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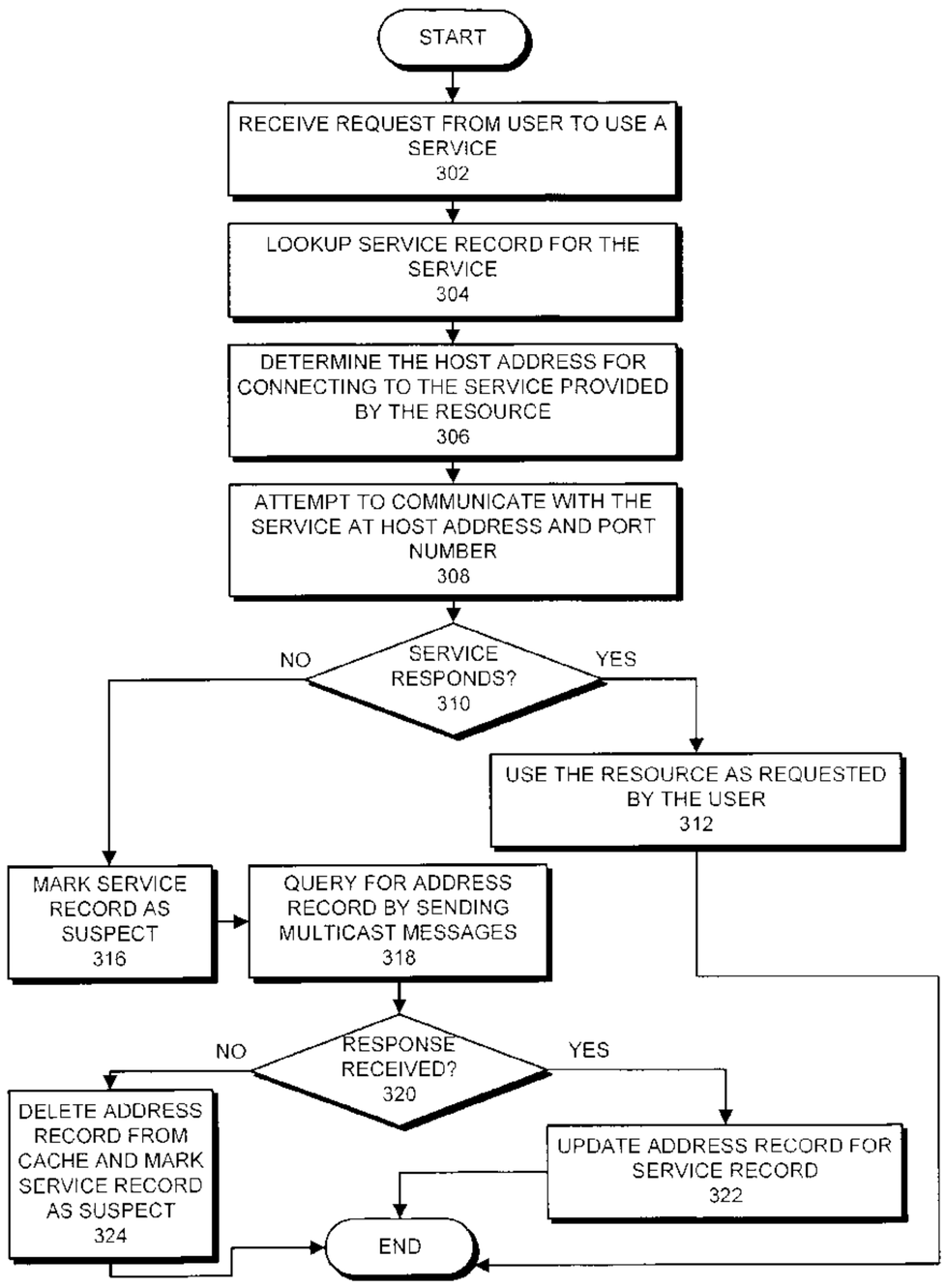
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(54) Titre : PROCEDE ET DISPOSITIF PERMETTANT D'ACCELERER L'EXPIRATION DES ENREGISTREMENTS DE RESSOURCES DANS UNE ANTEMEMOIRE LOCALE

(54) Title: METHOD AND APPARATUS FOR ACCELERATING THE EXPIRATION OF RESOURCE RECORDS IN A LOCAL CACHE



(57) Abrégé/Abstract:
One embodiment of the present invention provides a system that facilitates reconfirmation of resource records in a cache. The system starts by retrieving the resource record at a client and attempting to establish communication using the data in that resource

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(57) Abrégé(suite)/Abstract(continued):
record. In the event that communication is not successful, the system responds by issuing one or more queries for the resource record in question. The system then waits for a response to the query. If the response to the query is not received in a pre-determined amount of time, the system invalidates the resource record. The response from the device is a multicast response, thereby allowing other clients to update corresponding resource records in their local caches without querying the device, and thus saving network bandwidth.

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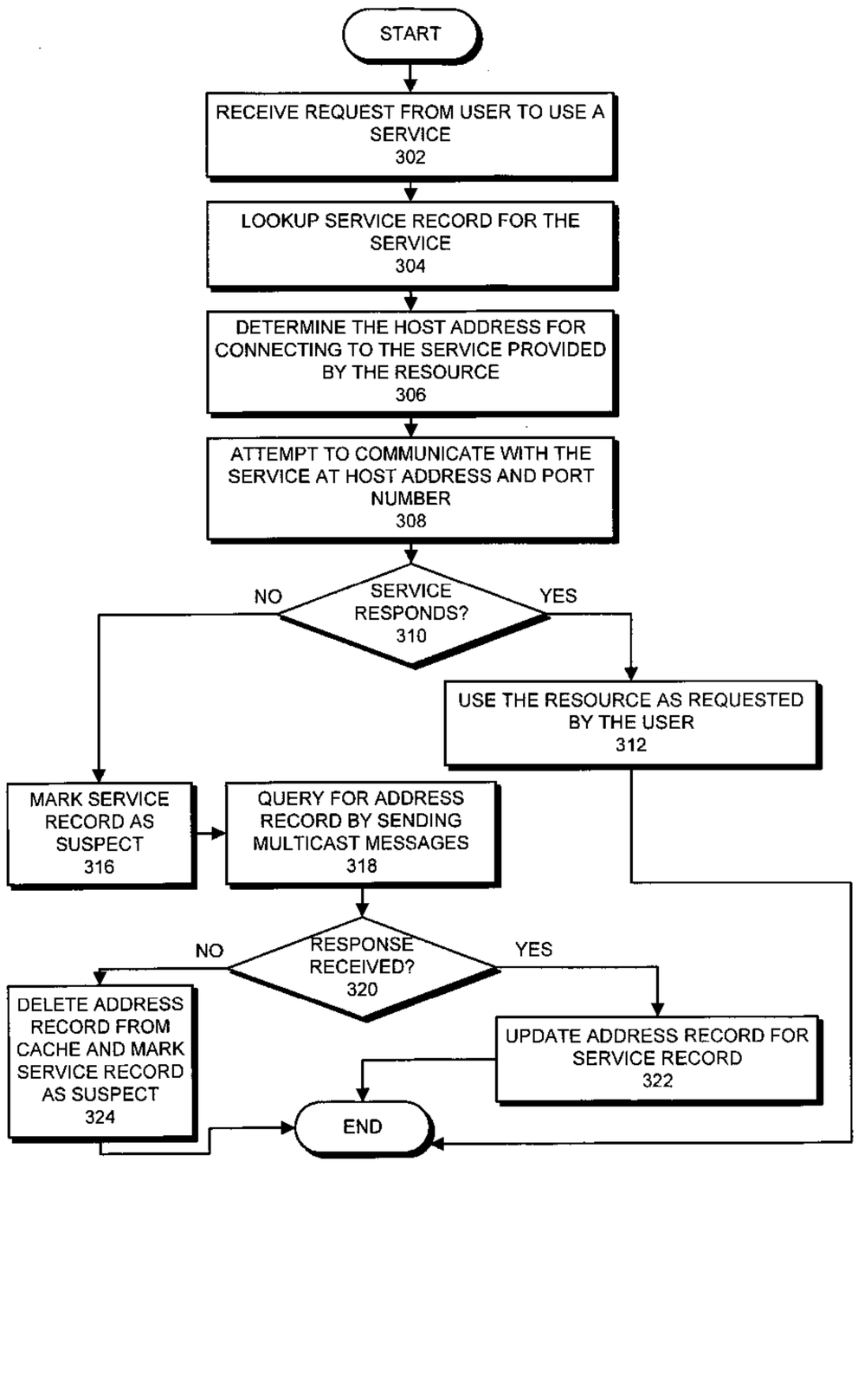
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(54) Title: METHOD AND APPARATUS FOR ACCELERATING THE EXPIRATION OF RESOURCE RECORDS IN A LOCAL CACHE



(57) Abstract: One embodiment of the present invention provides a system that facilitates reconfirmation of resource records in a cache. The system starts by retrieving the resource record at a client and attempting to establish communication using the data in that resource record. In the event that communication is not successful, the system responds by issuing one or more queries for the resource record in question. The system then waits for a response to the query. If the response to the query is not received in a pre-determined amount of time, the system invalidates the resource record. The response from the device is a multicast response, thereby allowing other clients to update corresponding resource records in their local caches without querying the device, and thus saving network bandwidth.

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METHOD AND APPARATUS FOR ACCELERATING THE EXPIRATION OF RESOURCE RECORDS IN A LOCAL CACHE

Inventor: Stuart D. Cheshire

BACKGROUND

Field of the Invention

[0001] The present invention relates to computer networks. More specifically, the present invention relates to a method and an apparatus accelerating the expiration of local resource records in a local cache.

Related Art

[0002] The explosive growth of broadband technology and network infrastructure, coupled with continually decreasing prices, has led to an increasing number of computer networks in homes and small businesses. Along with this small-office/home-office network revolution comes the daunting task of configuring and administering these networks. Plug-and-play network protocols, such as Apple Computer Inc.'s Rendezvous, have been developed to simplify administration tasks. Within Rendezvous, devices, such as printers, scanners, and network attached storage, automatically configure themselves and advertise their services upon being connected to the network. Computer systems on the network add resource records for these devices to their local cache upon receiving the advertisement, thus maintaining a list of available services on the network.

[0003] Along with the benefits of maintaining a local cache come problems. Computer systems on the network must continually update their cache records to maintain an accurate list of available services. Traditionally, computer systems have done this by querying the services and waiting for a response. If a response is not

received within a specified amount of time, or after a specified amount of tries, the record pertaining to the service or associated device is deleted from the cache. Frequently polling services (and related devices) in this way provides a more accurate list of services, but can dramatically increase network traffic.

[0004] One problem with caching resource records arises from stale data. A device may be removed from the network in a manner that does not allow it to report the unavailability of its services. Power failures, improper shutdowns, and disconnected network cables are just a few examples of common occurrences that can cause invalid cache records. Often, users unsuccessfully try to use a service because a corresponding locally cached record for the service is invalid, which causes the service incorrectly to show up locally as being available. This can result in frustration to the user because the service still shows up as available in the local list. Moreover, even if some cache records are invalidated on some computer systems, the same invalid cache records may still be present on other computer systems on the network.

[0005] Hence, what is needed is a method and an apparatus for maintaining resource records in a cache without the limitations listed above.

SUMMARY

[0006] One embodiment of the present invention provides a system that facilitates validating a resource record in a cache. The system starts by retrieving the resource record at a client and attempting to use this information to establish communication with the corresponding service. If the attempt to establish communication is unsuccessful, then this suggests that the data in the resource record may be incorrect, so a query for that resource record is issued on the network. If a response is received containing different resource record data, then the cache is updated with the new data, and the attempt to establish communication is repeated using the new information. If, after sending the query one, two, three, or more, times, as appropriate, no response is received, then this indicates that the resource record is no longer valid, and it is deleted from the cache. In this way the stale data is deleted

more promptly that it would be if the decision were made solely based on the time-to-live originally attached to that data.

[0007] When the record is deleted from the cache, this technique may then be applied recursively to call into question any records that refer to the now-deleted record. To take an example from the domain name system, if the now-deleted record were an address record, then any other records (e.g. SRV, PTR, CNAME, etc.) containing the name of this address record on their right-hand side are similarly suspect, and should be similarly updated or deleted as appropriate. In the case of Apple's Rendezvous, the response from the device is a multicast response, thereby allowing other clients to update corresponding resource records in their local caches without querying the device, and thus saving network bandwidth.

[0008] In a variation on this embodiment, prior to invalidating the resource record, the system issues a second query for the resource record and waits for a response to the second query from the device. If the response to the second query is not received in a pre-determined amount of time, the system invalidates the resource record.

[0009] In a variation on this embodiment, the system receives a message from a second client querying for a second resource record. Upon receiving the query, the system locates a second resource record and waits for a multicast response to the multicast message. If the multicast response to the multicast message is not received in the pre-determined amount of time, the system invalidates the second resource record.

[0010] In a variation on this embodiment, invalidating the resource record also involves invalidating a child record of the resource record.

[0011] In a variation on this embodiment, if the response to the query is not received in a pre-determined amount of time, the system retrieves a parent record of the resource record at the client and multicasts a query for the parent record. The system then waits for a response to the query from the device, and if the response to the query is not received in a pre-determined amount of time, the system invalidates the parent record.

[0012] In a variation on this embodiment, if the response to the query is not received in a pre-determined amount of time, the system retrieves a parent record of the resource record at the client and multicasts a query for the parent record. The system then receives a response to the query from the device, and updates the resource record with the information included in the response.

[0013] In a further variation, the system updates the parent record with the information received in the response.

[0014] In a variation on this embodiment, the system is invoked to validate resource records in the cache at a pre-specified time interval.

BRIEF DESCRIPTION OF THE FIGURES

[0015] FIG. 1 illustrates a computer network in accordance with an embodiment of the present invention.

[0016] FIG. 2 illustrates cached resource records in accordance with an embodiment of the present invention.

[0017] FIG. 3 presents a flowchart illustrating the process of updating a resource record in a cache in accordance with an embodiment of the present invention.

[0018] FIG. 4 presents a flowchart illustrating the process of updating a resource record in a cache in response to a query in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0019] The following description is presented to enable any person skilled in the art to make and use the invention, and is provided in the context of a particular application and its requirements. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present invention. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[0020] The data structures and code described in this detailed description are typically stored on a computer readable storage medium, which may be any device or medium that can store code and/or data for use by a computer system. This includes, but is not limited to, magnetic and optical storage devices such as disk drives, magnetic tape, CDs (compact discs) and DVDs (digital versatile discs or digital video discs), and computer instruction signals embodied in a transmission medium (with or without a carrier wave upon which the signals are modulated). For example, the transmission medium may include a communications network, such as the Internet.

Computer Network

[0021] FIG. 1 illustrates a computer network 100 in accordance with an embodiment of the present invention. Network 100 can generally include any type of wired or wireless communication channel capable of coupling together computing nodes. This includes, but is not limited to, a local area network, a wide area network, or a combination of networks. In one embodiment of the present invention, network 100 includes the Internet.

[0022] Network 100 includes computer systems 102 and 104, printers 106 and 108, and scanner 110. Computer systems 102 and 104 can generally include any type of computer system, including, but not limited to, a computer system based on a microprocessor, a mainframe computer, a digital signal processor, a portable computing device, a personal organizer, a device controller, and a computational engine within an appliance.

[0023] In one embodiment of the present invention, the devices on network 100 adhere to a plug-and-play protocol, such as Apple Computer, Inc.'s Rendezvous technology. Printers 106 and 108, and scanner 110 self-configure to network 100 and advertise their services via multicast messages to all nodes on network 100. Computer systems 102 and 104 each utilize a local cache that contains resource records for the known devices and services on network 100.

Cached Resource Records

[0024] FIG. 2 illustrates cached resource records in accordance with an embodiment of the present invention. Each device on network 100, such as printer 106, may have a several resource records containing information pertaining to that device, such as service pointer record 202, in the cache on computer systems in network 100. Service pointer record 202 includes the type of service and the name of the service instance. In the example shown in FIG. 2, service pointer record 202 identifies a printing service named "Stuart's Printer."

[0025] Each service pointer record 202 refers by name to a corresponding service record 204, which contains information about a service on the device named in service record 204. Note that one device may offer multiple services, and thus may have multiple service records. Service record 204 contains the name of the device that the service is provided by. In the example shown in FIG. 2, service record 204 contains the name of corresponding address record 206, which contains the Internet Protocol (IP) address for the service.

Validating Resource Records in a Local Cache

[0026] FIG. 3 presents a flowchart illustrating the process of updating or invalidating resource records in a local cache in accordance with an embodiment of the present invention. The system starts when a request is received from a user to use a service on network 100 (step 302). Upon receiving the request, the system looks up the service record 204 for the device (step 304).

[0027] Next, the system determines the host address for connecting to the service provided by the resource (step 306). This is accomplished by looking up address record 206 that is referenced by service record 204. Once the host address and port number are known, the system attempts to communicate with the service at the host and port number (step 308). If the communication is successful, the system uses the resource as requested by the user (step 312).

[0028] If the communication is not successful, the system marks address record 206 as suspect (step 316). The system then queries for the address record by sending one or more multicast messages to the entire network (step 318), and waiting

for a response (step 320). If the service responds, the system updates address record 206 with information included in the response and uses the service as directed by the user (step 322). If no response is received after a specified amount of time and a specified amount of queries, the address record is deleted from the cache and the system marks service record 204 as suspect (step 324).

[0029] At this point, the process repeats and the system sends queries for the service record 204 by sending a multicast message to the entire network, and waiting for a response. If no response is received then service record 204 is deleted from the cache, and the system proceeds to reconfirm service pointer 202 in the same way.

Second-Hand Updating of Resource Records in a Cache

[0030] FIG. 4 presents a flowchart illustrating the process of updating a resource record 202 in a local cache based on queries performed by other computer systems in accordance with an embodiment of the present invention. The system starts when computer system 102 receives a multicast message from computer system 104, wherein the multicast message queries a service provided by printer 106 (step 402). Computer system 102 looks in its local cache to locate service record 204 that corresponds to the query from computer system 104 (step 404). Next, computer system 102 waits for a response from the service (step 406). Note that in the present invention, devices and services respond to queries by sending a multicast message to network 100 rather than a unicast message directed only to the system that created the query. By sending a multicast response, this allows other devices on network 100 to update corresponding entries in their local caches without consuming extra bandwidth. If the service responds, computer system 102 updates corresponding resource records, such as address record 206 and service record 204, or creates new versions of address record 206 and service record 204, if necessary (step 408). If there is no response from the service, computer system 102 deletes service record 204 (step 410) as proceeds to reconfirm any records in the local cache which may refer to it.

[0031] The foregoing descriptions of embodiments of the present invention have been presented for purposes of illustration and description only. They are not

intended to be exhaustive or to limit the present invention to the forms disclosed. Accordingly, many modifications and variations will be apparent to practitioners skilled in the art. Additionally, the above disclosure is not intended to limit the present invention. The scope of the present invention is defined by the appended claims.

What Is Claimed Is:

1. A method for validating a resource record in a cache, comprising:

retrieving the resource record at a client;

issuing one or more queries for the resource record;

waiting for a response to the query; and

if the response to the query is not received in a pre-determined amount of time, invalidating the resource record.

2. The method of claim 1, wherein the response to the query is a multicast response, thereby allowing other clients to update corresponding copies of the resource records without querying the device, thus saving network bandwidth.

3. The method of claim 1, further comprising:

receiving a multicast message from a second client querying a second device;

locating a second resource record associated with the second device;

waiting for a multicast response to the multicast query; and

if after a pre-determined number of queries the multicast response to the multicast query is not received in the pre-determined amount of time, invalidating the second resource record.

4. The method of claim 1, wherein invalidating the resource record further comprises invalidating a child record of the resource record.

5. The method of claim 1, wherein if the response to the query is not received in a pre-determined amount of time, the method further comprises:

retrieving a parent record of the resource record at the client, wherein the parent record refers to the resource record;

issuing a query for the parent record;

waiting for a response to the query from the device; and

if the response to the query is not received in a pre-determined amount of time, invalidating the parent record, and then repeating the above process by applying it recursively to any records that refer to the now-invalidated parent record.

6. The method of claim 1, wherein if the response to the query is not received in a pre-determined amount of time, the method further comprises:

retrieving a parent record of the resource record at the client, wherein the parent record refers to the resource record;

issuing a query for the parent record;

receiving a response to the query from the device, wherein the response includes information for updating the resource record; and

updating the resource record with the information received in the response.

7. The method of claim 6, wherein the method further comprises updating the parent record with the information received in the response.

8. The method of claim 1, wherein the method is invoked at a pre-specified time interval.

9. A computer-readable storage medium storing instructions that when executed by a computer cause the computer to perform a method for validating a resource record in a cache, the method comprising:

retrieving the resource record at a client;

issuing one or more queries for the resource record;

waiting for a response to the query; and

if the response to the query is not received in a pre-determined amount of time, invalidating the resource record.

10. The computer-readable storage medium of claim 9, wherein the response to the query is a multicast response, thereby allowing other clients to update

corresponding copies of the resource records without querying the device, thus saving network bandwidth.

11. The computer-readable storage medium of claim 9, wherein the method further comprises:

receiving a multicast message from a second client querying a second device;

locating a second resource record associated with the second device;

waiting for a multicast response to the multicast query; and

if after a pre-determined number of queries the multicast response to the multicast query is not received in the pre-determined amount of time, invalidating the second resource record.

12. The computer-readable storage medium of claim 9, wherein invalidating the resource record further comprises invalidating a child record of the resource record.

13. The computer-readable storage medium of claim 9, wherein if the response to the query is not received in a pre-determined amount of time, the method further comprises:

retrieving a parent record of the resource record at the client, wherein the parent record refers to the resource record;

issuing a query for the parent record;

waiting for a response to the query from the device; and

if the response to the query is not received in a pre-determined amount of time, invalidating the parent record, and then repeating the above process by applying it recursively to any records that refer to the now-invalidated parent record.

14. The computer-readable storage medium of claim 9, wherein if the response to the query is not received in a pre-determined amount of time, the method further comprises:

retrieving a parent record of the resource record at the client, wherein the parent record refers to the resource record;

issuing a query for the parent record;

receiving a response to the query from the device, wherein the response includes information for updating the resource record; and

updating the resource record with the information received in the response.

15. The computer-readable storage medium of claim 14, wherein the method further comprises updating the parent record with the information received in the response.

16. The computer-readable storage medium of claim 9, wherein the method is invoked at a pre-specified time interval.

17. An apparatus that validates a resource record in a cache, comprising:

a retrieval mechanism at a client configured to retrieve the resource record; and

an invalidation mechanism configured to,

issue one or more queries for the resource record,

wait for a response to the query, and

if the response to the query is not received in a pre-determined amount of time, to invalidate the resource record.

18. The apparatus of claim 17, wherein the response to the query is a multicast response, thereby allowing other clients to update corresponding copies of the resource records without querying the device, thus saving network bandwidth.

19. The apparatus of claim 17, wherein the invalidation mechanism is configured to:

receive a multicast message from a second client querying a second device;

locate a second resource record associated with the second device;

wait for a multicast response to the multicast query; and

if after a pre-determined number of queries the multicast response to the multicast query is not received in the pre-determined amount of time, to invalidate the second resource record.

20. The apparatus of claim 17, wherein invalidating the resource record further comprises invalidating a child record of the resource record.

21. The apparatus of claim 17, wherein if the response to the query is not received in a pre-determined amount of time, the invalidation mechanism is additionally configured to:

retrieve a parent record of the resource record at the client, wherein the parent record refers to the resource record;

issue a query for the parent record;

wait for a response to the query from the device; and

if the response to the query is not received in a pre-determined amount of time, to invalidate the parent record, and to then repeat the above process by applying it recursively to any records that refer to the now-invalidated parent record.

22. The apparatus of claim 17, further comprising an updating mechanism, wherein if the response to the query is not received in a pre-determined amount of time, the updating mechanism is configured to:

retrieve a parent record of the resource record at the client, wherein the parent record refers to the resource record;

issue a query for the parent record;

receive a response to the query from the device, wherein the response includes information for updating the resource record; and to

update the resource record with the information received in the response.

23. The apparatus of claim 22, wherein the updating mechanism is additionally configured to update the parent record with the information received in the response.

24. The apparatus of claim 17, wherein the apparatus is invoked at a pre-specified time interval.

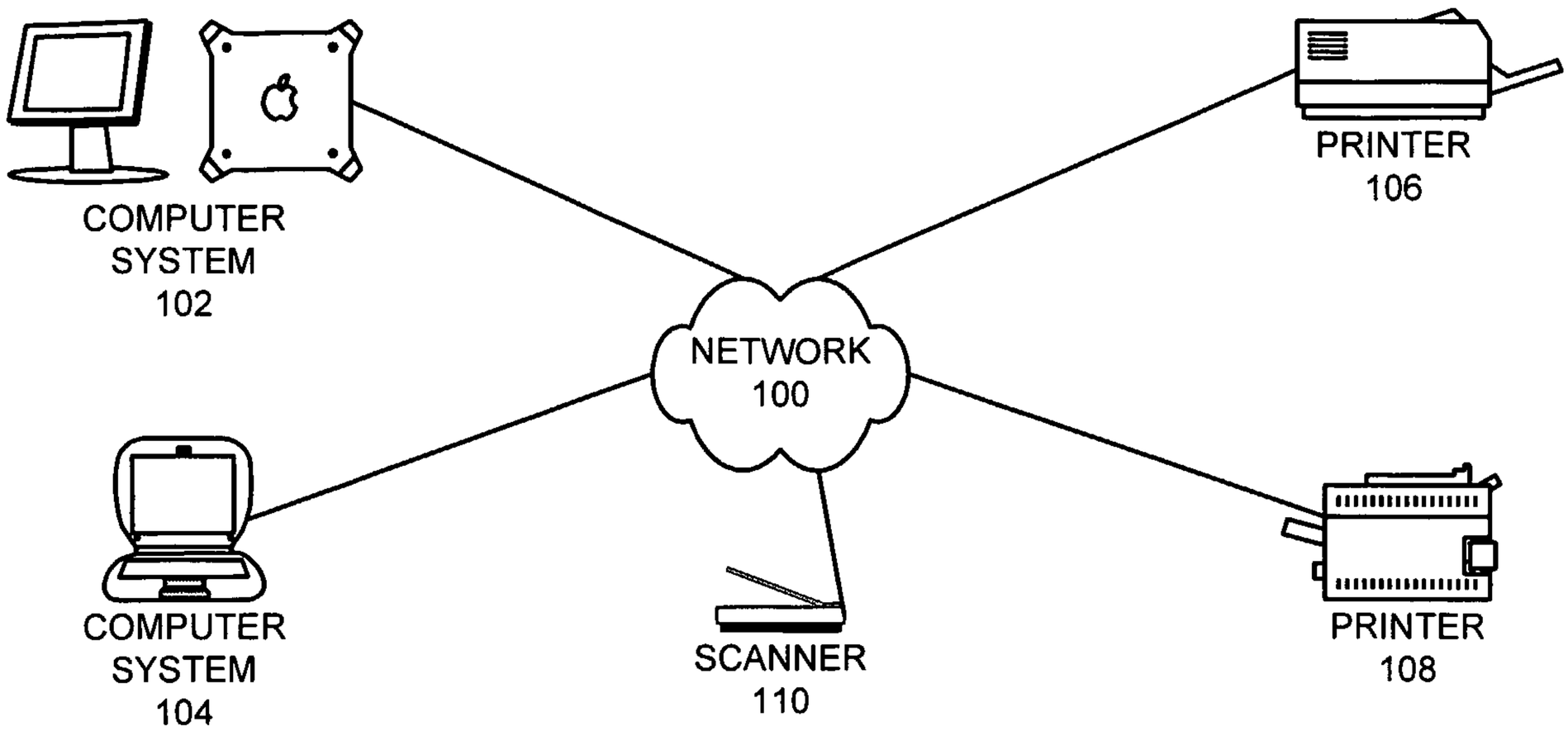

COMPUTER SYSTEM 102
NETWORK 100
PRINTER 106
COMPUTER SYSTEM 104
SCANNER 110
PRINTER 108

FIG. 1

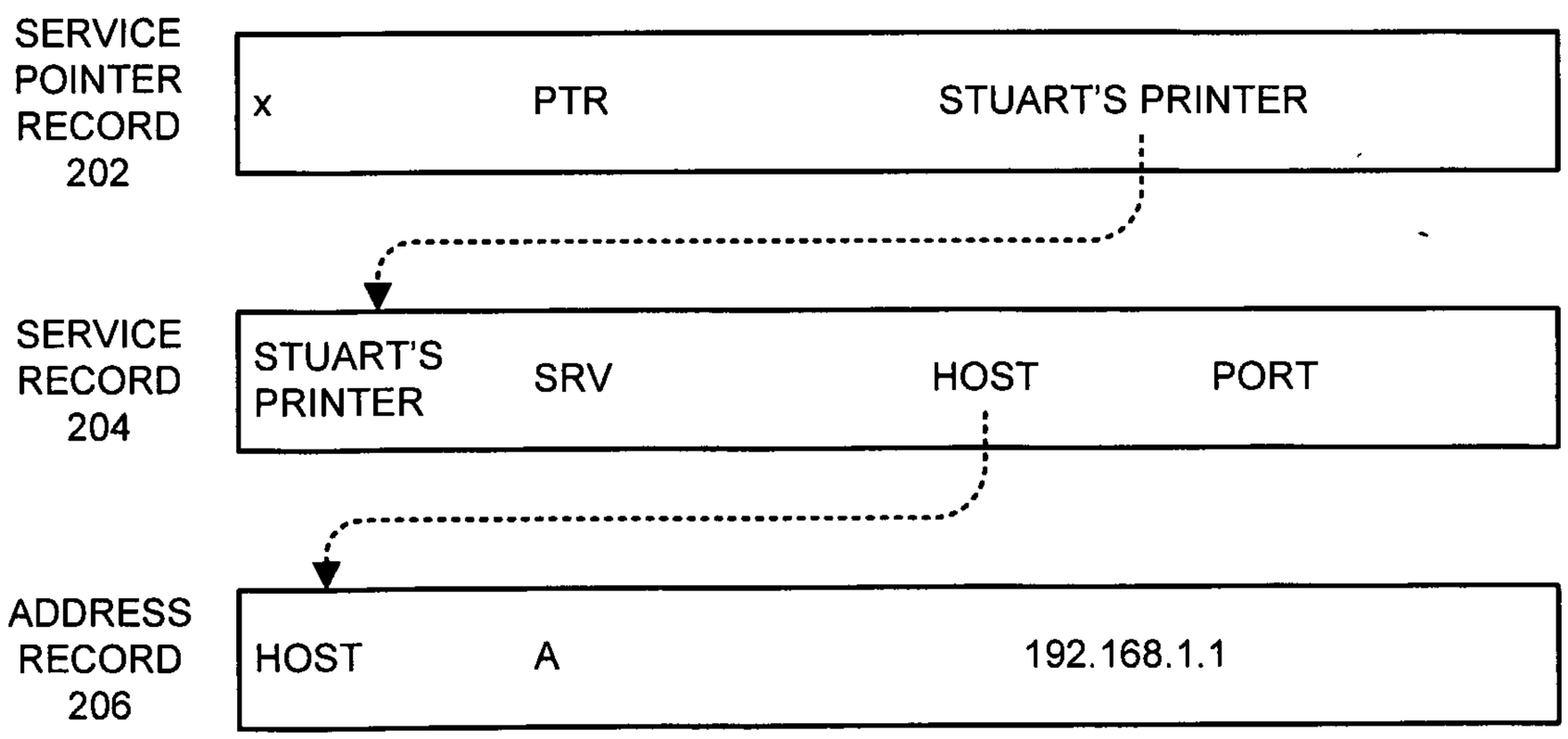

SERVICE POINTER RECORD 202
x PTR STUART'S PRINTER
SERVICE RECORD 204
STUART'S PRINTER SRV HOST PORT
ADDRESS RECORD 206
HOST A 192.168.1.1

FIG. 2

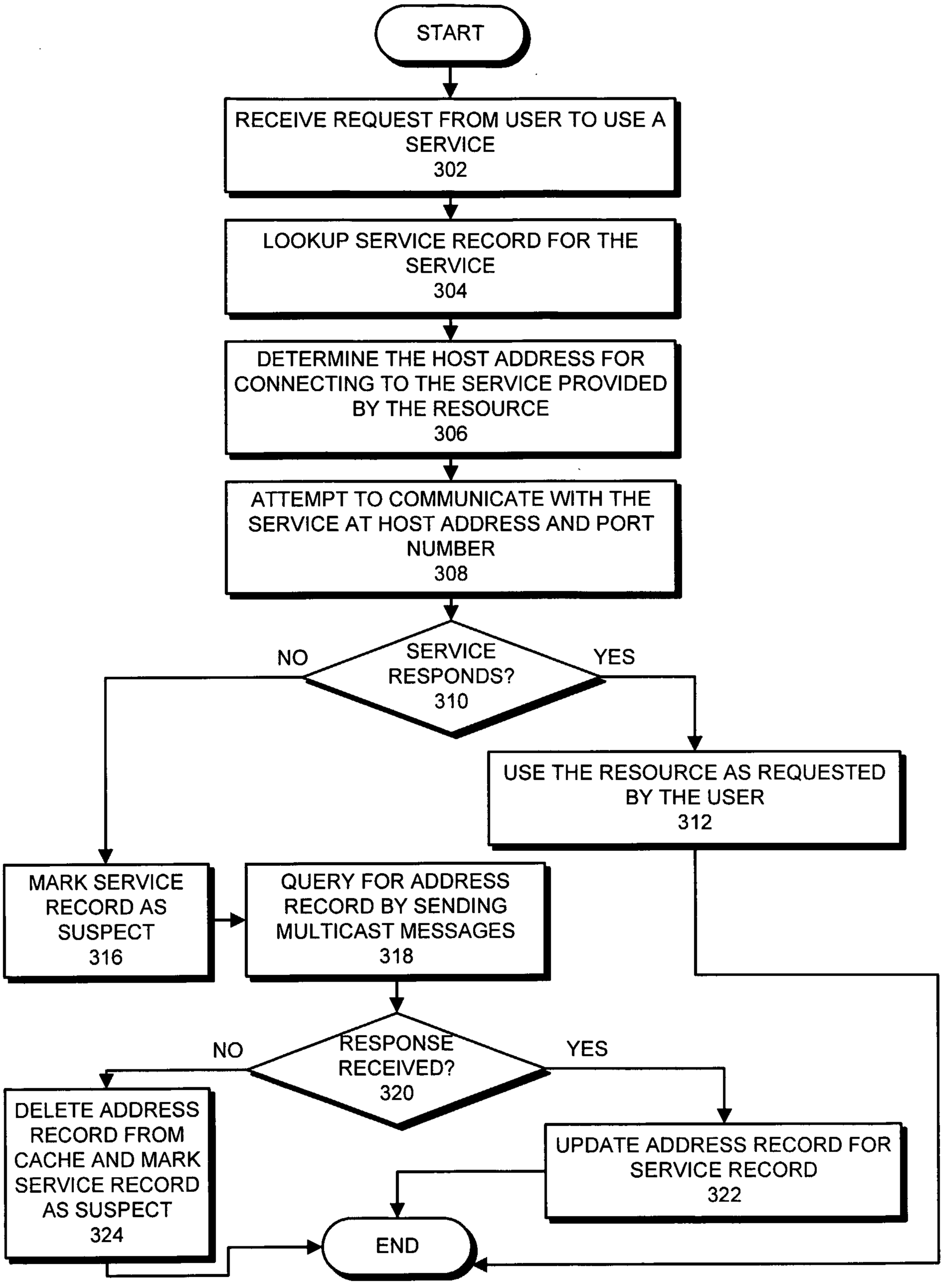

START
RECEIVE REQUEST FROM USER TO USE A SERVICE
302
LOOKUP SERVICE RECORD FOR THE SERVICE
304
DETERMINE THE HOST ADDRESS FOR CONNECTING TO THE SERVICE PROVIDED BY THE RESOURCE
306
ATTEMPT TO COMMUNICATE WITH THE SERVICE AT HOST ADDRESS AND PORT NUMBER
308
SERVICE RESPONDS?
310
NO
YES
USE THE RESOURCE AS REQUESTED BY THE USER
312
MARK SERVICE RECORD AS SUSPECT
316
QUERY FOR ADDRESS RECORD BY SENDING MULTICAST MESSAGES
318
RESPONSE RECEIVED?
320
NO
YES
DELETE ADDRESS RECORD FROM CACHE AND MARK SERVICE RECORD AS SUSPECT
324
UPDATE ADDRESS RECORD FOR SERVICE RECORD
322
END

FIG. 3

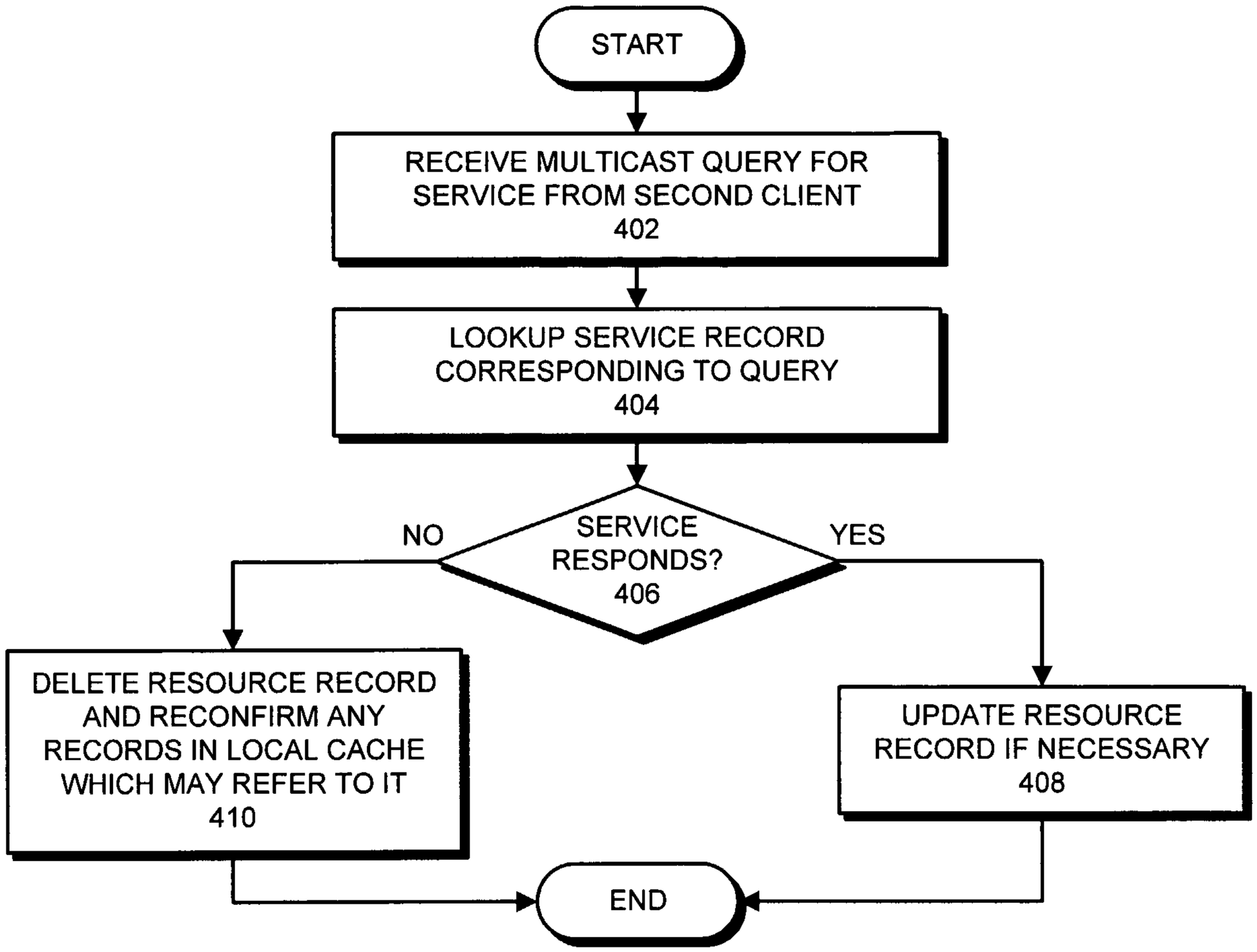
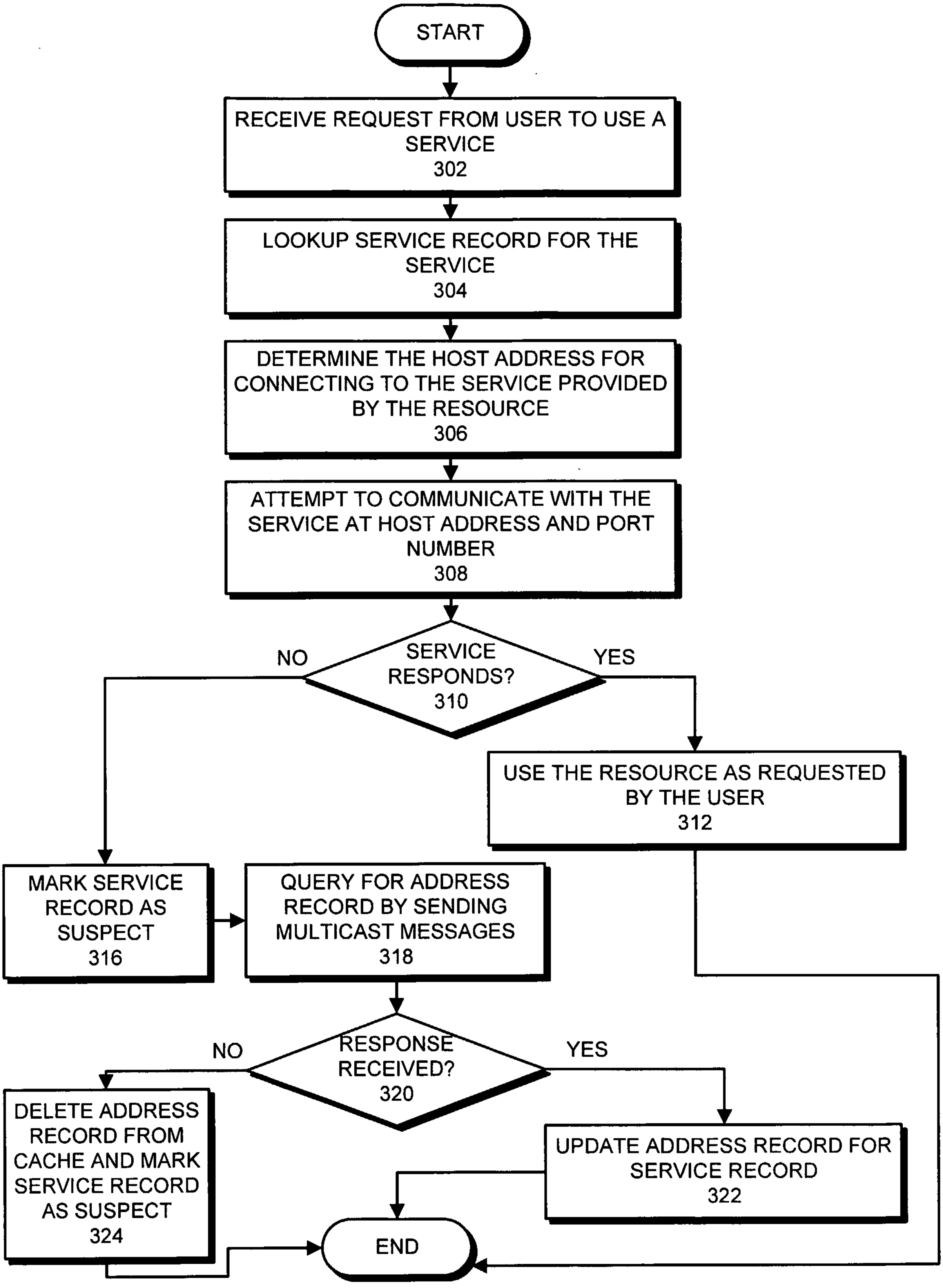

START
RECEIVE MULTICAST QUERY FOR SERVICE FROM SECOND CLIENT 402
LOOKUP SERVICE RECORD CORRESPONDING TO QUERY 404
SERVICE RESPONDS? 406
NO
YES
DELETE RESOURCE RECORD AND RECONFIRM ANY RECORDS IN LOCAL CACHE WHICH MAY REFER TO IT 410
UPDATE RESOURCE RECORD IF NECESSARY 408
END

FIG. 4


START
RECEIVE REQUEST FROM USER TO USE A SERVICE
302
LOOKUP SERVICE RECORD FOR THE SERVICE
304
DETERMINE THE HOST ADDRESS FOR CONNECTING TO THE SERVICE PROVIDED BY THE RESOURCE
306
ATTEMPT TO COMMUNICATE WITH THE SERVICE AT HOST ADDRESS AND PORT NUMBER
308
SERVICE RESPONDS?
310
NO
YES
USE THE RESOURCE AS REQUESTED BY THE USER
312
MARK SERVICE RECORD AS SUSPECT
316
QUERY FOR ADDRESS RECORD BY SENDING MULTICAST MESSAGES
318
RESPONSE RECEIVED?
320
NO
YES
DELETE ADDRESS RECORD FROM CACHE AND MARK SERVICE RECORD AS SUSPECT
324
UPDATE ADDRESS RECORD FOR SERVICE RECORD
322
END