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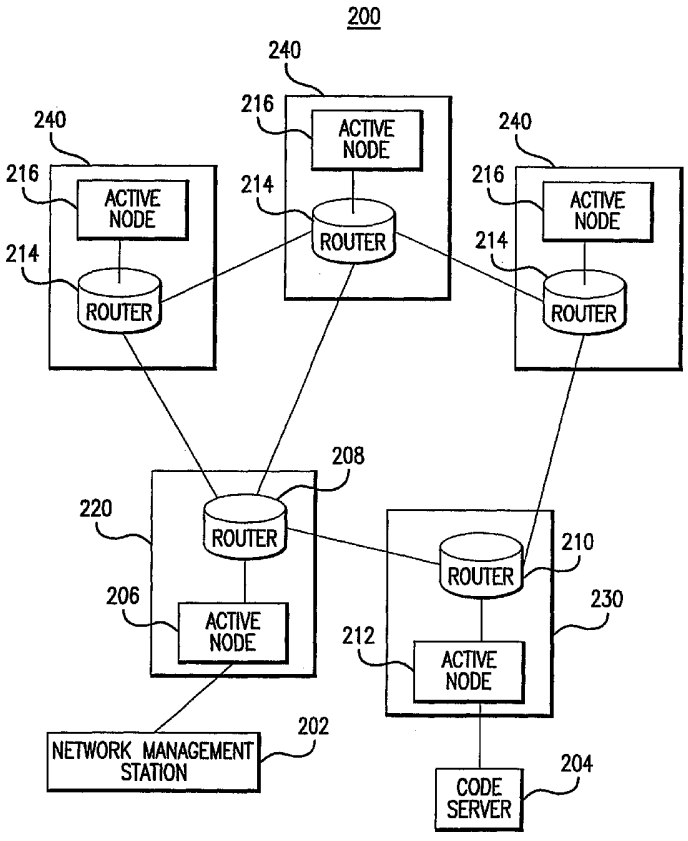
(54) Title: METHOD AND APPLICATION FOR CONDUCTING REAL-TIME LOCATION-BASED DISTRIBUTED SEARCH



(57) Abstract: A system and method for providing location-based services on an electronic communications network. Mobile agents or programs for location-based services are propagated on the electronic communications network from a launch node using an echo pattern for network navigation. The mobile agents or programs for location-based services include a specification of a localization distance. The echo pattern propagation of the mobile agents or programs on the echo pattern is limited only to network nodes within the specified localization distance form the launch node.

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METHOD AND APPLICATION FOR CONDUCTING REAL-TIME LOCATION-BASED DISTRIBUTED SEARCH

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application Serial No. 60/686,632 filed June 2, 2005. The present application also is related to and claims the benefit of International Patent Application No. PCT/US2004/14733 filed May 2, 2005 and International Patent Application No. PCT/US2004/010646 filed April 7, 2004. All of the aforementioned priority and related applications are incorporated by reference herein in their entireties.

FIELD OF THE INVENTION

The present invention relates to electronic communication networks that link users over geographically diverse areas. The invention, in particular, relates to the provision of network services or solutions that are tailored to the specific locations of individual users.

BACKGROUND OF THE INVENTION

Modern electronic communication networks (e.g., the Internet and corporate networks) provide unprecedented interaction between diverse individuals or entities without regard for their geographic location. The Internet has been described as at once a world-wide broadcasting capability, a mechanism for information dissemination, and a medium for collaboration. The electronic communication networks are accessible to users via microprocessor-based access devices, which may be stationary units (e.g., desktop computers, servers, etc.) or mobile units (e.g., laptop computers, cell phones, personal digital assistants (PDA), other handheld devices, etc.).

The electronic communication networks are now exploited by commercial and non-commercial entities to disseminate information to broad or indiscriminate audiences. Merchants, for example, may electronically advertise their wares by e-mail or on public web pages that are generally accessible to any network users. Conversely, individuals now search and receive information on any topic of interest from world-wide sources via the electronic communication networks using, for example, web browsers, search engines, or e-mail.

A drawback of the extensive nature of the electronic communication networks such as the Internet is that the information received by a user may be unrelated or irrelevant to the user's geographical circumstances. Conversely, information of local geographical interest put out over the electronic communication networks by commercial or non-commercial entities may be misdirected in the traffic on the network or lost in the information clutter on the network and not reach the intended or appropriate local audiences.

Consideration is now being given to systems and methods for providing location-based services on electronic communication networks. In particular, attention is directed to providing location-based searching and communication capability to individual users and network applications. The desirable location-based capability preferably is a real-time capability to accommodate, for example, mobile access device users whose locations can change.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figures showing illustrative embodiments of the invention. FIGS 1-3 and FIGS. 4-6 for convenience have been reproduced herein from International Patent Application No. PCT/US2004/14733 and International Patent Application No. PCT/US2004/010646, respectively. In the figures:

FIG. 1 is a schematic illustration of a pattern-based network management system;

FIG. 2 is an illustration of an echo pattern for network program dissemination;

FIG. 3 is a schematic illustration of the software architecture of an active network node of the system of FIG. 1;

FIG. 4 is a block diagram depicting a system for searching for network traffic and content data.

FIG. 5 is a block diagram of the functional elements of a network probe utilized in the system of FIG. 4.

FIG. 6 illustrates an exemplary distributed architecture of the present invention.

FIG. 7 illustrates an exemplary procedure for distributing location-based service agents or programs over an electronic communication network, in accordance with the principles of the present invention.

Throughout the figures, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the illustrated embodiments. Moreover, while the subject invention will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments. It is intended that changes and modifications can be made to the described embodiments without departing from the true scope and spirit of the subject invention as defined by the appended claims.

DESCRIPTION OF THE INVENTION

The present invention provides systems and methods for enabling location-based services over electronic communication networks. The location-based services are enabled in response to the real-time location of a network user or a network resident application. Exemplary location-based services may be services such as location-dependent information delivery services, electronic tour guides, transportation guides, Instant Messaging Buddy trackers, location-aware emergency services including roadside assistance and general emergency services (such as FCC's Phase II E911), location-based advertisement, and location-enhanced entertainment (e.g., mobile games).

Enablement of the location-based services advantageously allows users or applications to request and receive specific information and applications relevant to their geographic locations.

The inventive systems and methods deploy an array of known network elements (i.e. markers) dispersed in the electronic communication network to triangulate the real time geographical location of a target application or a mobile user The mobile user may, for example, be accessing the network via a network node at a particular location using a handheld access device. The inventive systems and methods may be integrated with distributed pattern-based network management schemes to deliver desired location-based services to the target application or mobile user. An exemplary distributed pattern-based network management program, which

efficiently propagates mobile network agents or programs through the network using an echo pattern for navigation is described in International Patent Application No. PCT/US2004/010646, incorporated by reference herein. These or similar mobile agents or programs may be used to deliver the desired location-based services to the target application or mobile user at the triangulated location or a network node in proximity to the triangulated location. The mobile agents or programs used to deliver the desired location-based services may be distributed over the network using an echo pattern or other suitable pattern for navigation. (See e.g., FIGS. 1-3).

Further, the inventive systems and methods for enabling location-based services may be integrated with schemes that are commonly used to monitor and analyze network traffic and content. Such monitoring and analysis schemes typically sift through a high volume of packets of information flowing in real-time to look for patterns, locate resources, aggregate data and correlate information. The geographical or geometrical resolution inherent in such schemes can be advantageously exploited to deliver or enable location-based services to target applications or mobile users.

An exemplary monitoring and analysis scheme with which the inventive systems and methods for enabling location-based services may be integrated is described in International Patent Application No. PCT/US2004/010646, incorporated by reference herein. The referenced patent application describes a real-time performance monitoring platform which allows the dynamics of packet traffic in large networks to be observed and monitored in real-time. (See FIGS. 4-6). The platform includes of an array of hardware network probes dispersed through the network. The platform can capture traffic at line rate and perform detailed analysis, measure quality of service metrics along network paths between pairs of probes, and store all analysis and measurement results in relational tables. The platform also may include a centralized management console which allows operators to issue queries to extract and compute data from tables stored on the network probes in real-time. The network probes autonomously detect the presence of other network probes during power up and create a peer-to-peer network encompassing other probes in the network. In the boot up process, and periodically afterwards, each probe registers its address (e.g., IP address) with the console.

The real-time performance monitoring platform utilizes distributed query propagation and processing. Queries issued from the console are propagated along a minimal delay spanning tree to all probes. Intermediate results are incrementally aggregated at each probe so that the amount of time required to execute a query is proportional only to the length of the longest path. This allows queries for very large networks to be completed in near real-time. The real-time performance monitoring platform can analyze information generated by all popular network applications including the web, email, instant messaging, etc. and can be extended to process information generated by other proprietary applications. This analysis is performed across each point in the network where network probes are installed, actively aggregating, correlating and processing information in parallel. Both simple keyword searches like a web search engine, as well as sophisticated structured database queries may be used, making it a unique tool for mining, processing and analyzing a network and its traffic content and for correlating events in space and time and track network traffic to physical locations.

In exemplary implementations of the inventive systems and methods for enabling location-based services, the network probes (e.g., probes 410, FIG. 6) serve as the array of known network elements or markers for real-time triangulation of geographical location of a target application or a mobile user.

FIG. 6 shows an exemplary network implementation of the inventive systems and methods for enabling location-based services. The network includes a collection of network probes/makers 410, connected to switches/routers 415, and a centralized management console 420. The network probes consist logically of a search, data collection, correlation and aggregation engine (called the query engine), 430, an interface tap 440 for passive wire-speed packet monitoring and protocol analysis, and an input 450 for synchronized time source 455. The network probes/markers 410, are placed at strategic points in the network and collaboratively create a distributed searchable, data collection, correlation, and aggregation grid. The centralized management console 420 provides an interface to the distributed system and allows the creation and dispatch of searches to the system.

The query engine 430 in a network probe/marker 410 may be optimized to execute queries which involve either retrieving data stored on the probe,

or aggregating intermediate results to be returned. Queries created at the console are dispatched in parallel across the network to network probes/markers 410 along a minimal delay spanning tree, and conversely the results are propagated back along the spanning tree with aggregation being performed by intermediate network probes. The dispatch point, forwarding and aggregation paths traversed by a query are chosen so as to minimize the overall delay. The queries may be dispatched and forwarded across the network in an echo pattern (See FIGS. 1-3).

The dynamics of the system operation is as follows: A network administrator sends a query via HTTP to the centralized management console, which dispatches it to a start or launch node (i.e. a network probe) in the network. For processing the query in the network, the system uses the echo pattern and a query aggregator that is invoked by the pattern on each node. During the expansion phase of echo, sub queries are distributed to the targeted node and the query aggregator performs the local database access. During the contraction phase of echo, partial results carried back by echo messages are incrementally added to the results obtained from the local query on all nodes of echo's execution tree. At the end of the contraction phase, the resulting table of the global query is sent from the start node, which is the root node of the execution tree, to the console, which forwards it to the administrator.

An exemplary embodiment of the present invention uses a query language modeled after the Structured Query Language (SQL). The query language used in the present invention is a flexible SQL-like language (encapsulated in XML) designed to allow the querying, aggregation and correlation of management information from network nodes to be specified without programming. Query tables can be exported in XML to third party applications for other uses.

A query in this SQL-like language is executed against a set of global virtual tables, which consist of all data records that make up the local tables stored on the network probes. For each type of local table, there is a corresponding virtual global table with the same structure. An exemplary implementation includes the following global virtual tables; namely, the Device, Interface, System and Flow tables.

Each global query is translated into three SQL sub-queries, which are executed on the network probes/markers against their local tables. The process of translating a global query to SQL sub-queries is tightly coupled with the state machine of the network navigation pattern (e.g., an echo pattern) and utilizes it to accomplish two key tasks – data transport and incremental aggregation. In the former, the explorer messages are used to propagate SQL sub-queries while the echo messages are used to carry back the results. In the latter, the echo pattern state machine is used to trigger incremental aggregation when the results are returned from a network probe's neighbors.

FIG. 5 shows the functional elements of a network probe/marker. A query, sent from the console is processed by each receiving network probe. An exemplary embodiment of the network probe has four main functional elements: acquisition, analysis, storage, and processing. First, at 210, the acquisition element captures network packets and frames from a monitoring point in the network. Next, these packets are passed to the analysis element, 220, which decodes and computes statistics, indices and summaries. The resulting data produced by the analysis element is then stored in a high performance database, 230. Finally, this data may be accessed in real time when processing a search, query or computation by the processing element 240.

Storage element 230 of the network probe may be constructed from any off-the-shelf relational database system that supports the Structured Query Language (SQL). The database schema of each network probe consists of a collection of relational database tables that contain information generated by the analysis element 220. Each table contains records of identical structures, which can be accessed via a local interface. Each such record contains data gathered by the network probe from its attached router via an access protocol — SNMP or Command Line Interface. In a preferred embodiment, network probes share the same schema, i.e. the type and the structure of information the network probes collect are identical. In general, each table holds information about traffic generated or consumed by a single type of application. The structure of each is thus highly specific to the type of application it represents. For network traffic monitoring applications as described for example, in International Patent Application No. PCT/US2004/010646, the tables

which include data gathered from the traffic generated by a number of commonly used applications may, for example, include tables by specific applications such as E-mail transaction table, a HTTP transaction table, a SIP transaction table, a FTP transaction table, an Instant messaging log table, and P2P activity table. In addition, the network probe may also contain a number of tables that represent general IP, TCP and layer 2 traffic.

For delivery of location-based services, the architecture of each network probe/marker includes a further relational database table ("System Table") which contains a single record which defines the physical co-ordinates of the network probe. Table 1 shows the schema of the System Table.

Table I:

Column name	**Column Description**
IP Address	**IP address of network probe**
Latitude	**Latitude of physical location of probe**
Longitude	**Longitude of physical location of probe**

When the System Table for a network probe/marker is created, the IP address of the network probe/marker is mapped to a physical location. The mapping may be accomplished by a traditional Geographical Information System (GIS), which looks up the street address associated with the probe/marker's location. Alternatively, the mapping may be accomplished by lookup in commercially available IP address geocoding databases (e.g., databases such as those made commercially available under the tradename GeoIP by MaxMind LLC, 306 Dartmouth Street, Suite 337, Boston, MA 02116, and www.maxmind.com). By either lookup technique or any other suitable technique, the latitude and longitude of the network probe/marker together with its IP address is entered into the System Table as a record. The System Table record may be renewed or updated as necessary, for example, when the network probe/marker is moved to a different physical location.

In an exemplary method for providing or distributing location-based services, when a global query is issued over the network, the record in the System

table is used to restrict its propagation to within a specified distance from its origination point. In particular, the System Table record is used to limit the geometrical reach of the network navigation pattern. FIG. 7 shows exemplary steps 701-706 of a procedure 700 for distributing location-based services by limiting the reach or extent of an echo pattern.

In procedure 700, at step 701 a mobile location-based service application or agent is initiated on a network node (i.e. the start or launch node) including a specification of the maximum distance (D) it is allowed to propagate from the launch node. The distance D defines the localization distance or extent of the service provided. The propagation of mobile location based service application or agent may be based on a suitable echo navigation pattern.

At step 702, the mobile location-based service application or agent propagates to all neighbor nodes of the launch node via explorers which contain the latitude and longitude information of the launch node as well as D.

At step 703, when an explorer arrives on an unvisited node, it marks the node as "visited." Next at step 704, the explorer arriving on the visited node checks to see if the node is more than D distance away from the launch node. The explorer may use any suitable algorithm or formula for the distance check. An exemplary distance checking algorithm is based on the Haversine formula, which gives great-circle distances between two points on a sphere from their longitudes and latitudes:

(Arccos[Cos[a1] Cos [b1] Cos [a2]

+ Cos[a1] Sin[b1] Cos [a2]Sin [b2] + Sin [a1] Sin[a2]]/360 * 2π * D,

where a1 is the latitude of the current node, a2 is the latitude of the launch node, b1 is the longitude of the current node, and b2 is the longitude of the launch node.

If the visited node is at a distance greater than D, at step 705, the explorer returns an echo to its parent. Conversely, if the visited node is a distance less than D, at step 706, the explorer launches explorers to all of the visited node's neighbors except for its parent as is routine in echo-pattern navigation.

By implementing procedure 700, location-based services may be provided over a restricted or limited geographical area (e.g., a radial area ~ πD^2).

In one implementation, the inventive platform of network probes/markers and procedure 700 may be used to design or construct a system of real-time location-based distributed search services for mobile handset users or other network users. In such a system, users with mobile handsets or other network access devices could submit search requests into the system to locate people, merchandise, and places of interest within a localized area. The location-based distributed search system may include provisions for running a client program on the user's handset or network access device, which translates search requests into SQL queries to be executed over the network monitoring platform. Further, the location-based distributed search system may, on the backend, include a set of distributed databases that are constructed around the network node architecture described in International Patent Application No. PCT/US2004/14733 and International Patent Application No. PCT/US2004/010646 (see FIGS.). This set of distributed databases may be populated with information pertaining to user profiles, merchandise information and geospatial information of places of interest.

The system of real-time location-based distributed search services may be configured to include a person locating service. The system may be configured to allow its users to seek out and identify other users having mutual or common interests based, for example, on a distributed search of user profiles, within their proximity. The system may be further configured to provide a communication channel (e.g., anonymous text messaging) between the user and identified mutually interesting users. The system may also be programmed to track the relationship of its users. Such relationship tracking may be beneficially used, for example, to inform a pair of communicating users that both users have a mutual friend in common in the same localized area.

Additionally, or alternately, the system of real-time location-based distributed search services may be configured to include a local area merchandise searching services. The system may be programmed to search through the inventories or catalogs of stores or merchants in the local areas. Each of these stores or merchants may host a network node containing or having access to their merchandise catalog and/or in-stock inventory. The local area merchandise searching services can beneficially allow users to avoid the trouble of store-to-store shopping or bargain

hunting. The system may further be programmed to continuously search a given distance around a mobile user and to issue an alert, for example, when it locates a store selling an item below a desired price wherever the store or user may be.

Further, in e-commerce applications, the system of real-time location-based distributed search services may be configured to provide mobility to merchant and vendors. The location-based services may include setup of "roving" stores or temporary flea-market-like stalls that are open for business for several hours before moving to another location. The system may enable merchants and vendors to deploy specialized merchandizing techniques to move stock (e.g., techniques involving combinations of "limited-time-only" and "location-specific" sales or pricing) on a frequency much higher than otherwise feasible.

Another localized service that may be included in the system of real-time location-based distributed search services may include locating local places of interest. The system maybe configured to respond to a user like an instant map, which allows the user to find interesting local locations (e.g., the nearest gas station, museum or Starbucks) and direction to the interesting locations.

The foregoing merely illustrates the principles of the invention. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous techniques which, although not explicitly described herein, embody the principles of the invention and are thus within the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A system for providing location-based services on an electronic communication network having a plurality of network nodes, the system comprising:

a plurality of network probes each having a database for storing information tables and a query engine for receiving and responding to queries for information stored in said tables, wherein the plurality of network probes is placed in said electronic communication network, and wherein the database in each network probe has stored in therein a record of the physical location and network address of the network probe;

a network management console for issuing a query over the network in a network navigation pattern to the network probes therein, the query comprising a localization distance defining the maximum distance the query should propagate from a launch node, and the query associated with a mobile agent for the location-based service to be provided within the localization distance about the launch node.

2. The system of claim 1 wherein the network navigation pattern is a minimal delay spanning tree whereby the speed at which queries complete is proportional to the diameter of the network.

3. The system of claim 1 wherein the network navigation pattern is an echo pattern.

4. The system of claim 1 wherein the queries are modeled after Structured Query Language (SQL) queries.

5. The system of claim 1, further comprising a client program on a user's network access device for translating user requests into the queries of claim 4 that can be executed at the network probes.

6. The system of claim 1 that is further configured to provide a location-based person locating service at about the launch node.

7. The system of claim 1 that is further configured to provide a local area merchandise searching service at about the launch node.

8. The system of claim 1 that is further configured to setup a roving temporary e-commerce store at about the launch node.

9. The system of claim 1 that is further configured to provide a local map searching service at about the launch node.

10. The system of claim 1 wherein an electronic communication network is the Internet.

11. A method providing location-based services on an electronic communication network having a plurality of network nodes, the method comprising:

configuring in the electronic communication network a plurality of network probes each having a database for storing information tables and a query engine for receiving and responding to queries for information stored in the tables, and wherein the database in each network probe has stored therein a record of the physical location and network address of the network probe;

propagating a mobile agent for providing a location based service from a launch node over the network in a network navigation pattern to neighboring network probes, and limiting the propagation of the mobile agent over the network in the network navigation pattern to network probes that are less than a defined distance D from the launch node,

whereby the location-based service is localized within the distance D from the launch node.

12. The method of claim 11 wherein configuring in the electronic communication network comprises configuring the query engines to receive and respond to queries modeled after Structured Query Language (SQL) queries.

13. The method of claim 11 wherein propagating a mobile agent for providing a location based service from a launch node over the network in a network navigation pattern to neighboring network probes comprises propagating a query over an echo pattern, and wherein the query comprises the defined distance D.

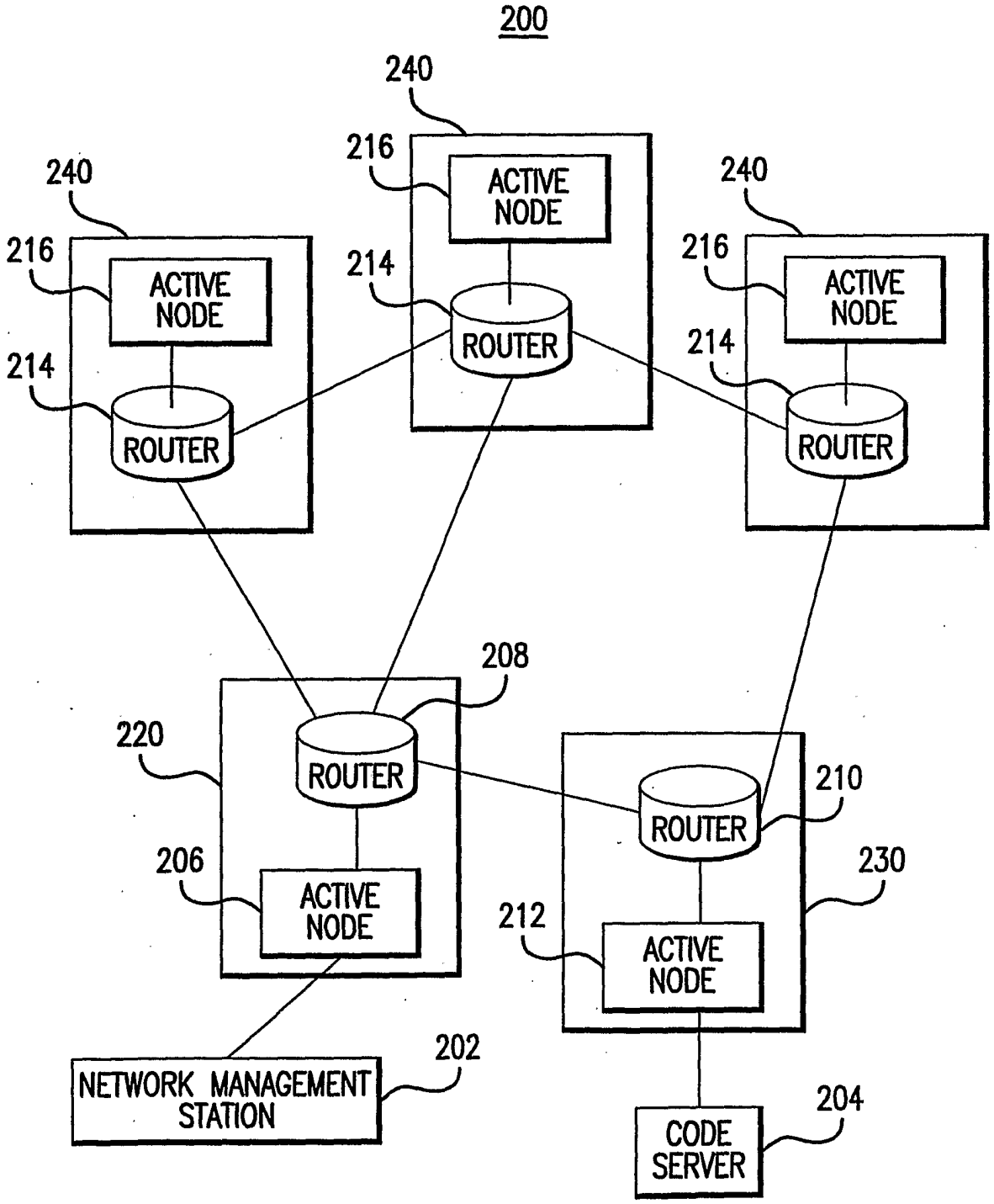
14. The method of claim 13 wherein propagating a mobile agent for providing a location based service from a launch node over the network in a network navigation pattern to neighboring network probes comprises propagating a mobile agent for providing a location based service from the launch node via explorers to successive neighboring network probes, wherein the explores contain the physical co-ordinates of the launch node and the defined distance D.

15. The method of claim 14 wherein propagating a mobile agent for providing a location based service from a launch node over the network in a network navigation pattern to neighboring network probes further comprises comparing the distance d between the launch node and the neighboring probe visited by an explorer and the defined distance D.

16. The method of claim 15 wherein comparing the distance d between the launch node and the neighboring probe visited by an explorer and the defined distance D comprises computing the distance d using Haversine's formula.

17. The method of claim 15 wherein if the distance d between the launch node and the neighboring probe visited by an explorer is larger than the defined distance D, the method further comprises the explorer returning an echo to the parent node.

18. The method of claim 15 wherein if the distance d between the launch node and the neighboring probe visited by an explorer is less than the defined distance D, the method further comprises the explorer launching explorers to further neighboring nodes.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NETWORK MANAGEMENT STATION
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CODE SERVER

FIG. 1

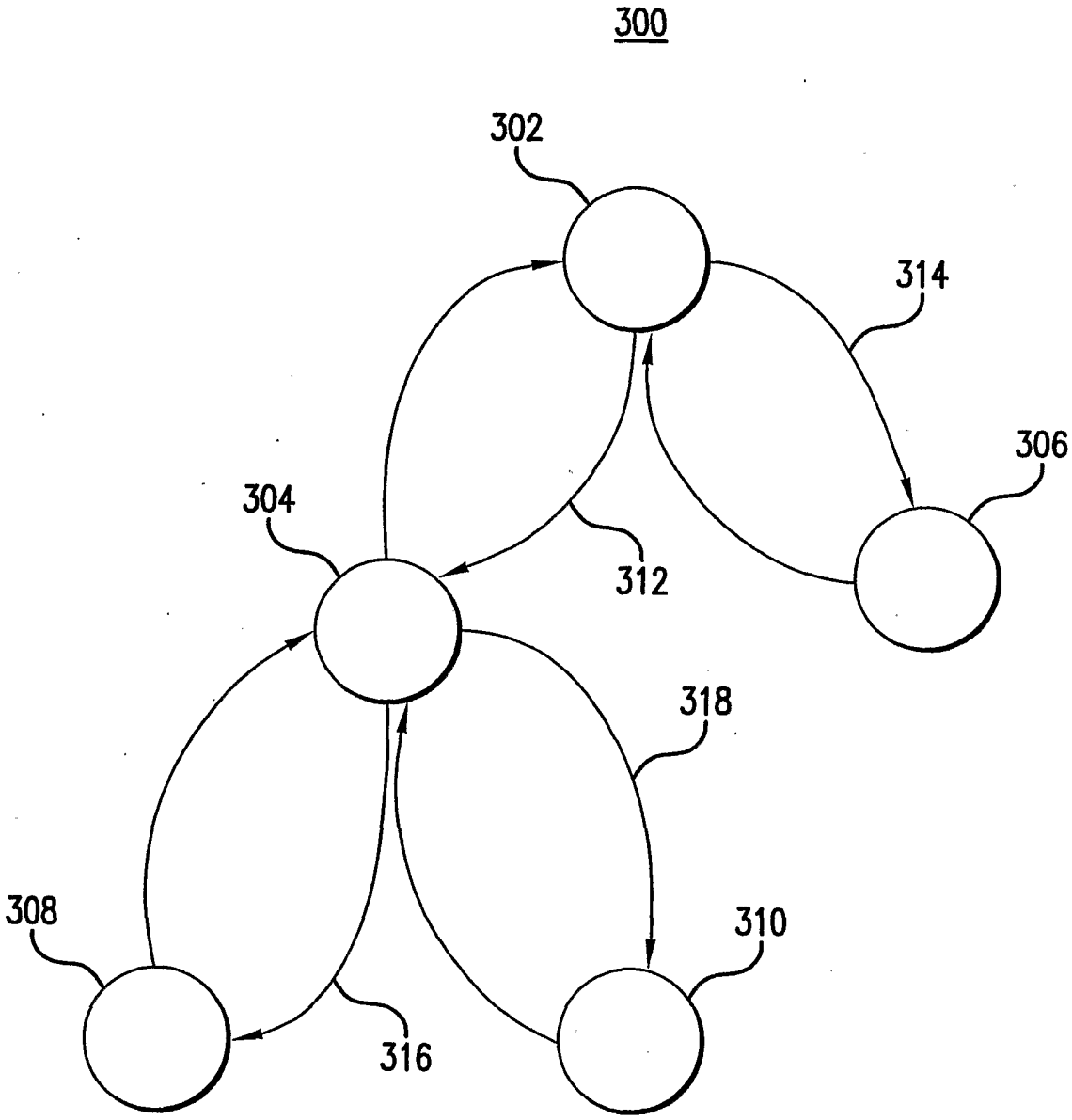
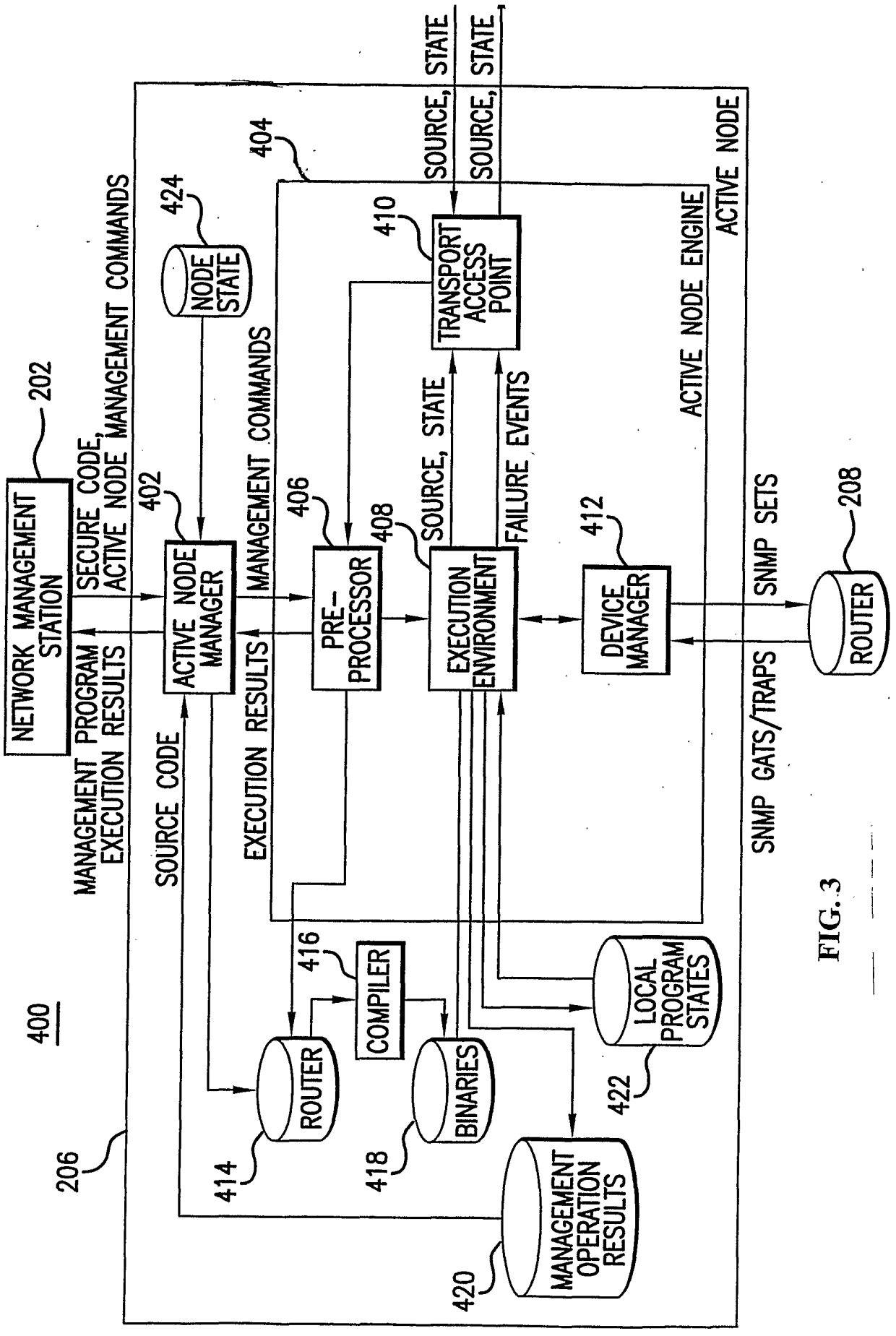


FIG. 2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EXECUTION RESULTS
SOURCE CODE
NODE STATE
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ACTIVE NODE ENGINE
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PRE-PROCESSOR
406
SOURCE, STATE
EXECUTION ENVIRONMENT
408
FAILURE EVENTS
DEVICE MANAGER
412
SNMP SETS
SNMP GATS/TRAPS
ROUTER
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LOCAL PROGRAM STATES
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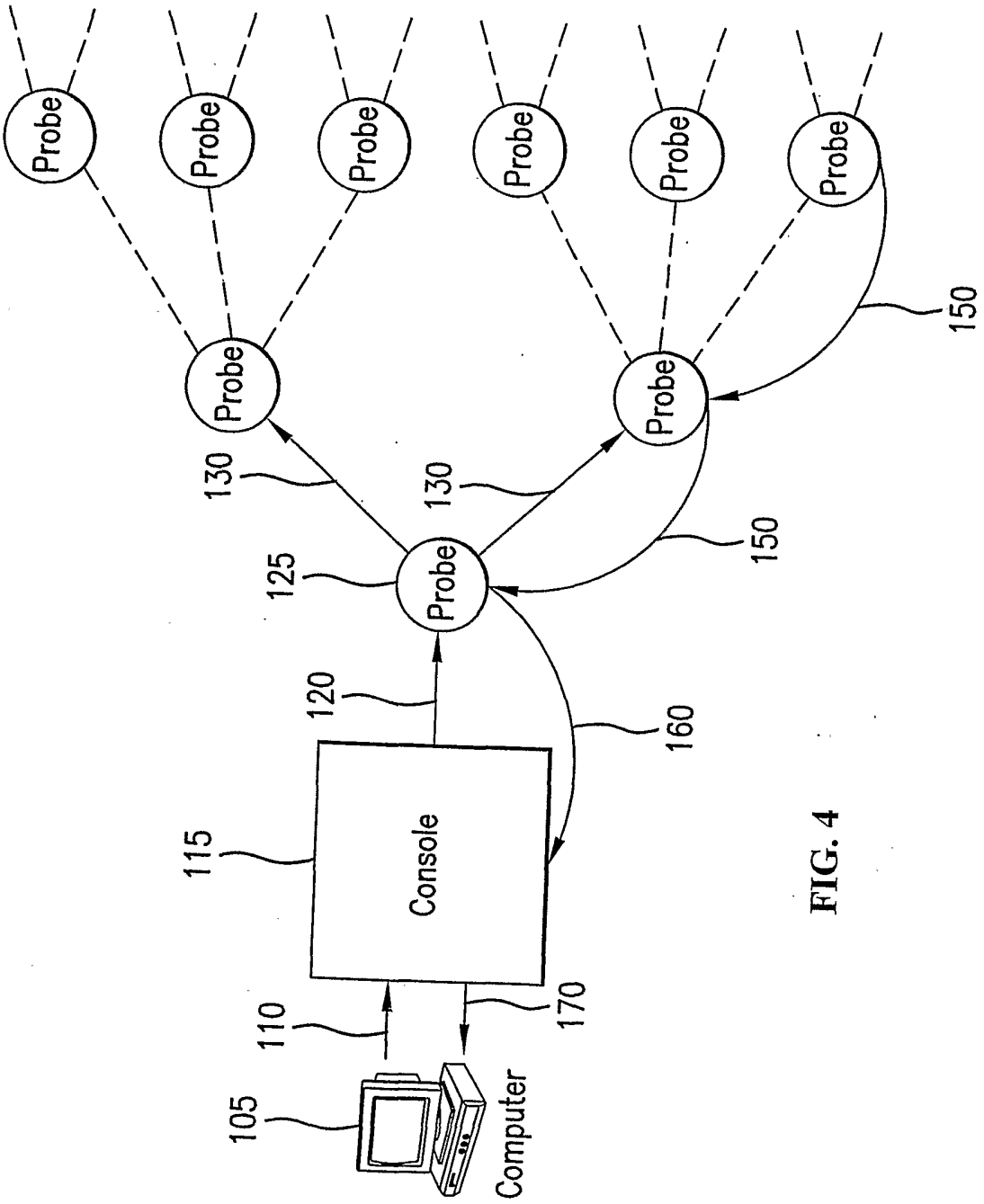
MANAGEMENT OPERATION RESULTS
420

FIG. 3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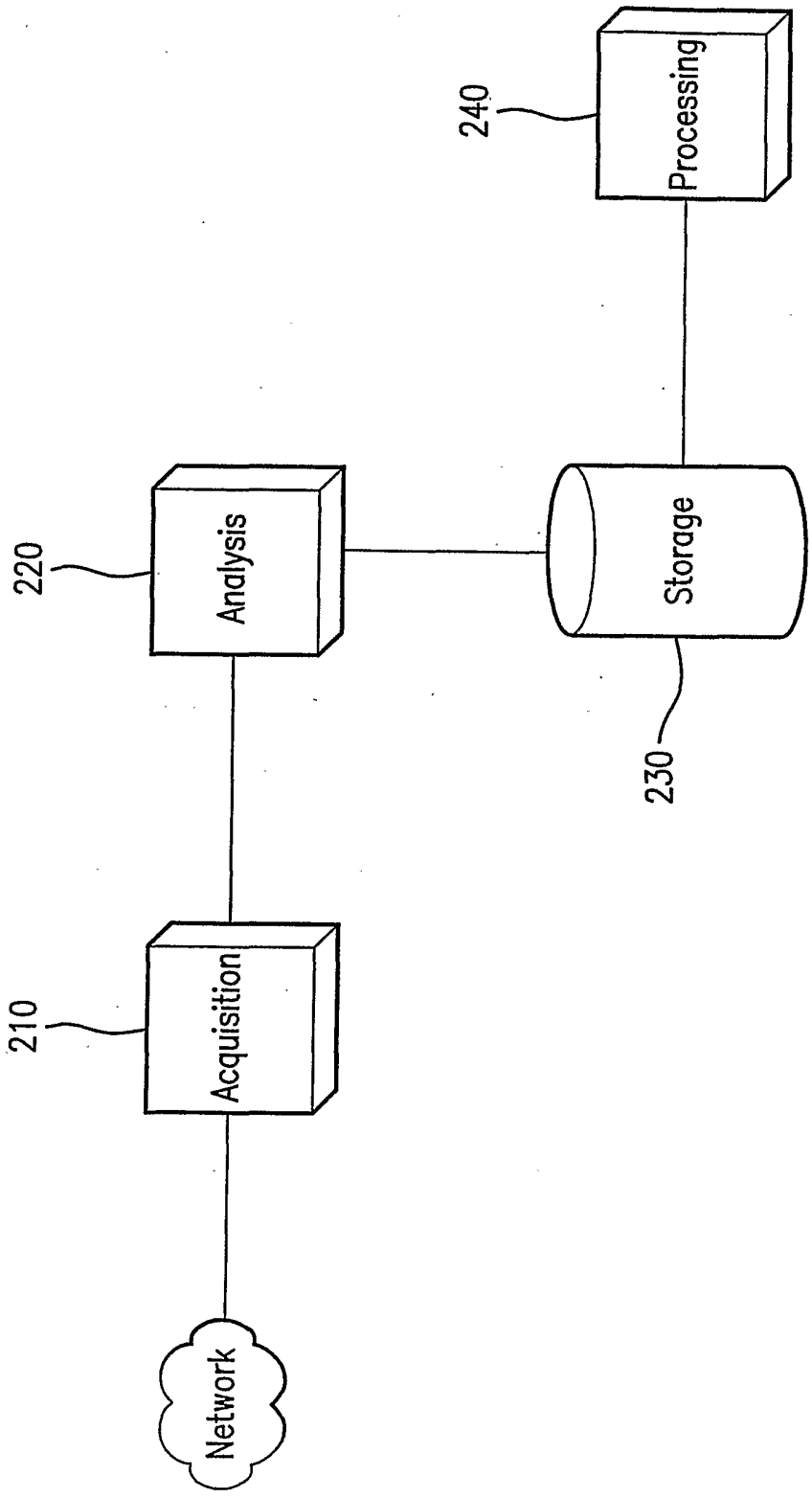
Computer

FIG. 4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Acquisition
Network

FIG. 5

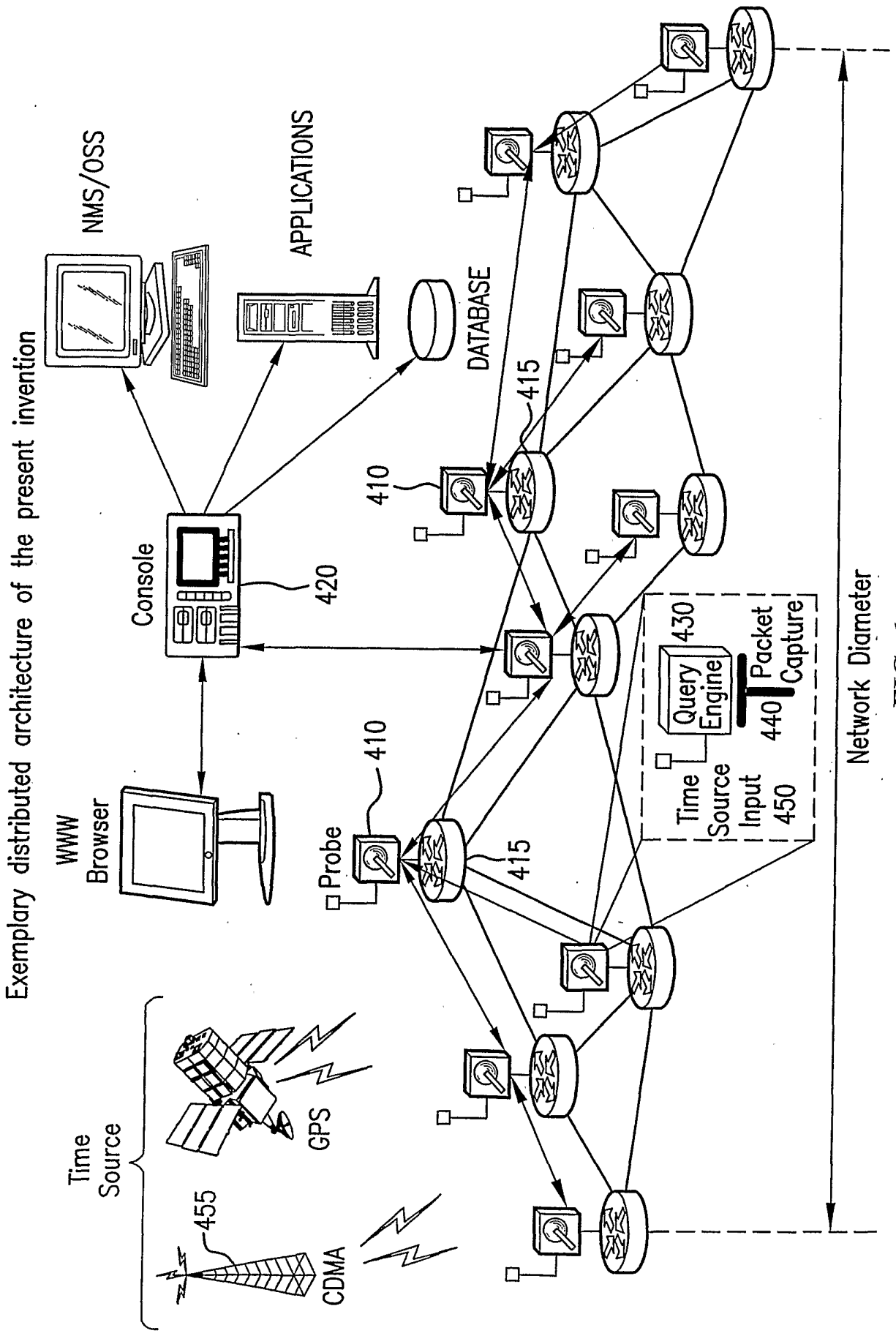
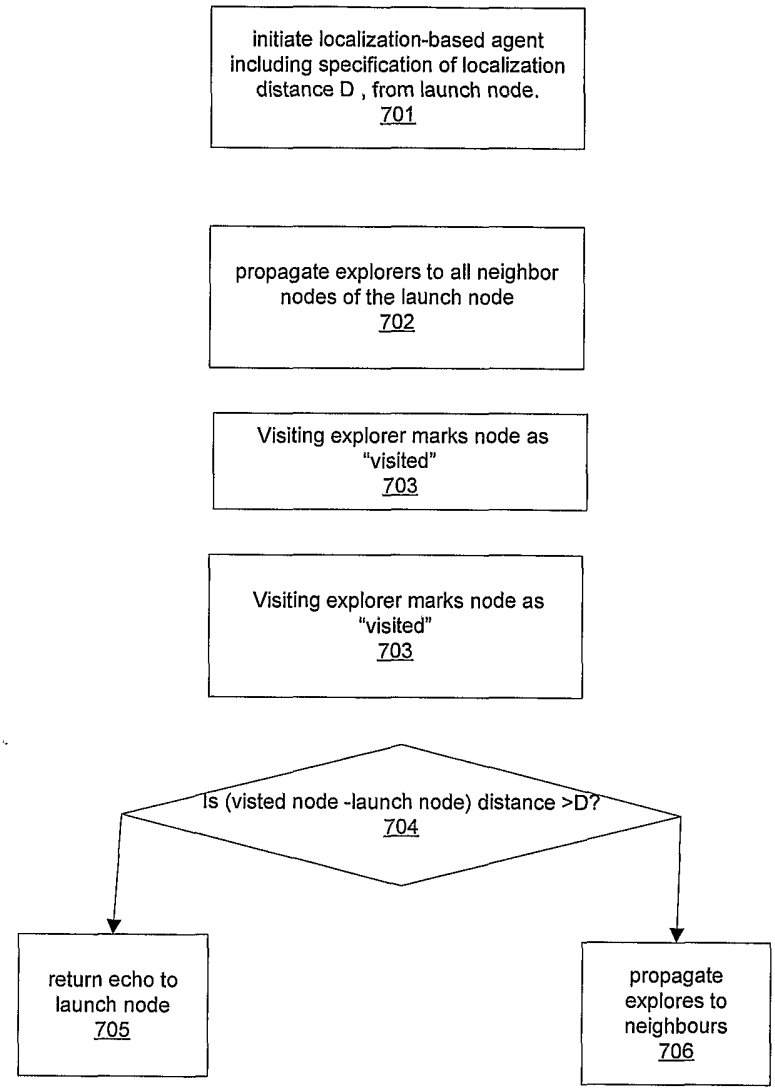

Exemplary distributed architecture of the present invention
NMS/OSS
APPLICATIONS
DATABASE
Console
420
WWW
Browser
Probe
410
415
Query
Engine
430
Packet
Capture
440
Time
Source
Input
450
Network Diameter
Time
Source
GPS
455
CDMA

FIG. 6


initiate localization-based agent including specification of localization distance D , from launch node.
701
propagate explorers to all neighbor nodes of the launch node
702
Visiting explorer marks node as "visited"
703
Visiting explorer marks node as "visited"
703
Is (visted node -launch node) distance >D?
704
return echo to launch node
705
propagate explores to neighbours
706

700

FIG. 7