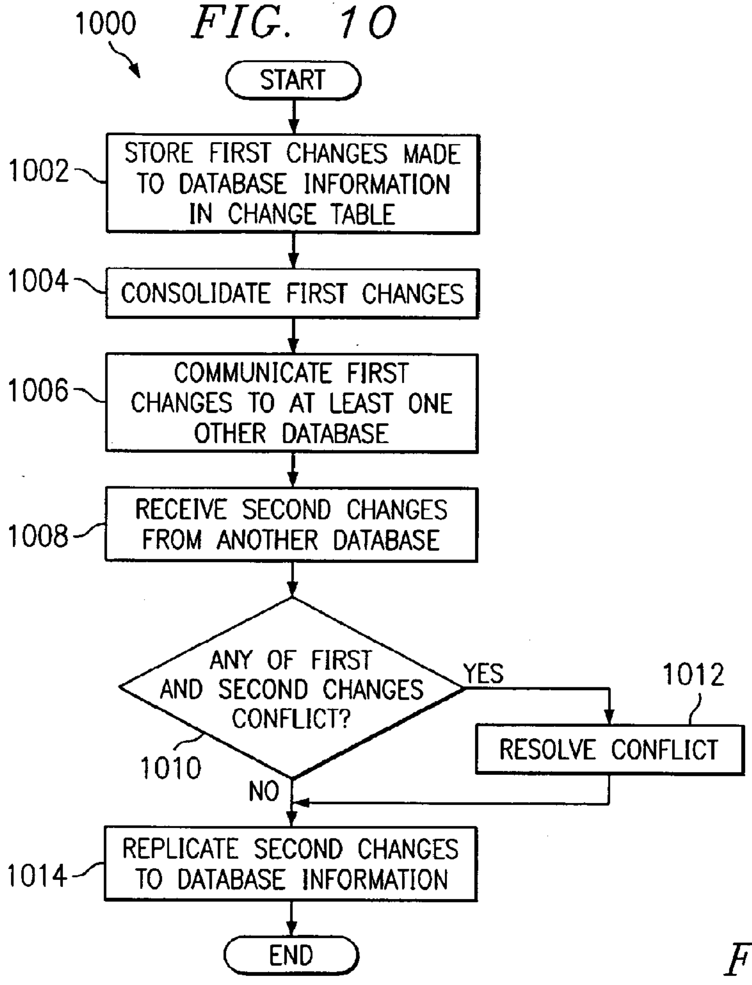
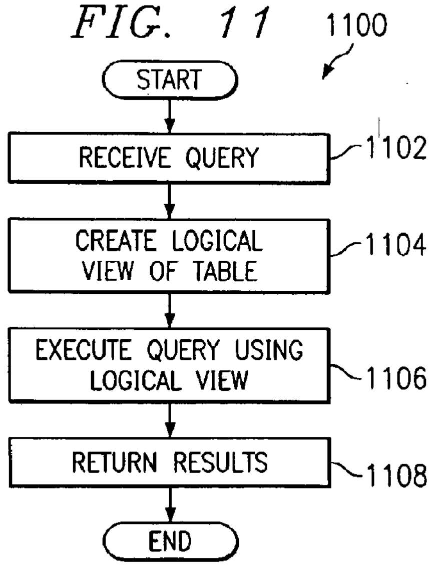

1000
START
1002
STORE FIRST CHANGES MADE TO DATABASE INFORMATION IN CHANGE TABLE
1004
CONSOLIDATE FIRST CHANGES
1006
COMMUNICATE FIRST CHANGES TO AT LEAST ONE OTHER DATABASE
1008
RECEIVE SECOND CHANGES FROM ANOTHER DATABASE
ANY OF FIRST AND SECOND CHANGES CONFLICT?
1010
YES
1012
RESOLVE CONFLICT
NO
1014
REPLICATE SECOND CHANGES TO DATABASE INFORMATION
END

FIG. 11


1100
START
RECEIVE QUERY
1102
CREATE LOGICAL VIEW OF TABLE
1104
EXECUTE QUERY USING LOGICAL VIEW
1106
RETURN RESULTS
1108
END

SYSTEM AND METHOD FOR ACCESSING INFORMATION IN A REPLICATED DATABASE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 11/211,320, filed Aug. 25, 2005, titled "System and Method for Accessing Information in a Replicated Database," the contents of which are incorporated herein by reference in their entirety; which itself is a continuation of U.S. patent application Ser. No. 10/042,034, filed Oct. 19, 2001, titled "System and Method for Accessing Information in a Replicated Database" (now U.S. Pat. No. 6,938,031); and is related to U.S. patent application Ser. No. 10/039,909, filed Oct. 19, 2001, titled "System and Method for Multi-Site Clustering in a Network" (now U.S. Pat. No. 7,000,016).

TECHNICAL FIELD

[0002] This invention relates generally to the field of information systems, and more particularly to a system and method for accessing information in a replicated database.

BACKGROUND

[0003] In a typical network, multiple databases may be used to store information used by clients accessing a web site. For example, one database may be used by one set of web servers in the network, and another database may be used by another set of web servers in the network. A client may access the information in one of the databases and change the information. A similar change then typically needs to be made in the other database to keep the information in the databases synchronized. Some techniques for database synchronization involve adding additional information to the tables in the database.

SUMMARY

[0004] In accordance with the present invention, a system and method for accessing information in a replicated database are provided that substantially eliminate or reduce disadvantages and problems associated with conventional systems.

[0005] In one embodiment of the invention, a method for accessing information in a replicated database includes receiving a request for information in a database. The request is associated with a table in the database. The table includes a plurality of identifiers each identifying a portion of the information in the table. The method also includes executing a logical structure associated with the table to produce a logical view of the table. The logical view contains at least a portion of the information from the table without containing the identifiers. The method further includes identifying the requested information in the logical view, and communicating the identified requested information in the logical view.

[0006] Numerous technical advantages are provided according to various embodiments of the present invention. Particular embodiments of the invention may exhibit none, some, or all of the following advantages depending on the implementation. For example, in one embodiment, a system for accessing information in a replicated database is provided. In a particular embodiment, tables of information in the database include identifiers that identify different portions of information in the database. The identifiers may, for example, be row identifiers that identify rows of information in the database tables. A logical structure in the database may create a logical view of a table. The logical view of the table extracts the information from the table without extracting the row identifiers. A user or an application may then retrieve information using the logical view of the table. This helps to prevent the user or the application from retrieving the row identifiers from the table.

[0007] Another advantage of at least some embodiments of the invention is that a user or an application need not know that the database tables include the additional identifiers. For example, an application may attempt to access a table having five columns of information. The presence of an additional column containing row identifiers may cause errors in the application. Also, an application may attempt to retrieve all information from a database table, which would include the row identifiers. Rewriting the application to retrieve all but the row identifier column would be time consuming and impractical. If the application may be executed in systems that have either replicated or non-replicated databases, different versions of the same application would need to be created for each system. The use of the logical view to extract the information from a database table reduces the need to rewrite the applications, which saves time and money in the development process.

[0008] Other technical advantages are readily apparent to one of skill in the art from the attached figures, description, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] To provide a more complete understanding of the present invention and features and advantages thereof, reference is made to the following description in conjunction with the accompanying drawings, in which:

[0010] FIG. **1** is a block diagram illustrating an example system for multi-site clustering in a network;

[0011] FIG. **2** is a block diagram illustrating an example domain name server;

[0012] FIG. **3** is a block diagram illustrating an example load balancer;

[0013] FIG. **4** is a block diagram illustrating an example database;

[0014] FIG. **5** is a block diagram illustrating an example data table;

[0015] FIG. **6** is a block diagram illustrating an example state information table;

[0016] FIG. **7** is a block diagram illustrating an example change table;

[0017] FIG. **8** is a flow diagram illustrating an example method for multi-site clustering in a network;

[0018] FIG. **9** is a flow diagram illustrating an example method for determining the status of components of a network site;

[0019] FIG. **10** is a flow diagram illustrating an example method for database replication in a network;

[0020] FIG. **11** is a flow diagram illustrating an example method for accessing information in a replicated database.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0021] FIG. **1** is a block diagram illustrating an example system **100** for multi-site clustering in a network. In the illustrated embodiment, system **100** includes clients **102**, domain name servers (DNS) **104**, secondary domain name servers **106**, load balancers **108**, web servers **110**, and databases **112**. Other embodiments of system **100** may be used without departing from the scope of the present invention.

[0022] In one aspect of operation, a domain name may be associated with multiple network addresses in network **114**. Each network address may correspond to a different site **101** in system **100**. When a client **102** attempts to communicate using a domain name, the domain name server **104** and/or secondary domain name server **106** may communicate one, multiple, or none of the network addresses to client **102**. For example, in a particular embodiment, a secondary domain name server **106***a* may monitor the status of another secondary domain name server **106***b* and the status of the components of a site **101***a*. The secondary domain name server **106***a* may then communicate one, both, or neither network address to client **102**, depending on the status of the other secondary domain name server **106***b* and the status of the components in site **101***a*. For example, if the components of the site **101***a* and the other secondary domain name server **106***b* are operational and able to serve clients **102**, secondary domain name server **106***a* may communicate both network addresses to client **102**. If site **101***a* is unable to serve clients **102** because one or more components are unavailable, secondary domain name server **106***a* may communicate the network address of site **101***b* to client **102**. This allows secondary domain name servers **106** to direct clients **102** to a first site **101***a* when the components serving that site **101***a* are available, and then redirect clients **102** to a second site **101***b* when the first site **101***a* becomes unavailable. This helps to ensure that secondary domain name servers **106** direct clients **102** to a working network address in network **114**.

[0023] In another aspect of operation, changes to the data in one database **112** may be replicated in the other database **112**, which helps to ensure that clients **102** have access to the same data no matter which site **101** the clients **102** are accessing. The information replicated may include state information associated with clients **102**, which helps to ensure that the state **30** information for a client **102** may be maintained when one of the sites **101** becomes unavailable.

[0024] In yet another aspect of operation, in one embodiment, the information stored in databases **112** is associated with identifiers, such as row identifiers, to facilitate database synchronization. In this embodiment, a database **112** may use logical structures to extract information from the database **112** without extracting the row identifiers. The extracted information may then be provided to users or applications, such as applications executed by web servers **110**. This reduces the likelihood that the row identifiers will be processed by web servers **110** and/or shown to clients **102**. This also reduces the need to rewrite the applications executed by web servers **110** to filter out or otherwise ignore the row identifiers.

[0025] Client **102** is coupled to network **114**. In this document, the term "couple" refers to any direct or indirect communication between two or more elements in system **100**, whether or not those elements are in physical contact with one another. Client **102** may communicate over network **114**. For example, client **102** may communicate information to and/or receive information from various servers and other computing devices coupled to network **114**. In one embodiment, client **102** may communicate with the computing devices in network **114** using domain names. For example, client **102** may submit a domain name to a domain name server **104** and receive one or more network addresses associated with the domain name. In one embodiment, a network address represents the Internet Protocol (IP) address of a computing device in network **114**, although any other suitable network addresses may be used. Client **102** may use a network address to communicate with a server or other computing device at that network address. Client **102** may include any hardware, software, firmware, or combination thereof that facilitates communication over network **114**. In one embodiment, client **102** may include a browser capable of displaying information to and collecting information from a user. In a particular embodiment, the browser may submit a domain name to domain name server **104** and receive multiple network addresses associated with the domain name. In this embodiment, the browser may attempt to communicate with a server or other computing device at the network address received first. If communication with that network address fails, such as when a connection cannot be established with the computing device or the attempt times out, the browser may attempt to communicate with a server or other computing device at the network address received second.

[0026] Domain name server **104** is coupled to network **114**. Domain name server **104** may receive a domain name from a client **102** over network **114**. Domain name server **104** may access a database, retrieve one or more network addresses associated with the domain name, and communicate the network addresses to client **102**. Domain name server **104** may also determine that secondary domain name server **106** is responsible for identifying the network address or addresses associated with the domain name, and domain name server **104** may communicate the domain name to secondary domain name server **106**. Domain name server **104** may include any hardware, software, firmware, or combination thereof that receives domain names and identifies associated network addresses.

[0027] In one embodiment, one of the domain name servers **104** acts as a primary domain name server. In this embodiment, clients **102** may first attempt to communicate with the primary domain name server **104**. Clients **102** may attempt to communicate with another domain name server **104** if communication with the primary domain name server **104** fails. Other arrangements may be used in system **100** without departing from the scope of the present invention.

[0028] Secondary domain name server **106** is coupled to domain name server **104** and load balancer **108**. Secondary domain name server **106** may also be coupled to network **114**. Secondary domain name server **106** may receive a domain name from domain name server **104** and determine which network address or addresses, if any, to communicate to client **102**. For example, if load balancer **108***a* is available to serve a client **102**, secondary domain name server **106***a* may communicate the network address of load balancer **108***a* to client **102**. If another secondary domain name server **106***b* is also available, secondary domain name server **106***a* may communicate the network address of secondary domain name server **106***b* to client **102**. Client **102** may use the network addresses to communicate with one or both of load balancer **108***a* and secondary domain name server **106***b*. In another embodiment, the network addresses communicated to client **102** may represent a virtual IP (VIP) address associated with a site **101**. If load balancer **108**, at least one web server **110**, and database **112** in a site **101** are available, the VIP address associated with that site **101** is communicated to client **102**. Client **102** may then attempt to access one of the web servers **110** in one of the sites **101** using a VIP address. Client **102** may be directed to the load balancer **108** associated with that site **101**, which would direct client **102** to one of the web servers **110**. Although the following descriptions may describe secondary domain name server **106** communicating the 30 network address of a load balancer **108** and/or another secondary domain name server **106** to a client **102**, secondary domain name server **106** could also communicate the VIP address associated with an available site **101** to client **102** without departing from the scope of the present invention.

[0029] Secondary domain name servers **106** may determine which network addresses to communicate to clients **102** using any suitable criteria. In one embodiment, the address or addresses communicated to client **102** by a secondary domain name server **106** depend, at least in part, on the status of the components in a site **101**. As particular examples, secondary domain name server **106** may communicate the network address of a load balancer **108** to client **102** when load balancer **108**, at least one web server **110**, and database **112** in a site **101** are available. If load balancer **108**, web servers **110**, and/or database **112** become unavailable, secondary domain name server **106** may determine that the network address associated with that site **101** should not be communicated to client **102**. One secondary domain name server **106*a*** may also communicate the network address of another secondary domain name server **106*b*** to client **102** when the other secondary domain name server **106*b*** is available. For example, each secondary domain name server **106** may communicate a signal to the other secondary domain name server **106** during regular intervals. These signals allow each secondary domain name server **106** to determine whether the other secondary domain name server **106** is available. If one secondary domain name server **106** becomes unavailable, the network address associated with the unavailable secondary domain name server **106** may not be communicated to client **102**. In this document, the term "unavailable" refers to the inability of a component in system **100** to communicate with, establish a connection with, and/or maintain a connection with a client **102**. A component may be unavailable due to power failure, failure of a hardware subsystem, software errors, communication link breakdowns, or any other condition or conditions that interrupt service. Also, the term "available" refers to the ability of a component in system **100** to communicate with, establish a connection with, and/or maintain a connection with a client **102**.

[0030] In addition to using the availability of the components in a site **101**, secondary domain name server **106** may identify the network address or addresses to communicate to a client **102** using the load placed on each site **101**, the response time of each site **101**, the locality of client **102** to a site **101**, and/or any other suitable factors. Secondary domain name server **106** 30 may determine which network address should be supplied first to a client **102** and which network address should be supplied second to client **102** by evaluating the various operational and other characteristics of each site **101**. For example, secondary domain name server **106** could execute a function that evaluates the different characteristics.

[0031] The order of the network addresses communicated to client **102** may determine the order in which client **102** uses the network addresses. For example, in one embodiment, client **102** attempts to communicate with the first network address received from secondary domain name server **106**. If communication with the first network address fails at some point during a session, client **102** may then attempt to communicate with the second network address. In a particular embodiment, secondary domain name servers **106** direct all clients **102** to a network address associated with one site **101**. If and when that site **101** becomes unavailable, such as due to the unavailability of load balancer **108**, web servers **110**, and/or database **112**, secondary domain name servers **106** may then direct all clients **102** to another site **101**. Other methodologies may be used without departing from the scope of the present invention. For example, secondary domain name servers **106** could direct a portion of clients **102** to one site **101** and a portion of clients **101** to another site **101**. In a particular embodiment, secondary domain name servers **106** use a round-robin approach to direct half of clients **102** to one site **101** and half of clients **102** to another site **101**. Secondary domain name servers **106** could also use the load placed on each site **101**, the response time of each site **101**, the locality of client **102** to a site **101**, and/or any other suitable factors to determine where to direct client **102**.

[0032] Secondary domain name servers **106** may include any hardware, software, firmware, or combination thereof capable of receiving domain names and identifying associated network addresses. One example embodiment of a secondary domain name server **106** is shown in FIG. **2**, which is described below. Although FIG. **1** illustrates domain name server **104** and secondary domain name server **106** as separate components in system **100**, domain name server **104** and secondary domain name server **106** may be combined into a single domain name server. In this document, the phrase "domain name server" may refer to domain name server **104**, secondary domain name server **106**, a combination of domain name server **104** and secondary domain name server **106**, and/or any other suitable domain name server.

[0033] Load balancer **108** is coupled to secondary domain name server **106** and two or more web servers **110**. Load balancer **108** may also be coupled to network **114**. Load balancer **108** may receive a request from client **102** to access a web site served by at least one of the web servers **110**. If multiple web servers **110** serve the requested web site, load balancer **108** directs the client **102** to one of the web servers **110**. For example, load balancer **108** may direct a client **102** to the web server **110** serving the least number of clients **102**. Load balancer **108** could also use a round-robin approach to directing clients **102** to web servers **110**. In this manner, load balancer **102** helps to distribute clients **102** to different web servers **110**, which helps to reduce the likelihood that an excessive number of clients **102** will be assigned to one web server **110**. Load balancer **108** may also monitor the status of the web servers **110** and/or database **112** in a site **101**. For example, load balancer **108** may determine whether any web servers **110** are available to serve a client **102** and whether web servers **110** may access database **112**. If no web servers **110** are available and/or web servers **110** cannot access database **112**, load balancer **108** may inform secondary domain name server **106** that site **101** may not serve clients **102**. Secondary domain name server **106** may then take any suitable actions, such as no longer communicating the network address of load balancer **108** to clients **102**. Load balancer **108** may include any hardware, software, firmware, or combination thereof capable of distributing clients **102** across multiple web servers **110**. One example embodiment of a load balancer **108** is shown in FIG. **3**, which is described below.

[0034] Web server **110** is coupled to load balancer **108** and database **112**. Web server **110** may also be coupled to network **114**. Web server **110** delivers information to and receives information from clients **102**. For example, web server **110** may communicate content such as web pages containing information from database **112** to client **102** over network **114**. Client **102** may also communicate information to web server **110**, such as information identifying a product that a user operating client **102** wishes to purchase. Web server **110** may also execute applications to perform different functions for or on behalf of clients **102**. For example, web server **110** may execute an application that allows web server **110** to verify credit card information supplied by a user using client **102**. In addition, web server **110** may store information in and retrieve information from database **112**. For example, in one embodiment, web server **110** may store state information associated with a communication session with a client **102** in database **112**. The state information could, for example, identify **30** the applications being executed for client **102**, the network address of client **102**, the length of a session, and the web site being viewed by client **102**. Web server **110** may include any hardware, software, firmware, or combination thereof capable of communicating with and delivering content to clients **102**.

[0035] In one embodiment, web servers **110** may also communicate with other web servers **110** to help ensure that changes to the web pages in one web server **110** are replicated to the web pages in other web servers **110**. For example, if a web page in one web server **110** is updated, that web server **110** may communicate with the other web servers **110** within that site **101** to update those web servers **110**. An updated web server **110** in one site may also communicate with the web servers **110** in another site **101** to update those web servers **110**. Web servers **110** may communicate with other web servers **110** using any suitable method and at any suitable interval. For example, web servers **110** may communicate with one another at predetermined intervals or after a change has been made to one of the web pages in a web server **110**.

[0036] Database **112** is coupled to web servers **110**. In one embodiment, database **112** stores information used by web servers **110** to provide service to clients **102**. Database **112** may store any suitable information. For example, database **112** may store information identifying products sold by a business that uses web servers **110**. Database **112** could also store information identifying customers of the business. In addition, database **112** could store state information identifying the status of a communication session with a client **102**. Any other suitable information could be stored in database **112** without departing from the scope of the present invention. In addition, databases **112** may communicate with one another to help ensure that changes to the information in one database are replicated in another database **112**. For example, if information in database **112***a* is stored in a table and three rows of the table are deleted, the same three rows in the same table in database **112***b* may also be deleted. Each database **112** monitors the changes made to the information stored in database **112** and communicates the changes to the other database **112**, thereby replicating the changes in the other database **112**. One example method for database replication is illustrated in FIG. **10**, which is described below. Database **112** may include any hardware, software, firmware, or combination thereof for storing and facilitating retrieval of information. Database **112** may reside at any suitable location that is accessible to web servers **110**. One example of database **112** is shown in FIG. **4**, which is described below.

[0037] In one embodiment, at least a portion of the information in database **112** may be stored in tables, and each row in the tables in database **112** may be assigned or otherwise associated with a row identifier to facilitate database synchronization. In a particular embodiment, each row identifier uniquely identifies a row in a database **112**. When a change is made to an entry in a row in database **112**, the changed entry in the row or the entire row may be copied to a table used to track changes to database **112**. An agent, such as a software program, in one database **112** may access the table and communicate the changes to another database **112**. An agent in the other database **112** may receive the information and make similar changes in the other database **112**. This allows changes in one database **112** to be replicated in another database **112**. While information in database **112** has been described as residing in tables, any other suitable data structures, compilations, or arrangements may be used to store the information contained in database **112**. Also, while database **112** has been described as using row identifiers to track changes made to the information, any other suitable identifiers, such as column identifiers, may be used without departing from the scope of the present invention.

[0038] Network **114** is coupled to client **102** and one or more components of sites **101**. Network **114** facilitates communication between different components coupled to network **114**. For example, network **114** may transport packets of information between client **102** and web server **110**. Network **114** may include any hardware, software, firmware, or combination thereof for transporting circuit-switched, packet-switched, and/or other information. Network **114** may, for example, include a Local Area Network (LAN), a Wide Area Network (WAN), a Metropolitan Area Network (MAN), a portion of a global computer network such as the Internet, or any other communication system or systems at one or more locations.

[0039] Although FIG. **1** illustrates one example embodiment of system **100**, various changes may be made to system **100** without departing from the scope of the present invention. For example, any suitable number of sites **101** may be present in system **100**, and a site **101** may include any number of load balancers **108**, web servers **110**, and/or databases **112**. Also, any number of domain name servers **104** and **106** may be present in system **100**. Further, domain name server **104** and secondary domain name server **106** may be combined, and/or additional domain name servers may be used in conjunction with domain name server 30 **104** and secondary domain name server **106**. In addition, while FIG. **1** illustrates a single database **112** in each site **101**, each site **101** could include multiple databases **112**. For example, each site **101** could have a primary database **112** and a backup or redundant database **112**.

[0040] FIG. **2** is a block diagram illustrating an example domain name server **106**. In the illustrated embodiment, domain name server **106** includes at least one processor **202**, a memory **204**, a network interface **206**, a resource interface **208**, and an alternate resource interface **210**. Other embodiments of domain name server **106** may be used without departing from the scope of the present invention. Although FIG. **2** may be described as representing domain name server **106**, the same or similar components may be used in domain name server **104** or any other suitable domain name server.

[0041] Processor **202** is coupled to memory **204**, network interface **206**, resource interface **208**, and alternate resource interface **210**. Processor **202** executes instructions and manipulates data to provide one or more network addresses associated with sites **101** to clients **102**. For example, processor **202** may monitor the status of load balancer **108**, web servers **110**, and database **112** in the site **101** associated with domain name server **106**. Processor **202** may also monitor the status of another domain name server **106**. Based on the status of these and/or other components in system **100**, processor **202** may communicate the network address of load balancer **108** and/or the network address of the other domain name server **106**. to a client **102**. Processor **202** may be any processor or processors suitable for performing domain name-network address translation functions. Although FIG. **2** illustrates a single processor **202**, multiple processors **202** may be used according to particular needs.

[0042] Memory **204** is coupled to processor **204**. Memory **204** stores and facilitates retrieval of information used by processor **202** to provide one or more network addresses associated with a domain name to clients **102**. For example, memory **204** may store network address information **212**, which associates at least one domain name with at least one network address. As a particular example, network address information **212** may associate a domain name with a network address of a load balancer **108** in one site **101** and with a network address of another secondary domain name server **106** serving a second site **101**. Memory **204** could also store status information **214** representing the status of one or more components of system **100**. For example, status information **214** may identify the status of load balancer **108**, web servers **110**, and database **112** in one site **101** and the status of another domain name server **106** serving a second site **101**. As a particular example, status information **214** may identify whether load balancer **108**, web servers **110**, and database **112** in one site **101** and another domain name server **106** serving a second site **101** are available. As another example, status information **214** may identify the load placed on each site **101**, the response time of each site **101**, the location of each site **101**, and/or any other suitable information. Memory **204** may include any hardware, software, firmware, or combination thereof for storing and facilitating retrieval of information. Although FIG. **2** illustrates memory **204** as residing within domain name server **106**, memory **204** may reside in any location or locations accessible by domain name server **106**.

[0043] Network interface **206**, resource interface **208**, and alternate resource interface **210** are each coupled to processor **202**. Interfaces **206-210** facilitate communication between domain name server **106** and other components of system **100**. For example, network interface **206** may facilitate communication with clients **102** over network **114**. Resource interface **208** may facilitate communication with a load balancer **108** in a site **101** served by domain name server **106**. Alternate resource interface **210** may facilitate communication with another domain name server **106**. Interfaces **206-210** each may include any hardware, software, firmware, or combination thereof capable of communicating with other components in system **100**. Although FIG. **2** illustrates three separate interfaces **206-210**, various interfaces **206-210** may be combined without departing from the scope of the present invention.

[0044] In one aspect of operation, processor **202** receives a domain name from a client **102** through network interface **206**. Processor **202** may access network address information **212** and identify the network address or addresses associated with the domain name. Processor **202** may also access status information **214** and determine if any of the identified network addresses are unavailable. If both network addresses may be used by client **102**, processor **202** may communicate the addresses to client **102** using network interface **206**. If only one network address may be used, processor **202** communicates that network address to client **102**.

[0045] Processor **202** may monitor the status of load balancer **108**, web servers **110**, and database **112** associated with one site **101** and the status of another domain name server **106** associated with another site **101** using any suitable method. In this document, the term "monitor" refers to both actively monitoring a component and passively receiving information identifying a component's status. For example, domain name server **106** may actively determine whether components of system **100**, such as load balancer **108**, web servers **110**, database **112**, and/or another domain name server **106**, are available by executing diagnostics tests, instructing the component to perform certain activities, and/or actively communicating with a component and receiving a response. Domain name server **106** could also passively receive information identifying the status of the components in system **100**. As a particular example, domain name server **106** could communicate with sites **101** and measure the load placed on each site **101** and the response time of each site **101** using any suitable method.

[0046] In a particular embodiment, load balancer **108** monitors the status of the web servers **110** and database **112** in a site **101**. If the web servers **110** and/or the database **112** become unavailable, load balancer **108** may inform domain name server **106** through resource interface **208** that the network address associated with load balancer **108** is unavailable and/or that web servers **110** or database **112** are unavailable. Also, if processor **202** cannot communicate with load balancer **108** through resource interface **208**, processor **202** may determine that load balancer **108** is unavailable. In either case, processor **202** may update status information **214** to reflect that the network address associated with load balancer **108** is unavailable.

[0047] Processor **202** could also monitor the status of another domain name server **106** using alternate resource interface **210**. For example, in one embodiment, processor **202** may communicate a message to another domain name server **106** and receive messages from that domain name server. As a particular example, processor **202** in domain name server **106***a* may communicate messages, called "pings," to another domain name server **106***b* through alternate resource interface **210**. Similarly, domain name server **106***b* may communicate pings to domain name server **106***a*, and processor **202** may receive the messages through alternate resource interface **210**. Processor **202** may determine the status of domain name server **106***b* based on the presence or absence of the ping messages received through alternate resource **210**. For example, if processor **202** fails to receive pings from domain name server **106***b* for five seconds, processor **202** may determine that domain name server **106***b* is unavailable. Processor **202** may communicate ping messages to another domain name server **106** under the control of a pinging application **216**. In another embodiment, another component in domain name server **106** may communicate messages to another domain name server **106**, rather than processor **202**. For example, a hardware component of domain name server **106** may be configured to repeatedly communicate a message through alternate resource interface **210**.

[0048] Although FIG. **2** illustrates one example embodiment of a domain name server **106**, various changes may be made to domain name server **106** without departing from the scope of the present invention. For example, any suitable number of processors **202**; memories **204**, and/or interfaces may be used in domain name server **106**. Also, the functions of domain name server **106** may be implemented using any hardware, software, firmware, or combination thereof. As a particular example, the functions may be implemented by software instructions stored in any suitable device, such as a random access memory (RAM), a read-only memory (ROM), an application-specific integrated circuit (ASIC), or a field programmable gate array (FPGA).

[0049] FIG. **3** is a block diagram illustrating an example load balancer **108**. In the illustrated embodiment, load balancer **108** includes at least one processor **302**, a memory **304**, a domain name server interface **306**, and a web server interface **308**. Other embodiments of load balancer **108** may be used without departing from the scope of the present invention.

[0050] Processor **302** is coupled to memory **304**, domain name server interface **306**, and web server interface **308**. Processor **302** executes instructions and manipulates data to perform load balancing functions within a site **101** in system **100**. For example, processor **302** may receive an indication from secondary domain name server **106** and/or client **102** that client **102** is attempting to access a web site associated with site **101**. Processor **302** may also determine which web server **110** should communicate with and provide services to client **102**. Processor **302** may further communicate the network address of the selected web server **110** to client **102** and/or instruct the selected web server **110** to communicate with client **102**. In addition, processor **302** may monitor the status of web servers **110** and/or database **112**. If the web servers **110** and/or the database **112** in a site **101** served by load balancer **108** become unavailable, load balancer **108** may notify client **102**, domain name server **104**, secondary domain name server **106**, and/or any other suitable component in system **100** that clients **102** may not be able to communicate with and receive service from site **101**. In a particular embodiment, load balancer **108** notifies secondary domain name server **106** that the network address associated with a site **101** is unavailable when all web servers **110** in site **101** are unavailable and/or the database **112** in site **101** is unavailable. Secondary domain name server **106** may then take any suitable action, such as no longer communicating the network address of the unavailable site **101** to clients **102**. Processor **302** may be any processor or processors suitable for performing load balancing functions in system **100**. Although FIG. **3** illustrates a single processor **302**, multiple processors **302** may be used according to particular needs.

[0051] Memory **304** is coupled to processor **304**. Memory **304** stores and facilitates retrieval of information used by processor **302** to perform load balancing functions. For example, memory **304** may store status information **310** representing the status of one or more components of site **101**. As particular examples, status information **310** may identify the status of web servers **110** and/or database **112** in a site **101**. Memory **304** may include any hardware, software, firmware, or combination thereof for storing and facilitating retrieval of information. Although FIG. **3** illustrates memory **304** as residing within load balancer **108**, memory **304** may reside in any location or locations accessible by load balancer **108**.

[0052] Domain name server interface **306** and web server interface **308** are each coupled to processor **302**. Interfaces **306** and **308** facilitate communication between load balancer **108** and other components of system **100**. For example, domain name server interface **306** may facilitate communication with domain name server **104** and/or secondary domain name server **106**. Web server interface **308** may facilitate communication with web servers **110** in a site **101**. Interfaces **306** and **308** each may include any hardware, software, firmware, or combination thereof capable of communicating with other components in system **100**. Although FIG. **3** illustrates two separate interfaces **306** and **308**, interfaces **306** and **308** may be combined without departing from the scope of the present invention.

[0053] In one aspect of operation, processor **302** receives an indication from a client **102**, domain name server **104**, and/or secondary domain name server **106** that client **102** wishes to receive service from a web server **110** in a site **101**. Processor **302** determines which web server **110**, if any, should be used to provide service to client **102**. For example, processor **302** may determine which web server **110** is serving the fewest number of clients **102**. Processor **302** may also direct clients **102** to web servers **110** using a round-robin approach, such as when processor **302** directs every third client to the same web server **110**. Other allocation approaches may be used without departing from the scope of the present invention. In determining which web server **110** should serve a client **102**, processor **302** may access status information **310** and determine if any of the web servers **110** and/or databases **112** are unavailable. If the database **112** or the web servers **110** in a site **101** are unavailable, processor **302** may inform domain name server **104** and/or secondary domain name server **106** that the network address associated with site **101** is unavailable. If at least one of the web servers **110** is available, processor **302** may direct clients **102** to those web servers **110**.

[0054] Processor **302** may monitor the status of web servers **110** and/or databases **112** in a site **101** using any suitable method. In a particular embodiment, processor **302** may determine which web servers **110** are available by communicating pings to web servers **110** and checking if web servers **110** respond to the pings. Based on the presence or absence of the responses to the pings, processor **302** may update status information **310**. Processor **302** may communicate ping messages to web servers **110** under the control of a pinging application **312**, although a hardware or other component in load balancer **108** and/or another component in system **100** may be configured to determine the status of web servers **110**.

[0055] Processor **302** may also monitor the ability of a web server **110** to execute applications. For example, processor **302** may instruct a web server **110** to execute an application to determine whether any hardware has failed in the web server **110**. The application executed by web server **110** may be an application that web server **110** executes to provide services for clients **102**. The application could also be a test program that causes web server **110** to perform one or more functions, thereby allowing load balancer **108** to determine if web server **110** is functioning properly. Any other suitable applications or activities may be performed by web server **110** without departing from the scope of the present invention. Processor **302** may instruct web servers **110** to execute an application under the control of a web server test application **314**, although a hardware or other component in load balancer **108** and/or another component in system **100** may be configured to initiate the execution of the application in web server **110**.

[0056] In addition, processor **302** may determine the status of one or more databases **112** in a site **101**. For example, processor **302** may instruct a web server **110** to execute a web page that uses information from the database **112**. The execution of the web page causes web server **110** to attempt to access database **112** and retrieve the information needed in the page. Processor **302** may determine the status of database **112** based on the information contained in the web page received from web server **110**. For example, in one embodiment, load balancer **108** instructs web server **110** to initiate execution of a web page, receives the executed web page, and looks for an expected keyword in the web page. As a particular example, web server **110** may execute a test web page that includes the name of the database server that serves database **112**. Processor **302** may receive the web page from web server **110** and determine if the appropriate database server name is contained in the web page. If the incorrect server name is included in the web page, or if no name could be retrieved from database **112**, processor **302** may determine that database **112** is unavailable and update status information **310**. Processor **302** may instruct web server **110** to execute a web page to determine the status of database **112** under the control of a database test application **316**, although a hardware or other component in load balancer **108** and/or another component in system **100** may be configured to initiate the execution of the web page in web server **110**. In one embodiment, load balance **108** uses a round-robin approach to pick which web server **110** executes the web page that tests database **112**. Load balancer **108** could also instruct each web server **110** to execute the same or a different web page that tests database **112**. Load balancer **108** may use any other suitable approach without departing from the scope of the present invention.

[0057] Although FIG. **3** illustrates one example embodiment of a load balancer **108**, various changes may be made to load balancer **108** without departing from the scope of the present invention. For example, any suitable number of processors **302**, memories **304**, and/or interfaces may be used in load balancer **108**. Also, the functions of load balancer **108** may be implemented using any hardware, software, firmware, or combination thereof. As a particular example, the functions may be implemented by software instructions stored in any suitable device, such as a RAM, a ROM, an ASIC, or a FPGA.

[0058] FIG. **4** is a block diagram illustrating an example database **112**. In the illustrated embodiment, database **112** includes a database server **402** and one or more data stores **404**. Other embodiments of database **112** may be used without departing from the scope of the present invention.

[0059] In the illustrated embodiment, database server **402** includes at least one processor **406**, at least one memory **408**, a web server interface **410**, a database interface **412**, and an alternate database interface **414**. Other embodiments of database server **402** may be used without departing from the scope of the present invention. Processor **406** is coupled to memory **408**, web server interface **410**, database interface **412**, and alternate database interface **414**. Processor **406** executes instructions and manipulates data to perform database functions in system **100**. For example, processor **406** may receive a request to retrieve information from one or more data stores **404**. Processor **406** may identify the location of the requested information and retrieve the information from the identified location in data store **404**. Processor **406** may also receive requests to store new information and/or modify existing information in data stores **404**. For example, processor **406** may receive a request to add an additional row of information into a table in data store **404** or a request to delete a row of information. Processor **406** may then access data store **404** and make the requested additions, modifications, and/or deletions. In addition, processor **406** may perform database replication functions in system **100**. For example, processor **406** may track the additions, deletions, and/or other changes made to the information in data stores **404**, and processor **406** may communicate these changes to the database server **402** in another database **112** in system **100**. Similarly, processor **406** may receive changes made to the information in the other database **112** in system **100**, and processor **406** may make the same changes to the information in data stores **404**. Processor **406** may be any processor or processors suitable to perform database replication functions in system **100**. Although FIG. **4** illustrates a single processor **406**, multiple processors **406** may be used according to particular needs.

[0060] Memory **408** is coupled to processor **406**. Memory **408** stores and facilitates retrieval of information used by processor **406** to perform database replication functions. For example, memory **408** may store a database replication agent **416**. Database replication agent **416** may, for example, represent a software application executed by processor **406** to provide the database replication functions in database **112**. As a particular example, database replication agent **416** may monitor the changes made to the information in data stores **404** and store the changes in one or more change tables **418**. In one embodiment, the database replication agent **416** may access the change tables **418** and communicate the changes to another database **112**. In a particular embodiment, the database replication agent **416** communicates the changes in the change tables **418** to another database **112** at regular intervals, such as every one or five seconds. While database replication has been described as occurring under the control of a database replication agent **416**, any hardware, software, firmware, or combination thereof in server **402** and/or other component of system **100** may be used to perform database replication. Also, although FIG. **4** illustrates memory **408** as residing within server **402**, memory **408** may reside in any location or locations accessible by server **402**.

[0061] In one embodiment, the information contained in change tables **418** may be removed from change tables **418** when database server **402** communicates that information to another database **112** and receives an acknowledgment from that database **112**. In this embodiment, the acknowledgment message indicates that the other database **112** successfully received the information in change tables **418**, and the other database **112** may replicate those changes. If the other database **112** fails to acknowledge the communication of the information from change table **418**, database server **402** may continue to store that information in change tables **418**. As a result, change tables **418** act as a queue for the changes to the information in data stores **404**. For example, if a first database **112** is unavailable, such as due to a power failure, a second database **112** may store the changes made to the information in its data stores **404** in change tables **418**. If and when the first database **112** becomes available, such as when power is restored to the first database **112**, the information in the first database **112** may be synchronized with the information in the second database **112** because the changes have been stored in change tables **418** in the second database **112**.

[0062] Web server interface **410**, database interface **412**, and alternate database interface **414** are each coupled to processor **406**. Interfaces **410-414** facilitate communication between server **402** and other components of system **100**. For example, web server interface **410** may facilitate communication with web servers **110**. Database interface **412** may facilitate communication with one or more data stores **404** in database **112**. Alternate database interface **412** may facilitate communication with another database **112** in system **100**. Interfaces **410-414** each may include any hardware, software, firmware, or combination thereof capable of communicating with other components in system **100**. Although FIG. **4** illustrates three separate interfaces **410-414**, various interfaces **410-414** may be combined without departing from the scope of the present invention.

[0063] Data stores **404** are coupled to database server **402**. Data store **404** stores and facilitates retrieval of information used by database server **402**. The information stored in data stores **404** may vary depending on the application. For example, data store **404** may include data tables **420** that store information identifying products sold by a business and customers of the business. Data stores **404** could also store state information tables **422** identifying the status of a communication session with a client **102**. Any other suitable information could be stored in data store **404** without departing from the scope of the present 30 invention. Each data store **404** may include any suitable data structures, compilations, and/or arrangements used to store information. While data stores **404** are illustrated as residing in database **112**, data stores **404** may reside in any location or locations accessible by database server **402**.

[0064] To facilitate the replication of changes to the information in data stores **404** across multiple databases **112**, the various tables in data stores **404**, such as tables **420** and **422**, may each include identifiers that identify one or more entries in the tables. In one embodiment, each table includes a column of row identifiers that identify the rows in the tables. In a particular embodiment, each row identifier uniquely identifies a row of entries in database **112**. When a modification is made to one or more entries in a row, all or a portion of the row may be copied to the change tables **418**. For example, if a row is added to a table, processor **406** may generate a new row identifier for that row, and the entries in the new row and the row identifier may be copied to a change table **418**. If an entry in a row is modified, the entire row or a portion of the row, such as the changed entry, may be stored in a change table **418** along with the row identifier associated with that row. If a row is deleted, the row identifier and an indication that the row has been deleted may be stored in a change table **418**. Database replication agent **416** may then communicate the information in change tables **418** to another database **112**, which allows the other database **112** to replicate the same changes in its data stores **404**. Similarly, database replication agent **416** may receive changes from another database **112** and replicate the same changes in data stores **404**. While data stores **404** have been described as using row identifiers to track changes made to information, any other suitable identifiers, such as column identifiers, may be used without departing from the scope of the present invention.

[0065] In one embodiment, the presence of the row identifiers in the database tables **420** and **422** may create difficulties with the applications that use the information in database **112**, such as the applications executed by web servers **110**. For example, the row identifiers increase the number of columns in tables **420** and **422**. An application that attempts to access table **420** and/or table **422** may not be configured to access a table having one extra column. Also, an application may be configured to retrieve all information from a table **420** or **422**, so the application would retrieve the row identifiers as well as the remainder of the information contained in the table. As a result, the presence of the row identifiers could interfere with the applications retrieving the information from database **112**. To reduce the likelihood that an application retrieves the row identifiers from a database **112**, database server **402** may create a logical structure **424**, which is used to retrieve information from a table **420** or **422**. For example, logical structure **424*a*** may be associated with a table **420**, and logical structure **424*b*** may be associated with a table **422**. When an application in web server **110** submits a query to database server **402** requesting information from a data table **420**, database server **402** may execute the logical structure **424*a*** associated with table **420**. The logical structure extracts the information contained in the table **420** without extracting the row identifiers in that table. Database server **402** may then execute the query from the application using the information extracted from the table **420** by logical structure **424**. This helps to provide the application with the requested information from database **112** without providing the row identifiers to the application. Logical structure **424** may include any hardware, software, firmware, or combination thereof for extracting information from a table **420** or **422**. In one embodiment, logical structure **424** creates a logical view of a table **420** or **422**. In this document, the term "view" refers to a subset of information extracted from or otherwise retrieved from a table or other structure in database **112**. In a particular embodiment, logical structure **424** includes a SQL database "CREATE VIEW" command.

[0066] In one embodiment, each data table **420** and/or state information table **422** may have a table name used by web servers **110** to access information in those tables **420** and **422**. For example, a data table **420** may be named CUSTOMER_DATA. In one embodiment, web servers **110** may access the information contained in that data table **420** by communicating a query to database server **402** containing the name of the data table **420**. For example, a web server **110** may retrieve the information in the CUSTOMER_DATA table **420** by issuing a query to database **112** containing the name CUSTOMER_DATA.

[0067] To facilitate the use of logical structures **424**, the data tables **420** and/or state information tables **422** in data stores **404** may be renamed. For example, each table **420** or **422** may be renamed by adding a prefix, suffix, extension, or other suitable identifier to the name of the table **420** or **422**. As a particular example, the CUSTOMER_DATA table **420** may be renamed to drv_CUSTOMER_DATA. In this embodiment, the logical structure **424** associated with a table **420** or **422** may create a logical view of that table, and the view may be given the original name of the table **420** or **422**. For example, the logical structure **424** associated with the drv_CUSTOMER_DATA table **420** may create a logical view having the name CUSTOMERDATA. As a particular example, if the drv_CUSTOMER_DATA table **420** has five columns of information and one column of row identifiers, logical structure **424** may extract the five columns of information from that table **420** and name the logical view CUSTOMER_DATA. In one embodiment, logical structure **424** may include an SQL command such as "CREATE VIEW CUSTOMER_DATA AS 1, 2, 3, 4, 5 FROM DRV_CUSTOMER_DATA." This creates a logical view of the drv_CUSTOMER_DATA table **420**, which includes the five columns of information used by an application executed by web server **110**.

[0068] When a user or an application attempts to access information in database **112**, the user or application may be unaware that the tables **420** and **422** have been renamed. For example, an application may submit a query requesting information from the CUSTOMER_DATA table **420**. When this occurs, database server **402** executes the logical structure **424** associated with the drv_CUSTOMER_DATA table, which extracts information from that table and generates a logical view having the name CUSTOMER_DATA. The logical view contains the information from the drv_CUSTOMER_DATA table without the row identifiers. Database server **402** may then execute the query using the logical view. This allows applications to use information from tables **420** and **422** without rewriting those applications to ignore the row identifiers.

[0069] Although FIG. **4** illustrates one example embodiment of a database **112**, various changes may be made to database **112** without departing from the scope of the present invention. For example, any suitable number of processors **406**, memories **408**, and/or interfaces may be used in database server **402**, and any number of data stores **404** may be used in database **112**. Also, the functions of server **402** may be implemented using any hardware, software, firmware, or combination thereof. As a particular example, the database replication agent functions may be implemented by software instructions stored in any suitable device, such as a RAM, a ROM, an ASIC, or a FPGA.

[0070] FIG. **5** is a block diagram illustrating an example data table **420**. In the illustrated embodiment, table **420** includes a data section **502** and row identifiers **504**. Other embodiments of table **420** may be used without departing from the scope of the present invention. Data section **502** may include any suitable information. For example, data section **502** may include the names, addresses, and phone numbers of customers of a business using 30 sites **101** to sell products. Data section **502** could also include the names, descriptions, and product numbers of the products sold by the business. Data section **502** could include any other suitable information in any suitable format. In one embodiment, data section **502** contains information in rows and columns.

[0071] Row identifiers **504** identify the rows of information in data section **502**. In one embodiment, each row identifier **504** uniquely identifies a row in a database **112**. Database server **402** may use row identifiers **504** to facilitate the replication of changes to the information in data stores **404**. For example, a row identifier **504** may identify one row in a particular table **420**. When a change is made to one or more entries in that row, the row identifier **504** and at least a portion of the row may be copied to a change table **418**. Database replication agent **416** may then communicate the information in change table **418** to another database **112**. The database replication agent **416** in the other database **112** may receive the information and modify a data store **404** in the other database **112**. For example, if a row was added to a data table **420** in one database **112**, the database replication agent **416** in the other database **112** may not find a matching row identifier **504** in the other database **112**. This causes the database replication agent **416** in the other database **112** to add the new row to a table **420**. If one or more entries in a row are modified in one database **112**, the database replication agent **416** in the other database **112** may identify the row in a table **420** that has a matching row identifier **504** and then replicate the changes to the entries in the identified row.

[0072] Although FIG. **5** illustrates one example embodiment of a data table **420**, various changes may be made to data table **420** without departing from the scope of the present invention. For example, while the information is illustrated as residing in a table structure, any other suitable data structures, compilations, or arrangements may be used to store the information contained in data table **420**. Also, database **112** could use column identifiers or any other suitable identifiers to identify entries in table **420** in place of row identifiers **504**.

[0073] FIG. **6** is a block diagram illustrating an example state information table **422**. In the illustrated embodiment, table **422** includes one or more entries **602**, each including a session identifier **604**, state information **606**, and a row identifier **608**. Other embodiments of table **422** may be used without departing from the scope of the present invention.

[0074] Session identifier **604** identifies a communication session with a client **102**. For example, each session with a client **102** may be identified by a unique session identifier **604**, which allows database **112** to store information about that session in an appropriate entry **602**. State information **606** represents information about the communication session with a client **102**. State information **606** may include any suitable information, such as the applications a client **102** is using and information provided to a web server **110** by client **102**. Row identifiers **608** identify the rows of information in table **422**. In one embodiment, each row identifier **608** uniquely identifies an entry **602** in table **422**.

[0075] As described above, database server **402** may use row identifiers **608** to facilitate the replication of changes to the information in data stores **404**. For example, as the state information **606**. is updated in table **422**, database replication agent **416** may use row identifiers **608** to copy at least a portion of an entry **602** to a change table **416**. This allows the information about communication sessions with clients **102** to be synchronized across multiple databases **112**. If one site **101** fails in system **100**, the clients **102** communicating with that site **101** may be redirected to a second site **101**. Some or all of the information about communication sessions with those clients **102** may be stored in the database **112** in the second site **101**, which enables to second site **101** to provide service to clients **102** with fewer interruptions. In another embodiment, web servers **110** may execute "state-less" applications in which state information is stored at a client **102**. In this embodiment, state information table **422** may be omitted from database **112**.

[0076] Although FIG. **6** illustrates one example embodiment of a state information table **422**, various changes may be made to table **422** without departing from the scope of the present invention. For example, any other and/or additional information about the communication sessions may be stored in table **422**. Also, while the information is illustrated as residing in a table structure, any other suitable data structures, compilations, or arrangements may be used to store the information contained in table **422**. Further, database **112** could use column identifiers or any other suitable identifiers to identify the information in table **422** in place of row identifiers **608**. In addition, although FIG. **6** illustrates state information **604** indexed by session identifier **602**, other identifiers may be used to identify state information **604** without departing from the scope of the present invention. For example, a "cookie" associated with a client **102** may be used to identify the state information **604** associated with that client **102**.

[0077] FIG. **7** is a block diagram illustrating an example change table **418**. In the illustrated embodiment, table **418** includes one or more entries **702**. Each entry **702** may include at least one table entry **704**, a row identifier **706**, and a time stamp **708**. Other embodiments of change table **418** may be used without departing from the scope of the present invention.

[0078] In one embodiment, a change made to the information in a database **112** is stored in change table **418** as an entry **702**. In this embodiment, each entry **702** represents at least one change to information in database **112**. Table entries **704** represent the entries in a table **420** or **422** that have been added, deleted, and/or modified. For example, in one embodiment, when at least one entry in a row in tables **420** or **422** is changed, the entire row is copied into an entry **702** in table **418**. Any other suitable number of entries from a table **420** or **422** may be copied into an entry **702** in table **418** without departing from the scope of the present invention. For example, in another embodiment, only the changed entries in a table **420** or **422** are copied into an entry **702**.

[0079] Row identifier **706** identifies the row associated with the table entries **704** contained in an entry **702**. Time stamp **708** identifies the time when the table entry **704** was changed in database **112**. Time stamp **708** could, for example, identify the date and time of the change or simply the time of the change.

[0080] In one aspect of operation, database replication agent **416** generates a new entry **702** in table **418** each time information in database **112** is added, deleted, or modified. For example, if a new row is added to a table **420** or **422**, the entries in the new row may be stored in an entry **702** in table **418**. Similarly, if one or more entries of a row in a table **420** or **422** are modified, the modified entries or the entire row may be copied to another entry **702** in table **418**. If a row is deleted in a table **420** or **422**, an entry **702** may be set to indicate that the row associated with entry **702** has been deleted. The row identifier associated with the row being added, modified, or deleted may be stored in table **418** as a row identifier **706** in entry **702**. In addition, a time of the addition, modification, or deletion may be recorded in table **418** as a time stamp **708** in an entry **702**. Database replication agent **416** may routinely communicate the information contained in change tables **418** to another database **112**. The other database **112** may then replicate the changes, helping to ensure that the information stored in databases **112** remain consistent.

[0081] In one embodiment, database replication agent **416** uses the time stamp **708** of an entry **702** to resolve conflicting changes to the same information in databases **112**. For example, a first client **102** may modify particular information in one database **112**, while a second client **102** modifies the same information in another database **112**. When the database replication agent **416** in each database receives the changes made to the information in the other database **112**, database replication agent **416** may compare the received changes to the changes contained in change table **418**. If the same information was modified in both databases **112**, database replication agent **416** may use the time stamp **708** associated with each change to determine which change has priority. For example, database replication agent **416** could treat later changes as having priority over earlier changes, or changes made by a particular client **102** or user have priority over other clients **102** or users. Other suitable criteria for resolving conflicting database changes may be used without departing from the scope of the present invention.

[0082] In one embodiment, multiple entries **702** in change table **418** may represent modifications to information in the same row of a table **420** or **422**. For example, one entry **702** in change table **418** may represent a modification to the first entry of a row in table **420**, while a second entry **702** represents a modification to the last entry in the same row in table **420**. Database replication agent **416** may or may not consolidate entries **702** associated with the same row in a table **420** or **422**. For example, if two entries **702** represent changes to different information in the same row of a table **420** or **422**, database replication agent **416** may combine those two entries **702**. This produces a single entry **702** containing all of the modified information and the row identifier **706** associated with the modified row. If two entries **702** represent changes to the same information in a table **420** or **422**, database replication agent **416** may use time stamp **708** or other suitable criteria to determine which entry **702** has a higher priority, and database replication agent **416** could delete the entry **702** having a lower priority.

[0083] Any suitable number of change tables **418** may be used in system **100** without departing from the scope of the present invention. For example, a change table **418** may be associated with each table **420** or **422** contained in a database **112**. In this embodiment, each change table **418** would store changes made to the information in the table **420** or **422** associated with that change table **418**. Different change tables **418** may also be used in system **100** based on the type of change made. For example, in one embodiment, one change table **418** may store changes involving the addition of a new row to a table **420** or **422**, another change table **418** may store changes involving the deletion of a row from a table **420** or **422**, and a third change table **418** may store modifications to existing information in a 30 table **420** or **422**. Other embodiments may be used without departing from the scope of the present invention.

[0084] Although FIG. **7** illustrates one example embodiment of a change table **418**, various changes may be made to change table **418** without departing from the scope of the present invention. For example, although FIG. **7** illustrates each entry **702** containing a row of table entries **704**, each entry **702** could be associated with any number of entries from a table **420** or **422**. Also, other suitable identifiers, such as column identifiers, may be used in place of row identifier **706**.

[0085] FIG. **8** is flow diagram illustrating an example method **800** for multi-site clustering in a network. Method **800** may, for example, be performed by domain name server **104**, secondary domain name server **106**, and/or any other suitable component of system **100**. Although method **800** may be described as being performed by secondary domain name server **106**, other components of system **100** may perform method **800** without department from the scope of the present invention. Also, secondary domain name server **106** may be described as determining the order of the network addresses communicated to a client **102** based on the availability of sites **101**. Secondary domain name server **106** could use any other suitable criteria, such as the load placed on each site **101**, the response time of each site **101**, and the locality of client **102** to a site **101**.

[0086] Secondary domain name server **106** receives a domain name at step **802**. This may include, for example, secondary domain name server **106** receiving the domain name from a client **102** over network **114**. Secondary domain name server **106** identifies at least a first network address and a second network address associated with the received domain name at step **804**. This may include, for example, secondary domain name server **106** accessing network address information **212** in memory **204** and retrieving the network addresses associated with the domain name.

[0087] Secondary domain name server **106** determines the status of the network addresses associated with the received domain names at step **806**. This may include, for example, secondary domain name server **106** receiving information from a load balancer **108** in a site **101** associated with secondary domain name server **106**. The information received from load balancer **108** may identify the status of load balancer **108**, web servers **110**, and/or database **112** associated with that site **101**. This may also include secondary domain name server **106** 30 determining whether ping messages have been received from another secondary domain name server **106** associated with another site **101** in a given time period.

[0088] Based on the identified status of the various components of system **100**, secondary domain name server determines which network addresses, if any, associated with the received domain name to communicate to a client **102**. Secondary domain name server **106** determines whether both network addresses are available at step **808**. The first network address may be available if the load balancer **108**, at least one web server **110**, and database **112** in a site **101** are available. The second network address may be available if the secondary domain name server **106** associated with another site **101** is available. If both network addresses are available, secondary domain name server **106** communicates the first network address followed by the second network address to client **102** at step **810**. In one embodiment, each secondary domain name server **106** in system **100** directs all clients **102** to a single site **101** until that site **101** is no longer available. At that point, the secondary domain name servers **106** may direct clients **102** to another site **101**. In the illustrated embodiment, each secondary domain name server **106** may direct clients **102** to the site **101** associated with the first network address. If and when that site **101** fails, secondary domain name servers **106** may direct clients **102** to the site **101** associated with the second network address. Other allocations of clients **102** to sites **101** may be used without departing from the scope of the present invention. For example, secondary domain name servers **106** may use a round-robin approach, directing half of clients **102** to one site **101** and half of clients **102** to another site **101**.

[0089] If both network addresses are not available at step **808**, secondary domain name server **106** determines if the first network address is available at step **812**. If the first network address is available, secondary domain name server **106** communicates the first network address to client **102**. In this situation, the second network address is unavailable, and secondary domain name server **106** need not communicate the second network address to client **102**. If the first network address is unavailable at step **812**, secondary domain name server **106** determines whether the second network address is available at step **816**. If the second network address is available, secondary domain server **106** communicates the second network address to client **102** at step **818**. In this situation, the first site **101** is unavailable, so secondary domain name server **106** need not communicate the first network addressed to 30 client **102**. If neither network address is available, secondary domain name server **106** need not communicate any network addresses to client **102**. Secondary domain name server **106** could communicate an error message or any other suitable information to client **102**, or secondary domain name server **106** may communicate no information to client **102**.

[0090] Although FIG. **8** illustrates one example embodiment of a method **800** for multi-site clustering, various changes may be made to method **800** without departing from the scope of the present invention. For example, more than two network addresses may be associated with a domain name. Also, secondary domain name server **106** may direct clients **102** to the second network address first and then to the first network address when the second network address fails.

[0091] FIG. **9** is a flow diagram illustrating an example method **900** for determining the status of components of a network site **101**. Method **900** may, for example, be used by a load balancer **108** in site **101**. Other components of system **100** may perform method **900** without departing from the scope of the present invention.

[0092] Load balancer **108** pings web servers **110** at step **902**. This may include, for example, load balancer **108** communicating messages to web servers **110** through web server interface **308**. Load balancer **108** determines if web servers **110** respond to the pings at step **904**. This may include, for example, load balancer **108** determining if a response message has been received from each web server **110** through web server interface **308**. If at least one of the web servers **110** is operational, the operational web server **110** should respond to the ping message with a response message. If none of the web servers **110** are operational, load balancer **108** may not receive any response to the ping messages. Based on the presence or absence of response messages, load balancer **108** may determine the status of web servers **110**. Load balancer **108** may make any suitable use of this information. For example, if no web servers **110** are available, load balancer **108** may inform secondary domain name server **106** that site **101** is unavailable. Load balancer **108** may communicate this information to secondary domain name server **106** at predetermined intervals, in response to a query from secondary domain name server **106**, or at any other suitable time.

[0093] Load balancer **108** instructs one or more web servers **110** to initiate execution of a web page at step **906**. This may include, for example, load balancer **108** communicating the instruction to web server **110** through web server interface **308**. Load balancer **108** could instruct a single web server **110** or multiple web servers **110** to execute a web page, and each web server **110** could execute the same or a different web page. Load balancer **108** receives the executed web page at step **908**. This may include, for example, load balancer **108** receiving the web page from web server **110** through web server interface **308**. Load balancer **108** may receive one or more web pages from one or more web servers **110**. Load balancer **108** determines if the received web page contains an anticipated or expected key word at step **910**. For example, the web page executed by web server **110** could attempt to extract the name of the database server **402** serving database **112** in site **101**. Load balancer **108** examines the web page received from web server **110** and determines if the web page contains the correct name of database server **402**. If the web page contains the expected keyword or keywords, load balancer **108** may determine that web servers **110** have the ability to execute web pages and/or that database **112** is operational and able to provide information to web servers **110**. If the web page does not contain the anticipated keywords, load balancer **108** may determine that site **101** is unavailable due to problems with web servers **110** and/or database **112**.

[0094] Although FIG. **9** illustrates one example embodiment of a method **900** for determining the status of a site **101**, various changes may be made to method **900** without departing from the scope of the present invention. For example, any suitable test may be used to determine whether web servers **110** and/or database **112** are available. Also, load balancer **108** may determine the status of database **112** before determining the status of web servers **110**.

[0095] FIG. **10** is a flow diagram illustrating an example method **1000** for database replication in a network. While method **1000** is described as being performed by database replication agent **416**, any other suitable component or components in database **112** and/or system **100** may perform method **1000** without departing from the scope of the present invention.

[0096] Database server **402** stores first changes made to the information in database **112** at step **1002**. This may include, for example, database replication agent **416** storing the changes to the information in data stores **404** as entries **702** in change table **418**. This may also include database replication agent **416** storing the row identifiers **706** associated with the rows in which the information was changed. This may further include database replication agent **416** storing a time stamp **708** identifying the time at which the information in data stores **404** was changed. Database replication agent **416** may use one or multiple change tables **418** to track the changes to the information in data stores **404**. Database server **402** consolidates the first changes made to database **112** at step **1004**. This may include, for example, database replication agent **416** combining entries **702** in change table **418** that represent changes to the same row of information in database **112**. If two entries **702** represent changes to different information in the same row, database replication agent **416** may combine these changes into a single entry **702** in change table **418**. If two entries **702** represent conflicting changes to the same information in a row, database replication agent **416** may use the time stamps **708** for those entries **702** and/or other suitable criteria to determine which entry **702** has priority, and database replication agent **416** may delete the entry **702** having lower priority. Database server **402** communicates the first changes to at least one other database **112** at step **1006**. This may include, for example, database replication agent **416** communicating the changes contained in table **418** to another database server **402** through alternate database server interface **414**.

[0097] Database server **402** receives second changes from another database **112** at step **1008**. This may include, for example, database server **402** receiving changes made to the information in data stores **404** in another database **112** in system **100**. Database server **402** determines if any of the first and second changes conflict at step **1010**. This may include, for example, database replication agent **416** determining if the first and second changes modified the same information in the same row of a table **420** or **422**. For example, one of the first changes in change table **418** may indicate that a client **102** deleted a row in a particular data table **420**, while a second change received from another database **112** indicates that another client **102** modified the entries in that row.

[0098] If any of the first and second changes conflict, database server **402** resolves the conflict at step **1012**. This may include, for example, database replication agent **416** using the time stamps **708** on the first and second changes to resolve the conflict. As particular examples, database replication agent **416** could give higher priority to the changes having the earliest time stamp **708**, the latest time stamp **708**, or any other suitable time stamp **708**. Database replication agent **416** could also support a hierarchy of changes, where changes higher in the hierarchy have priority over changes that are lower in the hierarchy. For example, database replication agent **416** could give priority to a change that deletes a row in a table **420** or **422** over a change that modifies an entry in that row. Database server **402** may **30** use any other suitable criteria for resolving conflicts between changes to information stored in databases **112**.

[0099] Database server **402** replicates the second changes to the information stored in database **112** at step **1014**. This may include, for example, database replication agent **416** reproducing the second changes to the information stored in data stores **404** of database **112**.

[0100] Although FIG. **10** illustrates one example embodiment of a method **1000** for database replication, various changes may be made to method **1000** without departing from the scope of the present invention. For example, database server **402** need not consolidate the first changes at step **1004**. Also, database server **402** may receive the second changes from another database **112** before communicating the first changes to the other database **112**.

[0101] FIG. **11** is a flow diagram illustrating an example method **1100** for accessing information in a replicated database **112**. Database server **402** receives a query at step **1102**. This may include, for example, database server **402** receiving the query from a web server **110** through web server interface **410**. The query may represent any suitable query, such as a request to view information about a specific product, a specific customer, or all information in a table **420** or **422**. Database server **402** creates a logical view of the information in table **420** or **422** at step **1104**. This may include, for example, database server **402** executing a logical structure **424** associated with the table **420** or **422**. The logical structure **424** may, for example, extract all information from a table **420** or **422** except for the row identifiers **504** or **608** contained in that table **420** or **422**. Database server **402** executes the query using the logical view of table **420** or **422** at step **1106**. This may include, for example, database server **402** extracting the information requested by the query from the logical view of table **420** or **422**. Database server **402** returns the query results at step **1108**. This may include, for example, database server **402** communicating the query results to the web server **110** that communicated the query to database server **402**. This allows web server **110** to receive the requested information from database **112**, while helping to ensure that the row identifiers contained in the tables **420** and **422** are not communicated to web server **110**.

[0102] Although FIG. **11** illustrates one example of a method **1100** for accessing data in a replicated database **112**, various changes may be made to method **1100** without departing from the scope of the present invention. For example, database server **402** may use any suitable logical structure **424** to create a logical view of a table **420** or **422**. Also, while database server **402** is described as extracting information from a table **420** or **422**, database server **402** may extract information from any suitable data structure, compilation, or arrangement.

[0103] Although the present invention has been described with several embodiments, a number of changes, substitutions, variations, alterations, and modifications may be suggested to one skilled in the art, and it is intended that the invention encompass all such changes, substitutions, variations, alterations, and modifications that fall within the spirit and scope of the appended claims.

1. A method, comprising:

storing information in a first database, the information being logically represented as a first table comprising a set of rows and columns;

generating, for each row in the first table, a row identifier that uniquely identifies the row;

receiving a modification to a first row in the first table;

automatically modifying information in a second table of a second database based on the modification to the first row in the first table, wherein the modifying includes:

identifying, based on the row identifier, a second row in the second table that corresponds to the first row in the first table, and

modifying the second row in the second table based on the modification to the first row in the first table;

receiving a request for information in the first database, the request corresponding to a query, to the first table, for information in the first row; and

providing the requested information, the providing including providing information in the first row of the first table without providing the row identifier.

2. The method of claim **1**, wherein the query for the information in the first row includes a query for all information stored in the first row.

3. The method of claim **2**, wherein the query for the information in the first row is received from an application that is not designed to process the row identifier.

4. The method of claim **1**, wherein the row identifier is hidden from a user, from whom the modification is received.

5. The method of claim **1**, wherein automatically modifying the information in the second database occurs without a request to modify the information in the second database.

6. The method of claim **1**, wherein generating, for a particular row in the first table, a particular row identifier includes:

automatically generating the particular row identifier when the particular row is added to the first table.

7. The method of claim **1**, wherein providing the requested information includes:

generating a logical structure that represents at least a portion of the first table, the at least the portion of the first table including at least the information associated with the first row,

wherein the logical structure does not include the row identifier associated with the first row; and

using the information associated with the first row, in the logical structure, to provide the requested information.

8. A system, comprising:

a plurality of memory devices, storing:

first information regarding a first database, the first information being logically represented as a first table comprising a first set of rows and columns,

second information regarding a second database, the second information being logically represented as a second table comprising a second set of rows and columns, and

a set of processor-executable instructions; and

one or more processors to execute the set of processor-executable instructions, wherein executing the set of processor-executable instructions causes the one or more processors to:

generate, for each row in the first table, a row identifier that uniquely identifies the row;

receive a modification to a first row in the first table;

identify, based on the row identifier, a second row in the second table that corresponds to the first row in the first table,

modify the second row in the second table based on the modification to the first row in the first table;

receive a request for information in the first database, the request corresponding to a query, to the first table, for information in the first row; and

provide, based on the request, information in the first row of the first table without providing the row identifier associated with the first row.

9. The system of claim **8**, wherein the query for the information in the first row includes a query for all information stored in the first row.

10. The system of claim **9**, wherein the query for the information in the first row is received from an application that is not designed to process the row identifier.

11. The system of claim **8**, wherein the row identifier is hidden from a user, from whom the modification is received.

12. The system of claim **8**, wherein automatically modifying the information in the second database occurs without a request to modify the information in the second database.

13. The system of claim **8**, wherein, for a particular row in the first table, a particular row identifier is automatically generated when the particular row is added to the first table.

14. The system of claim **8**, wherein executing the processor-executable instructions, to provide the requested information, causes the one or more processors to:

generate a logical structure that represents at least a portion of the first table, the at least the portion of the first table including at least the information associated with the first row,

wherein the logical structure does not include the row identifier associated with the first row; and

use the information associated with the first row, in the logical structure, to provide the requested information.

15. A non-transitory computer-readable medium, storing a plurality of instructions, which, when executed by a processor, cause the processor to:

generate, for each row in a first table that comprises a set of rows and columns, a row identifier that uniquely identifies the row;

receive a modification to a first row in the first table;

identify, based on the row identifier, a second row in a second table, the second row corresponding to the first row in the first table,

modify the second row in the second table based on the modification to the first row in the first table;

receive a request for information in the first database, the request corresponding to a query, to the first table, for information in the first row; and

provide, based on the request, information in the first row of the first table without providing the row identifier associated with the first row.

16. The non-transitory computer-readable medium of claim **15**, wherein the query for the information in the first row includes a query for all information stored in the first row.

17. The non-transitory computer-readable medium of claim **16**, wherein the query for the information in the first row is received from an application that is not designed to process the row identifier.

18. The non-transitory computer-readable medium of claim **15**, wherein the row identifier is hidden from a user, from whom the modification is received.

19. The non-transitory computer-readable medium of claim **15**, wherein automatically modifying the information in the second database occurs without a request to modify the information in the second database.

20. The non-transitory computer-readable medium of claim **15**, wherein the processor-executable instructions, to provide the requested information, include instructions to:

generate a logical structure that represents at least a portion of the first table, the at least the portion of the first table including at least the information associated with the first row,

wherein the logical structure does not include the row identifier associated with the first row; and

use the information associated with the first row, in the logical structure, to provide the requested information.

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