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Pu et al.

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(54) **MOBILE NAVIGATION SYSTEM**

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(52) **U.S. Cl.** **701/202**; 701/117; 701/209; 455/456

(58) **Field of Search** 701/200, 201, 701/202, 207, 208, 209, 211, 213, 117; 340/988, 990, 995; 455/456, 457

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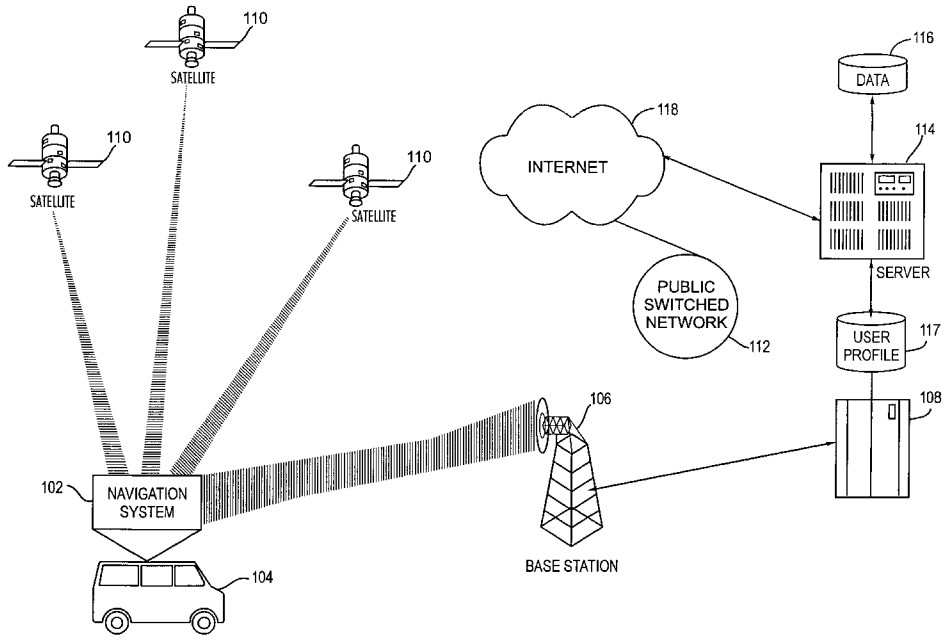
(57) **ABSTRACT**

A client navigation system establishes a wireless connection to a navigation server on a computer network. The client requests a route by uploading start and stop specifications. The server calculates an optimal route based on real-time data available on the network. A generic natural language description is used to specify the optimal route downloaded to the client. The natural language description is independent from the local mapping database software on the client and includes a plain text description for each link using pre-defined generic terms. The client interprets the route, interfaces with the local mapping database and reconstructs the optimal route using a mapping reconstruction algorithm. The route is displayed on the client navigation system using whatever mapping database is present. An enhanced user-interface data-entry feature is provided that anticipates data being entered by users to minimize the data-entry process. The current time zone is derived from the current GPS position and is used to set the clock on the navigation system in the client. Maps are automatically scrolled on a display screen so that a representation of the automobile is always pointing to the right or to the left to allow for additional look-ahead space on certain display systems. A telephone coupled with the navigation system automatically displays the current local time for a called party upon dialing out. The dialed number is used to query a local database for providing local time information.

22 Claims, 10 Drawing Sheets



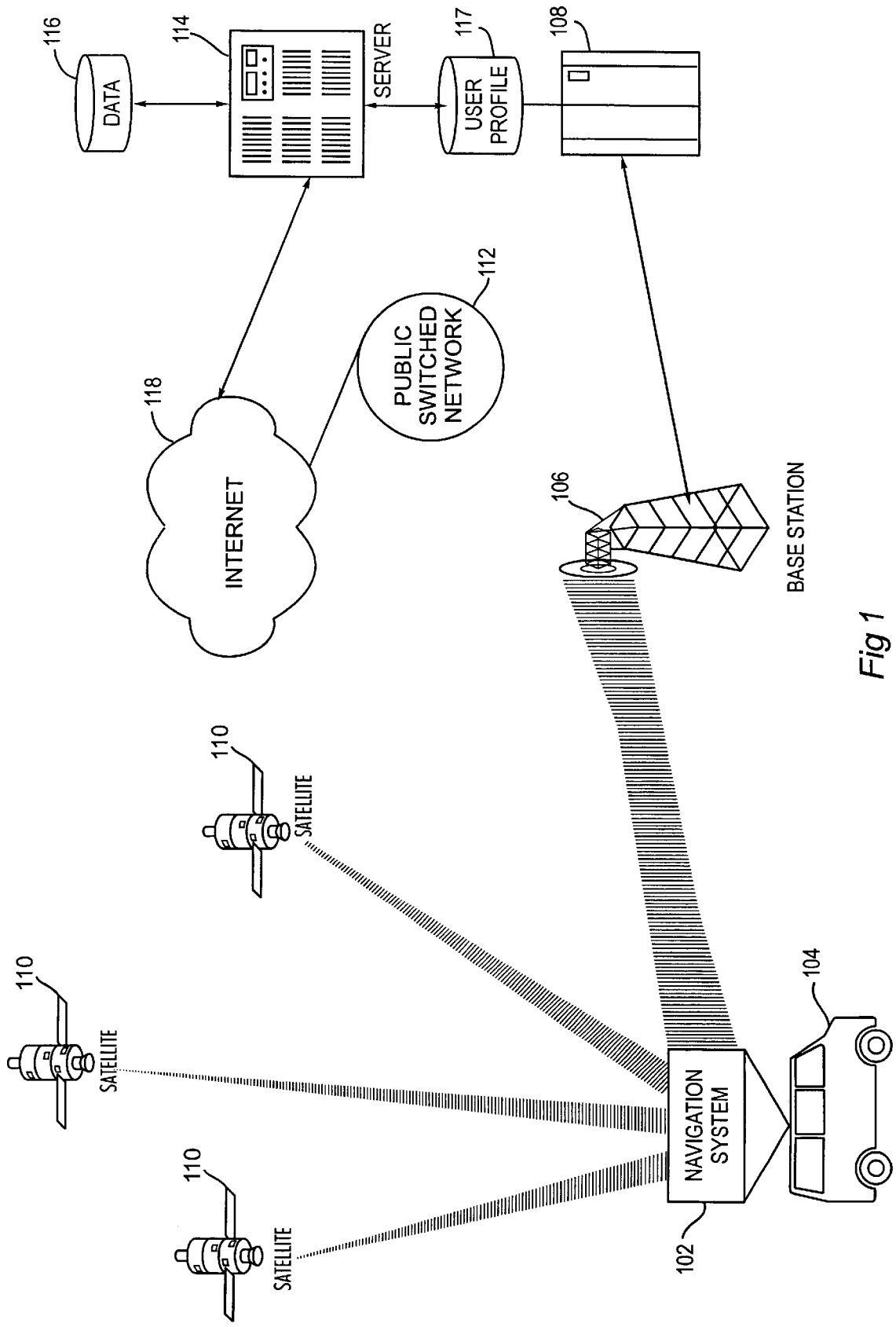

116
DATA
114
SERVER
117
USER PROFILE
108
112
PUBLIC SWITCHED NETWORK
118
INTERNET
106
BASE STATION
110
SATELLITE
110
SATELLITE
110
SATELLITE
NAVIGATION SYSTEM
102
104

Fig 1

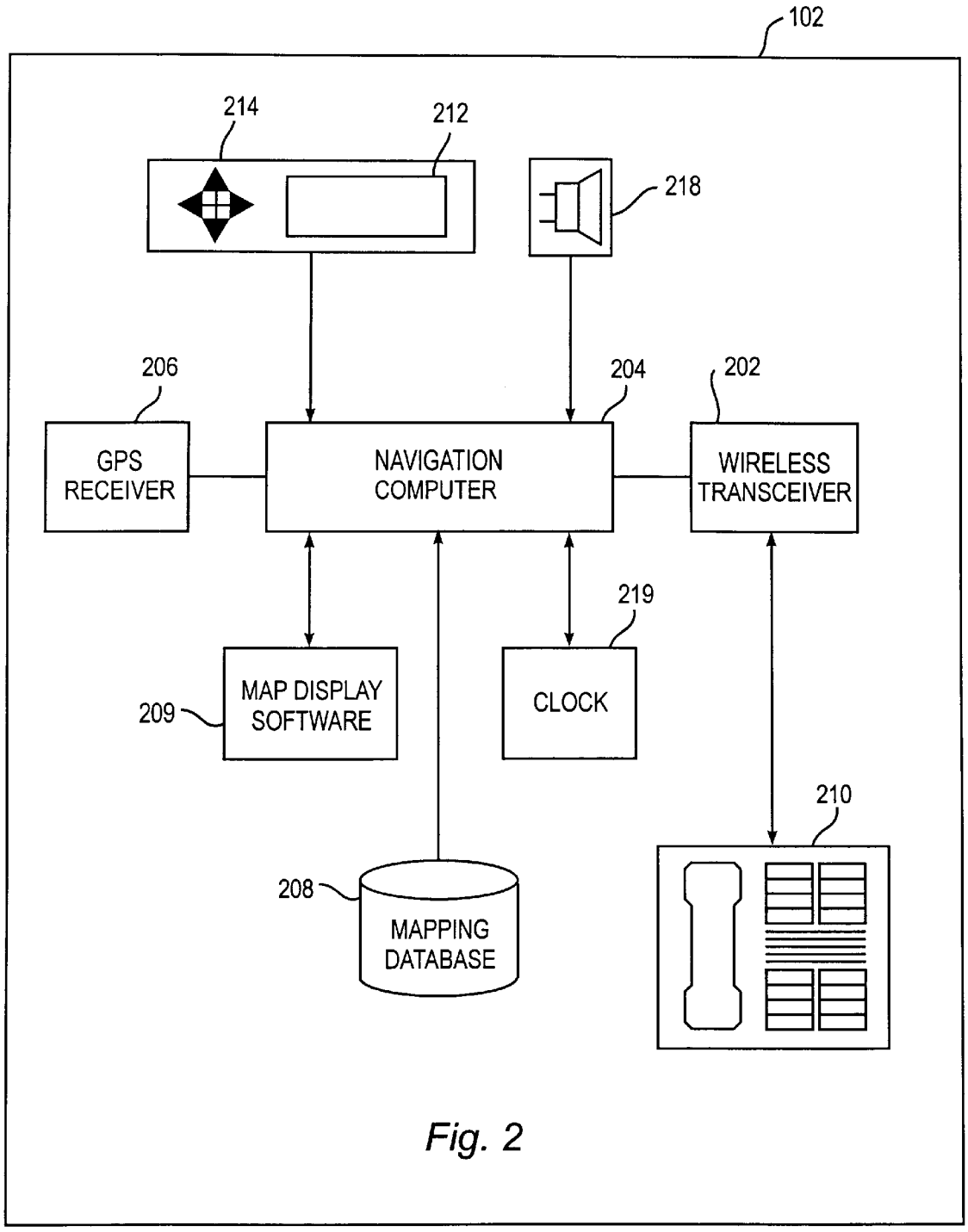

102
214
212
218
206
204
202
GPS RECEIVER
NAVIGATION COMPUTER
WIRELESS TRANSCEIVER
219
209
MAP DISPLAY SOFTWARE
CLOCK
210
208
MAPPING DATABASE

Fig. 2

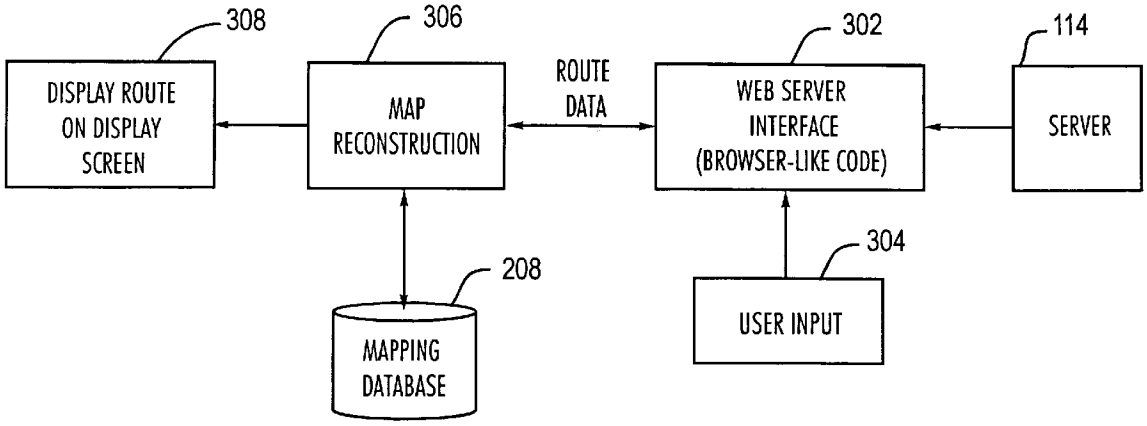

308
306
302
114
DISPLAY ROUTE ON DISPLAY SCREEN
MAP RECONSTRUCTION
ROUTE DATA
WEB SERVER INTERFACE (BROWSER-LIKE CODE)
SERVER
208
304
MAPPING DATABASE
USER INPUT

Fig. 3

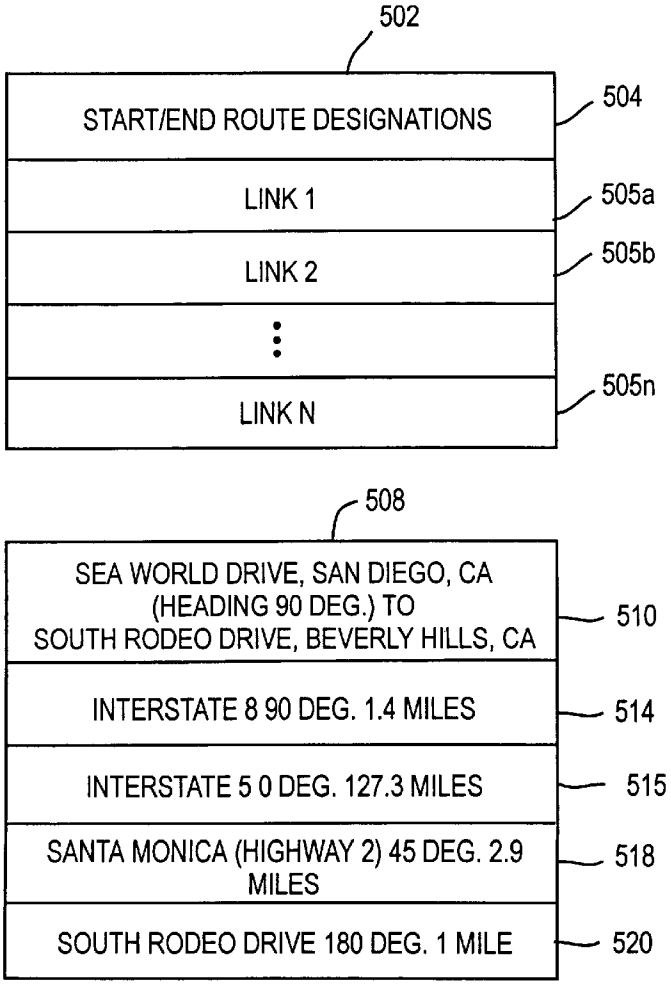
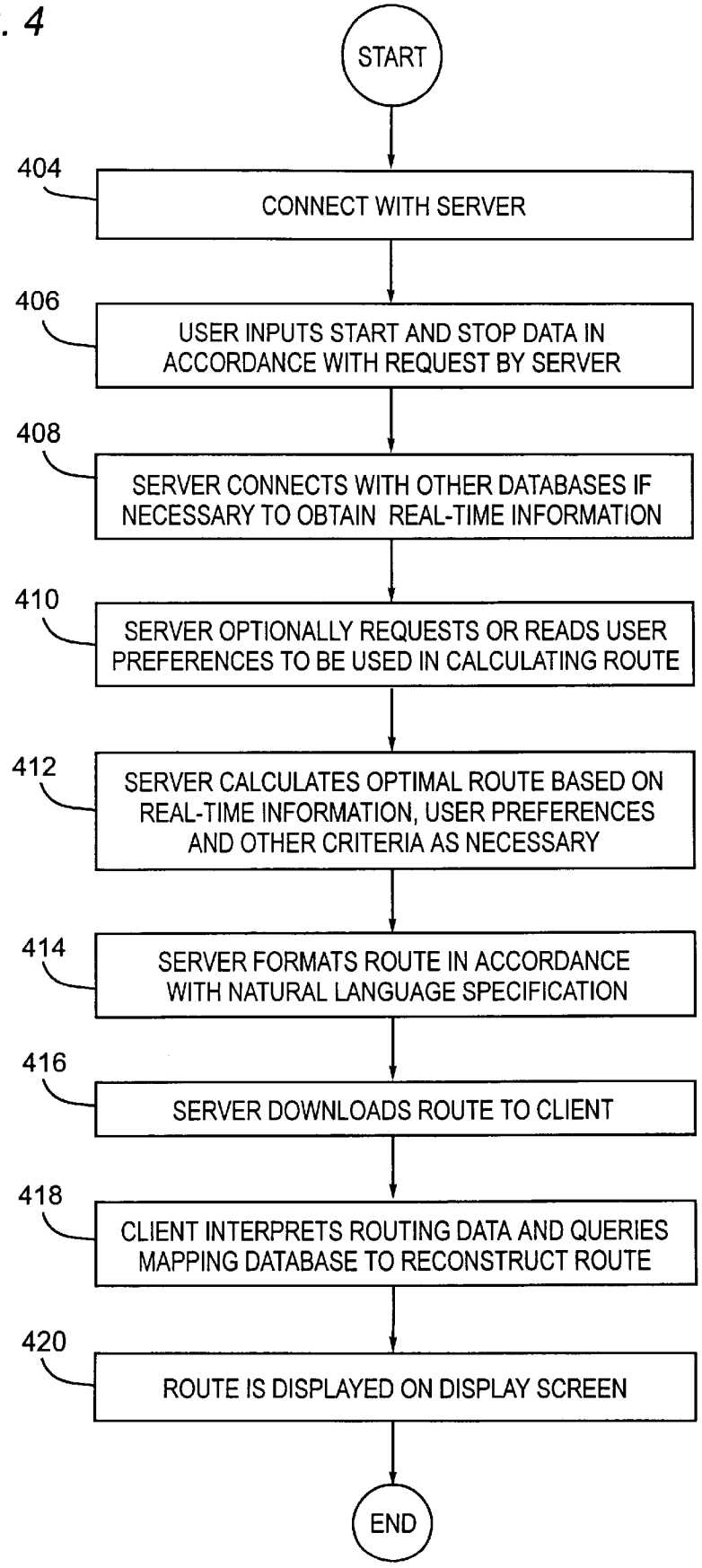

502
START/END ROUTE DESIGNATIONS
504
LINK 1
505a
LINK 2
505b
LINK N
505n
508
SEA WORLD DRIVE, SAN DIEGO, CA (HEADING 90 DEG.) TO SOUTH RODEO DRIVE, BEVERLY HILLS, CA
510
INTERSTATE 8 90 DEG. 1.4 MILES
514
INTERSTATE 5 0 DEG. 127.3 MILES
515
SANTA MONICA (HIGHWAY 2) 45 DEG. 2.9 MILES
518
SOUTH RODEO DRIVE 180 DEG. 1 MILE
520

Fig. 5

Fig. 4


START
404
CONNECT WITH SERVER
406
USER INPUTS START AND STOP DATA IN ACCORDANCE WITH REQUEST BY SERVER
408
SERVER CONNECTS WITH OTHER DATABASES IF NECESSARY TO OBTAIN REAL-TIME INFORMATION
410
SERVER OPTIONALLY REQUESTS OR READS USER PREFERENCES TO BE USED IN CALCULATING ROUTE
412
SERVER CALCULATES OPTIMAL ROUTE BASED ON REAL-TIME INFORMATION, USER PREFERENCES AND OTHER CRITERIA AS NECESSARY
414
SERVER FORMATS ROUTE IN ACCORDANCE WITH NATURAL LANGUAGE SPECIFICATION
416
SERVER DOWNLOADS ROUTE TO CLIENT
418
CLIENT INTERPRETS ROUTING DATA AND QUERIES MAPPING DATABASE TO RECONSTRUCT ROUTE
420
ROUTE IS DISPLAYED ON DISPLAY SCREEN
END

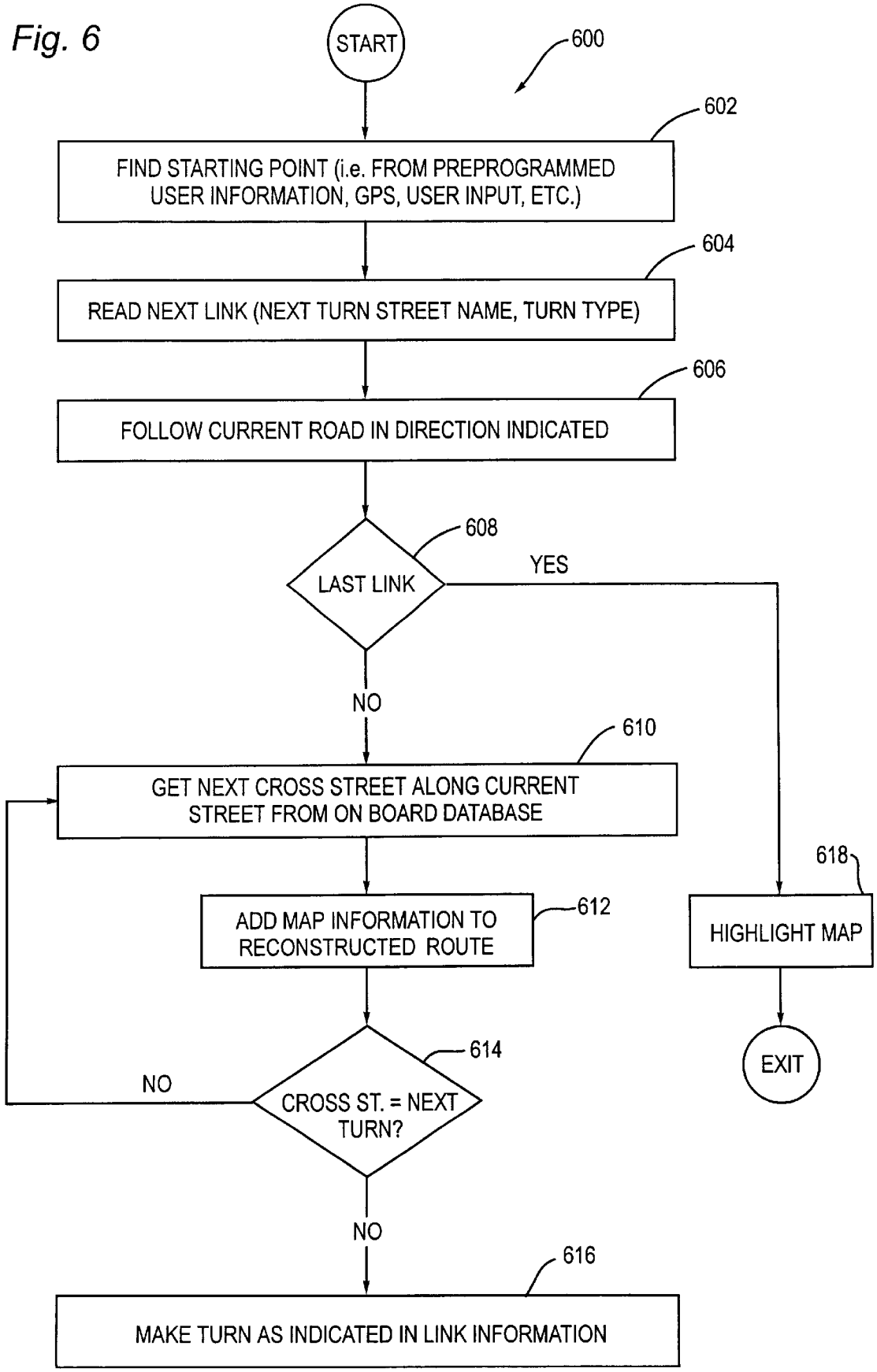


Fig. 6
START
600
602
FIND STARTING POINT (i.e. FROM PREPROGRAMMED USER INFORMATION, GPS, USER INPUT, ETC.)
604
READ NEXT LINK (NEXT TURN STREET NAME, TURN TYPE)
606
FOLLOW CURRENT ROAD IN DIRECTION INDICATED
608
LAST LINK
YES
NO
610
GET NEXT CROSS STREET ALONG CURRENT STREET FROM ON BOARD DATABASE
612
ADD MAP INFORMATION TO RECONSTRUCTED ROUTE
618
HIGHLIGHT MAP
EXIT
614
NO
CROSS ST. = NEXT TURN?
NO
616
MAKE TURN AS INDICATED IN LINK INFORMATION

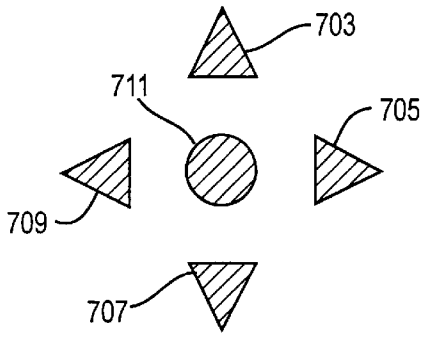


Fig. 7A

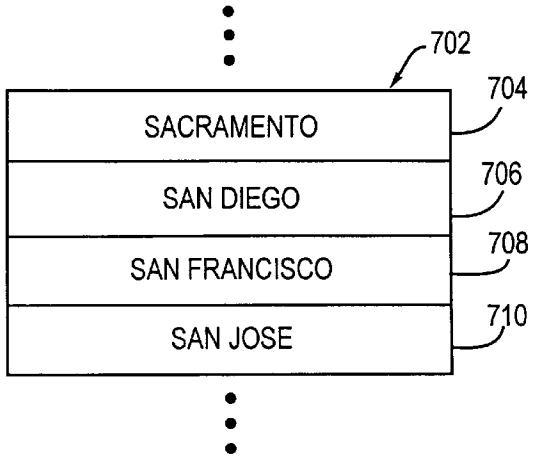


Fig. 7B

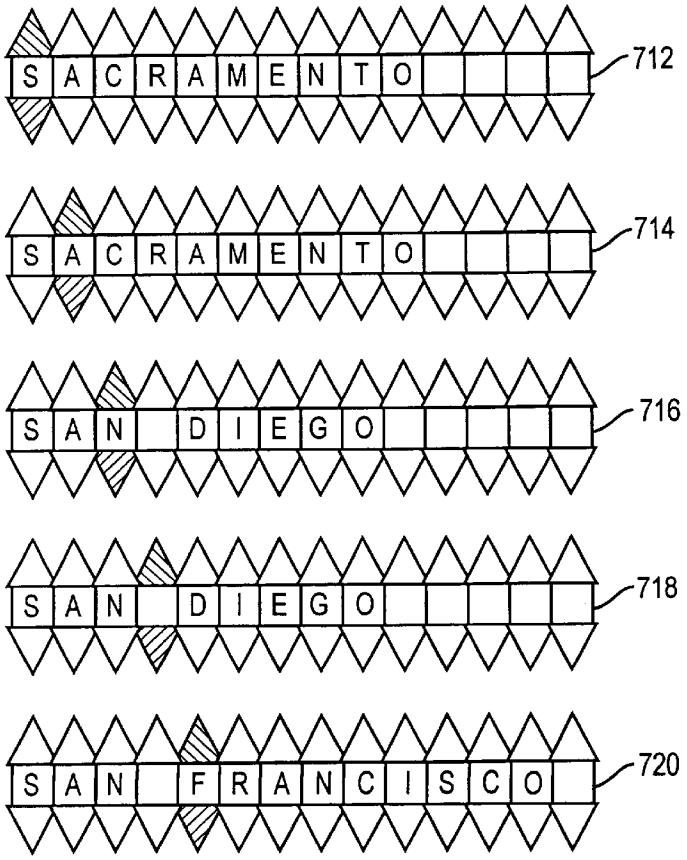
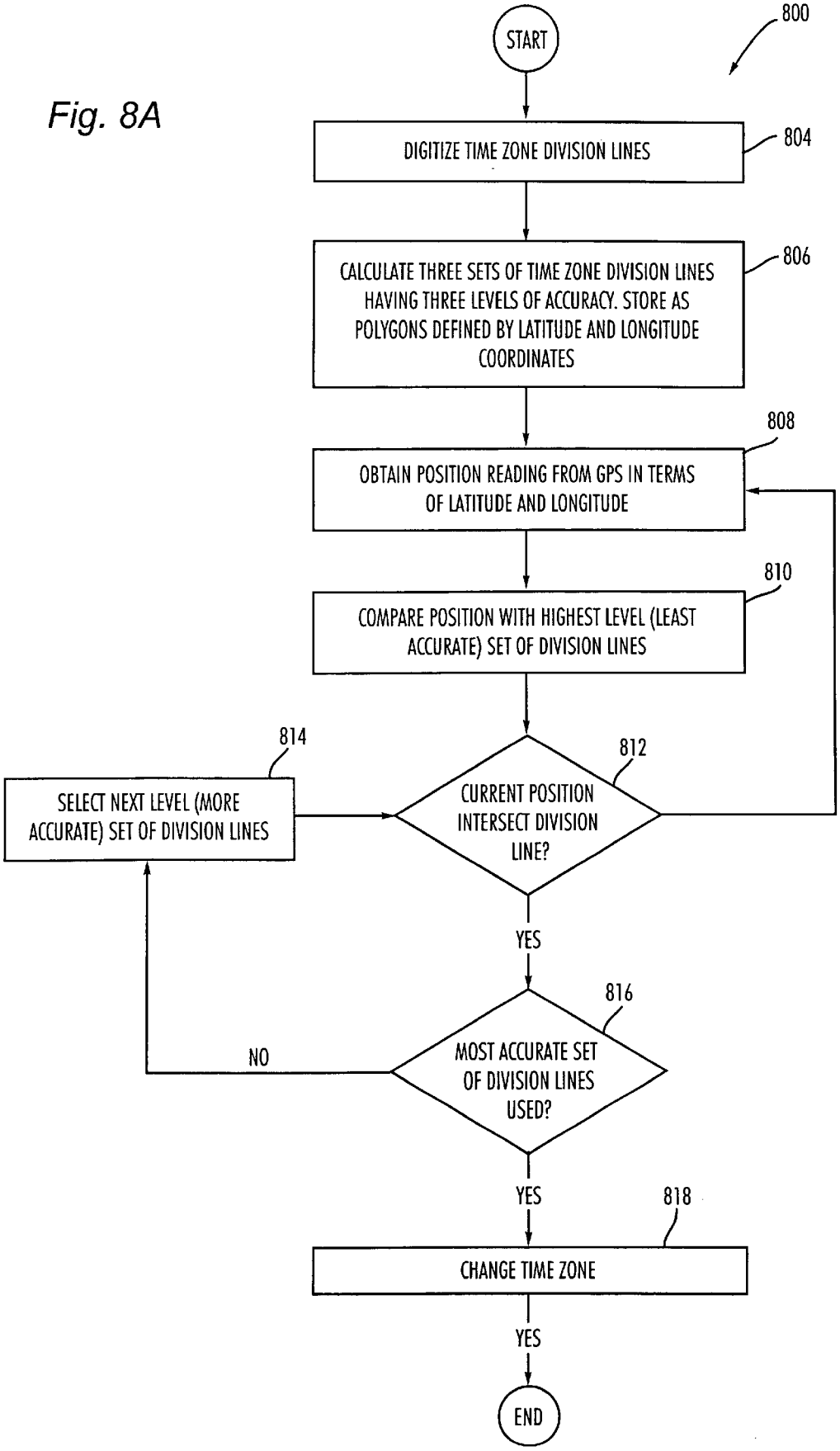


Fig. 7C

Fig. 8A


800
START
DIGITIZE TIME ZONE DIVISION LINES
804
CALCULATE THREE SETS OF TIME ZONE DIVISION LINES HAVING THREE LEVELS OF ACCURACY. STORE AS POLYGONS DEFINED BY LATITUDE AND LONGITUDE COORDINATES
806
808
OBTAIN POSITION READING FROM GPS IN TERMS OF LATITUDE AND LONGITUDE
810
COMPARE POSITION WITH HIGHEST LEVEL (LEAST ACCURATE) SET OF DIVISION LINES
814
SELECT NEXT LEVEL (MORE ACCURATE) SET OF DIVISION LINES
812
CURRENT POSITION INTERSECT DIVISION LINE?
YES
816
NO
MOST ACCURATE SET OF DIVISION LINES USED?
YES
818
CHANGE TIME ZONE
YES
END

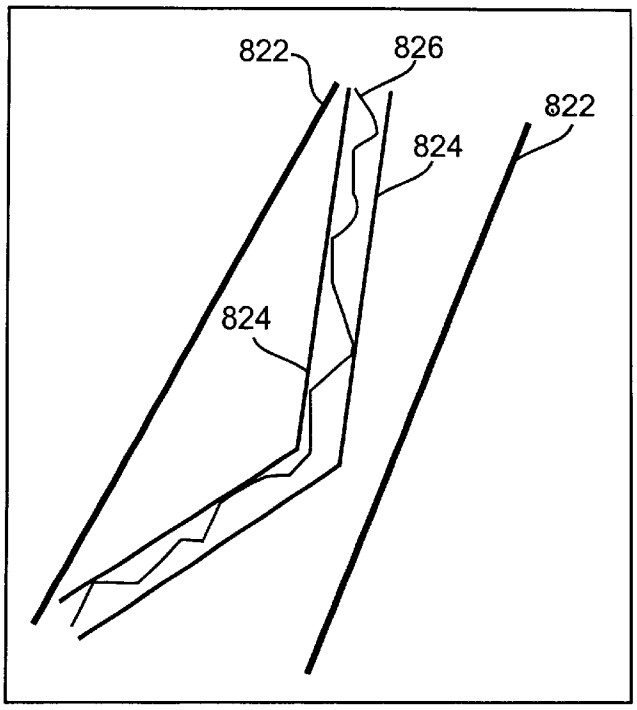

822
826
822
824
824

Fig. 8B

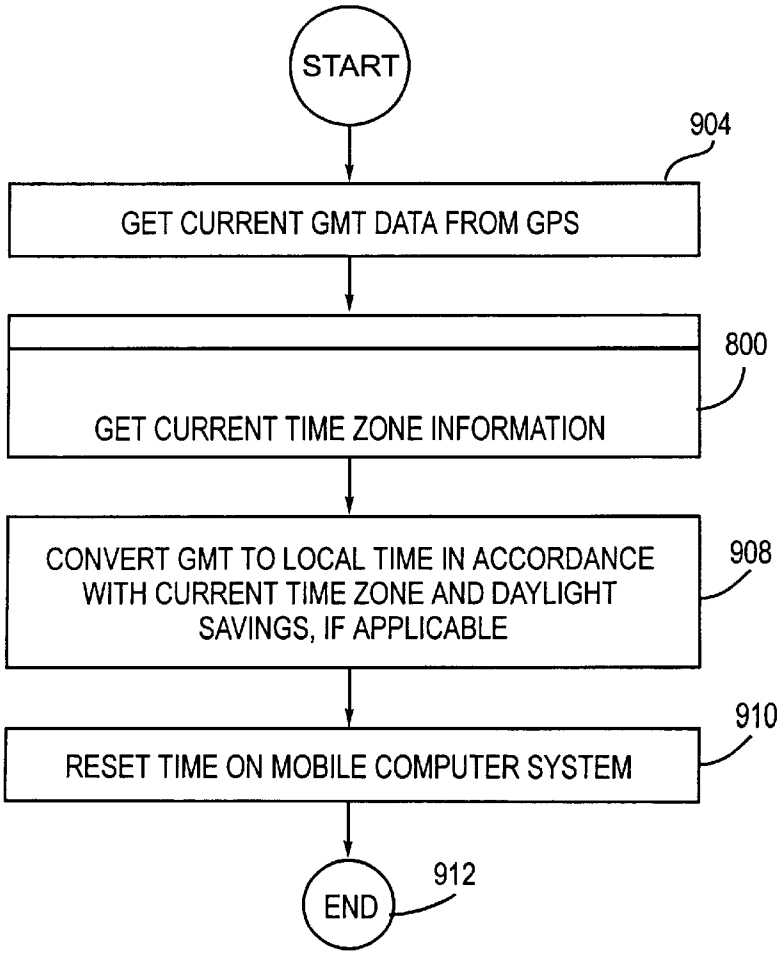

START
904
GET CURRENT GMT DATA FROM GPS
800
GET CURRENT TIME ZONE INFORMATION
908
CONVERT GMT TO LOCAL TIME IN ACCORDANCE WITH CURRENT TIME ZONE AND DAYLIGHT SAVINGS, IF APPLICABLE
910
RESET TIME ON MOBILE COMPUTER SYSTEM
912
END

Fig. 9

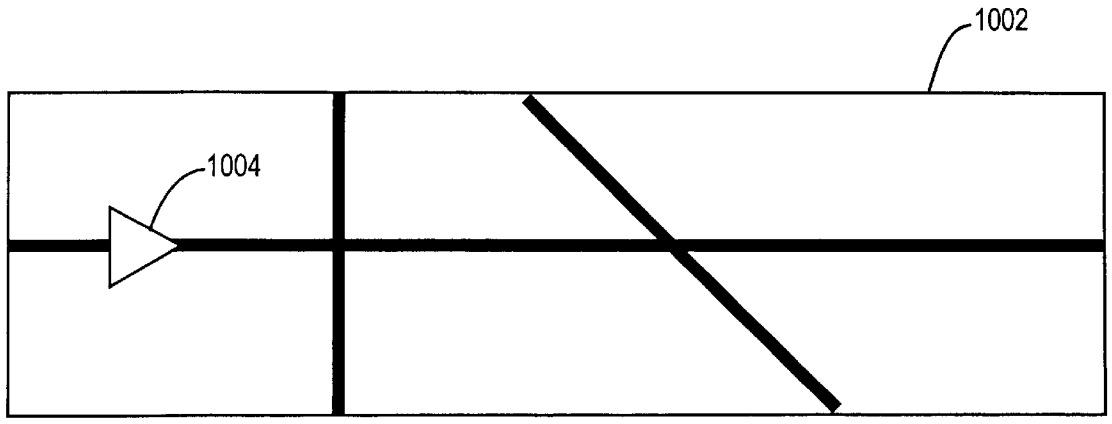


Fig. 10A

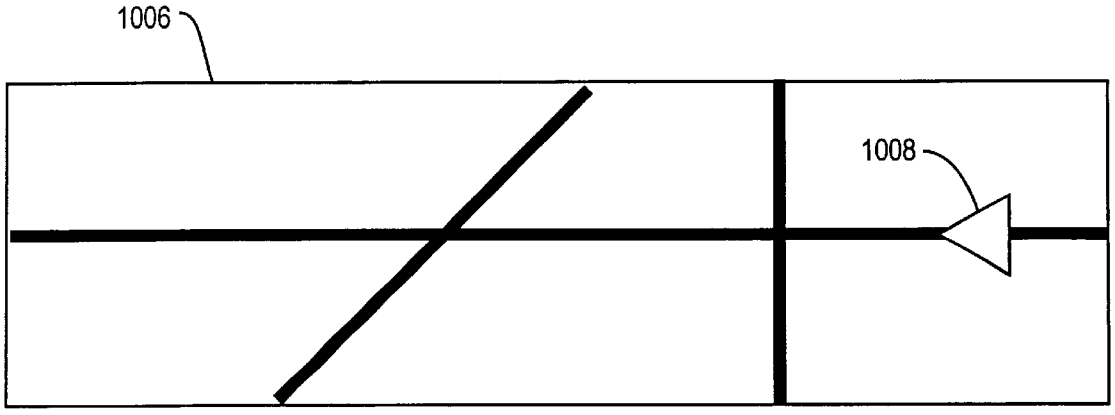


Fig. 10B

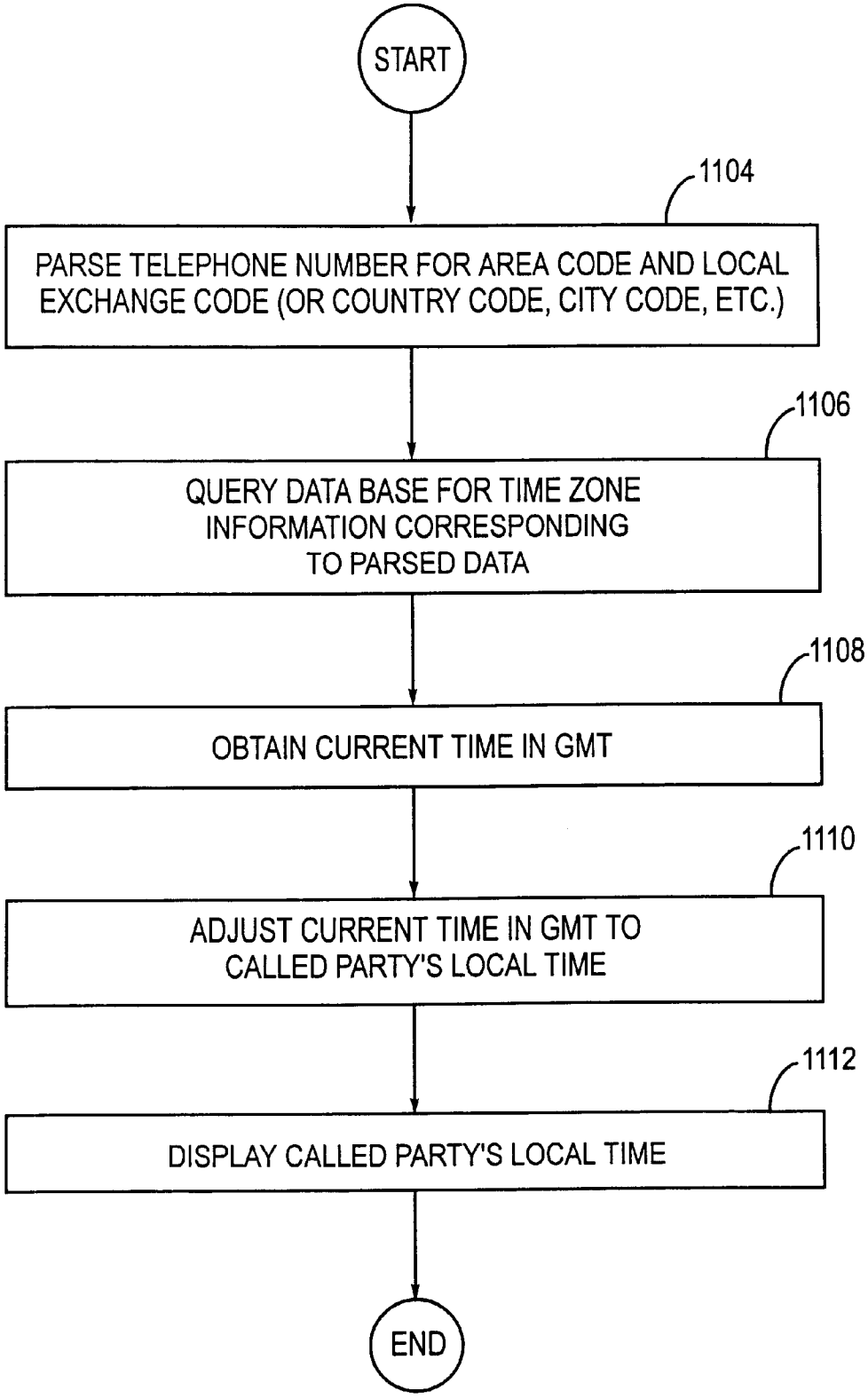

START
1104
PARSE TELEPHONE NUMBER FOR AREA CODE AND LOCAL EXCHANGE CODE (OR COUNTRY CODE, CITY CODE, ETC.)
1106
QUERY DATA BASE FOR TIME ZONE INFORMATION CORRESPONDING TO PARSED DATA
1108
OBTAIN CURRENT TIME IN GMT
1110
ADJUST CURRENT TIME IN GMT TO CALLED PARTY'S LOCAL TIME
1112
DISPLAY CALLED PARTY'S LOCAL TIME
END

Fig. 11

MOBILE NAVIGATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to mobile navigation system and apparatus, and more particularly to a distributed navigation system having a wireless connection to a server for calculating optimal routes using real-time data.

2. Related Art

In recent years, navigation systems, in which automobiles are equipped with a navigational computer that includes a display screen, an input means such as a keypad or a remote control, and a storage means such as a CD, have become popular. Geographical map and routing data is typically stored on the CD. The map database on the CD can have various levels of detail. At the very least, the map database includes geographical information at the major road level. Additional details that can be included are minor roads, turn restrictions, one-way streets, highway ramp configurations, hotel, restaurant and other business information, traffic history, emergency facility locations and the like. The map databases with routing information are referred to as navigable map data or turn-by-turn data. The levels of detail stored on such databases depend on product and marketing factors, including cost and demand, as well as the physical storage capacity limitations.

Such navigation systems are stand-alone devices that rely completely on data stored on the local storage device for geographical and other information. Thus, the capacity of the storage device becomes a limiting factor as to how much information is available to users. In addition, users must update their mapping databases frequently to stay current. Typically, the cost of mapping databases increase with the amount of details provided thereon.

It would be desirable to have a navigation system that provides current information to users without the need to update their local databases whenever changes occur. In addition, it would be desirable to include real-time information such as traffic, weather and road conditions and the like for determining optimal routes. Further, it would be desirable to increase the level of details provided by current navigation systems without requiring expensive databases and/or databases that are beyond the capacity of the local storage device.

A current system, which connects to on-line servers in real-time, is Toyota's MONET navigation system implemented in Japan. The MONET system establishes a connection to the server that is responsive to requests for real-time information including current traffic conditions and the like. The server gathers the requested information and downloads the data to the client.

In this fashion, the MONET system, and other similar current systems, provide information and/or services to users in real-time. This information and/or services include real-time traffic data, road restrictions, email services, news, sports, and weather reports, points-of-interest data, and emergency information such as police, hospital and roadside assistance. These current systems also typically allow the user to download pictures of current traffic conditions, points of interest and the like.

In these current systems, all geographical data transmitted by the server is in a propriety format. That is, downloaded information used to describe geographical data, such as point-of-interest addresses and detailed map data, includes data points, indices and the like that are specific to the particular mapping database used on the client.

Accordingly, the client navigation system must have a particular pre-defined mapping database installed in order to work with the server. In some cases, the mapping database used by the client and server must be identical. If there is a mismatch between the expected mapping database and the actual mapping database used on the client, the client cannot properly interpret the geographical data downloaded from the server and the system will fail to operate.

Accordingly, customers using these current systems must obtain the latest version of the mapping database software available. This presents a major burden for customers and manufacturers alike due to the high frequency in which these databases must be updated.

In addition, the data downloaded by the client generally requires high bandwidth communication channels due the shear volume of data transmitted by these current systems. Such high bandwidth communication channels are expensive and may not be readily available in all areas. It would be desirable to develop a system that requires lower bandwidth communication channels than that required by these current systems.

Another problem with the current systems outlined above is that the client must include sophisticated algorithms for calculating optimal routes. In addition, these route-calculating algorithms in the client must be updated in accordance with current services and options available on the server. For example, if the server were updated to provide a new or modified feature to the client, the client must be specifically customized to support the new or modified feature. Thus, a very close coordination between the software installed on the server and the software installed on the clients must be maintained. This creates an additional economic burden for customers.

Another problem with the current systems is that the proprietary server cannot be used with navigation systems and mapping databases provided by other manufacturers. As stated, using current systems, client software must be frequently customized and very specific mapping software must be used. It would be desirable to have a navigation system that can be easily adapted to work with a variety of mapping software and navigational systems.

SUMMARY OF THE INVENTION

The present invention alleviates many of the failings of the prior art. One advantage of the present invention is that it alleviates the need to have specific pre-defined turn-by-turn mapping databases installed on the client. The present invention can be used with any mapping database installed on the client navigation system. In addition, the level of detail necessary for the client-installed mapping database is minimal.

Another advantage of the present invention is that the client navigation system can be made much less complex than those used in current systems. A feature of the present invention is that the server performs routing generation on behalf of the client. The routing generation takes all real-time variables into account, as well as user preferences and the like. Accordingly, the present invention alleviates the need to install sophisticated and expensive routing algorithms and/or complex hardware components on the client that are used to perform local routing calculations. In many cases, the role of the client system can be limited to displaying routes generated by the server.

Another advantage of the present invention is that it does not require software changes on the client navigation systems whenever the server provides new and/or modified

features. All enhancements to the services provided by the server are independent from the software installed on the client.

Another advantage of the present invention is that it alleviates the need for users to update their mapping database whenever a new version is available. A feature of the present invention is that the server is hardware and software independent from the client. In this fashion, navigation systems from any vendor can be easily adapted to work with the server of the present invention.

Another feature of the present invention is that is uses a natural language to describe optimal routing information that can be interpreted by a variety of clients with minimal software additions. An advantage of the present invention is that low bandwidth communication channels can be used to download the information from the server to the clients. A further advantage of the present invention is that the natural language routing descriptions can be highly compressed to thereby reduce the already low bandwidth requirements of the wireless communication channels.

A generic natural language description is used to specify optimal routing information that is transmitted from the server to the client. The natural language description is completely independent from the local mapping database software used on the clients, and can therefore be used in conjunction with any type of mapping database software.

The client navigation system establishes a wireless connection to the server via cellular telephone technology or the like. Once connected, the client requests a specific route by uploading start and stop specifications to the server. The server independently calculates an optimal route for the user based on real-time and current data available to the server, as well as user preferences or the like.

The routing information is formatted using a natural language specification in accordance with each specific embodiment of the present invention. Generally this specification includes a plain text description for each link in the route using pre-defined generic terms such as road names and turning directions. The client interprets this routing data and interfaces with the local mapping database to reconstruct, in the format required by the client, the optimal route from the natural language description. This is accomplished by using a mapping reconstruction algorithm stored on the client.

Once the route is reconstructed, it is displayed on the display screen on the client navigation system, using whatever mapping database is present on the client. In this fashion, the database software used on the server is completely hardware and software independent from that used on the client.

In one embodiment of the present invention, an enhanced user-interface data-entry feature is provided. This "auto complete" feature anticipates data being entered by users to minimize the data-entry process. This feature is especially useful in an automobile navigation system due to the inherent difficulty in entering data while driving.

In another embodiment of the present invention, the current time zone is derived from the current GPS position. This information is used to set the clock on the navigation system to a highly accurate local time. In addition, this feature avoids the problem found in current systems that do not update local clocks.

In another embodiment of the present invention, maps are automatically scrolled on the display screen so that a representation of the automobile always points to the right or to the left. This enhanced user-interface feature provides a more efficient display allowing for more look-ahead space on displays that are wider than they are tall.

In another embodiment of the present invention, a telephone coupled with the navigation system automatically displays the current local time for a called party, even if the called party is in a foreign country. The dialed number is used to query a local database for providing local time information for the called party.

Further features and advantages of the invention, as well as the structure and operation of various embodiments of the invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

The present invention is described with reference to the accompanying drawings, wherein:

FIG. **1** depicts an operational environment according to an embodiment of the present invention;

FIG. **2** is a block diagram depicting details of the navigation system according to an embodiment of the present invention;

FIG. **3** is a block diagram depicting some of the functional components of the navigation system in accordance with an embodiment of the present invention;

FIG. **4** is a flowchart that depicts a process that can be used in an embodiment of the present invention;

FIG. **5** is a block diagram describing a natural language format that can be used to specify route in accordance with an embodiment of the present invention;

FIG. **6** is a flowchart depicting a process that can be used to implement the map reconstruction feature in accordance with an embodiment of the present invention;

FIGS. **7**A, **7**B and **7**C are block diagrams depicting an enhanced user-interface feature for data-entry in accordance with an embodiment of the present invention;

FIG. **8**A is a flowchart depicting a process that can be used to implement an enhanced feature for determining current time zone information in accordance with an embodiment of the present invention;

FIG. **8**B is a depicts three sets of time zone division lines ranging in accuracy from course to medium to fine in accordance with an embodiment of the present invention;

FIG. **9** is a flowchart depicting a process that can be used to calibrate a real-time clock in the navigation computer **204** in accordance with an embodiment of the present invention;

FIGS. **10**A and **10**B depict a navigational mapping system display in accordance with an embodiment of the present invention; and

FIG. **11** is a flowchart depicting a process that can be used to implement the current time reporting feature of the present invention.

In the figures, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements. The figure in which an element first appears is indicated by the leftmost digit(s) in the reference number.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** depicts an operational environment according to an embodiment of the present invention. A navigational system **102** is installed in a mobile unit such as an automobile **104**. In one embodiment, the navigation system **102** receives data from Global Positioning System (GPS) satellites **110** for

tracking purposes. A minimum number of three satellites is needed to obtain accurate readings. As described below, the connection to the GPS satellites **110** is an optional component of the navigation system **102** according to the present invention.

The navigation system **102** has the capability for wireless communications. In this example, one use of the wireless communication feature is to connect the navigation system **102** with a computer network, such as the Internet **118**. The wireless communication feature of the present invention is also used for providing standard telephony functions.

In one example, cellular technology is used to implement the wireless communication feature of the present invention. In FIG. **1**, the base station **106** and the mobile switching office **108** represent a portion of a typical cellular network. The base station **106** sends and receives radio signals to and from the navigation system **102**. The mobile switching office **108** is coupled to the base station **106** via standard telecommunication transmission lines. Likewise, the mobile switching office **108** is coupled to the public switched telephone network **112** via standard telecommunication transmission lines. The public switched network **112** is coupled to the Internet **118** via a point-of-presence, which is typically implemented using high bandwidth T3 telecommunication channels or the like.

A navigation server **114** is coupled to the Internet **118**. The navigation server **114** is used to generate and download optimal routing information to the navigation system **102** in accordance with real-time data gathered from various providers on the Internet **118**, and current mapping data stored in the database **116**, and user profile information stored in the database **117**.

Note that the cellular network is just one example of a technology that can be used to implement the wireless communication feature of the present invention. In other embodiments, different types of wireless technology can be used, such as low orbit or geosynchronous orbit satellite communications. In fact, any type of wireless technology can be used to provide the wireless communication feature of the present invention.

Further, the Internet **118** is used in a preferred embodiment of the present invention due to its wide use and availability. However, any type of computer network can be used in alternate embodiments of the present invention. As such, the use of the examples of a cellular network and the Internet **118** should not be construed to limit the scope and breadth of the present invention.

Details of the navigational system **102** are depicted in FIG. **2**. Specifically, the navigation system comprises a navigation computer **204**, a mapping database **208**, a display screen **212**, a keypad input device **214**, a speech interface **218**, a GPS receiver **206**, a wireless transceiver **202** and a telephony device **210**.

Note that these components, such as the GPS receiver **206** and/or the wireless transceiver **202** may be imbedded within the navigation computer **102**. Alternatively, such components may be implemented as discrete external devices coupled to the navigation computer **102** through external ports, such as RS-232, SCSI, USB ports or the like.

Any type of general or special purpose computer system can be used to implement the navigation computer **204**. Typically the navigation computer **204** includes a CPU, local working memory, or RAM, non-volatile program memory, or ROM, and some form of non-volatile external memory such as a CD storage system or the like. An example of a general-purpose computer system that can be used in an embodiment of the present invention is a Clarion Auto PC manufactured by Clarion Corporation of America.

The display screen **212** is used to display output from the navigation computer **204**. For example, geographical maps from the mapping database **208** are displayed on the display screen **212**. In this example, the display screen **212** is a liquid crystal display that conforms to the Auto PC platform specification maintained by Microsoft Corporation. In this example, using the Auto PC platform specification, the navigation system **102** fits into a standard 1-DIN unit in the dash of an automobile **104**. In accordance with this example standard, the display screen **212** is 256 pixels wide by 64 pixels tall. An improved method for displaying a navigational mapping system on such a display is described in detail below with reference to FIGS. **10**A and **10**B.

The keypad device **214** is coupled to the navigation computer **204** and is used for inputting data. For example, start and stop designations for a desired navigational route are input into the navigation computer **204** via the keypad **214**. An improved method for efficiently inputting data into the navigation system via the keypad **214** is described in detail below with reference to FIGS. **7**A, **7**B and **7**C.

A clock **219** coupled to the navigation computer **204** displays the local time. In one embodiment, the clock **219** has a mode in which it displays the local time of a called party via the telephonic device **210**. Note that in one embodiment, the time is displayed on the display screen **212**. Alternatively, in another embodiment, the time is displayed on a display on the telephonic device **210**. Alternatively, in yet another embodiment, the time is displayed on another display device coupled to the navigation computer **204**.

In this example, a speech interface **218** is also coupled to the navigation computer **204**. The speech interface **218** uses voice recognition techniques to accept spoken commands from users for controlling the navigation computer **204**. The speech interface **218** is used in a preferred embodiment to allow users to control the computer **204** via spoken voice commands for promoting safe driving conditions while operating the navigation system **102**.

The mapping database **208** is used to store local mapping data. As described in detail below, the local mapping database can be any type of mapping database supported by a specific implementation of the present invention. The mapping database need not match the mapping database **116** used by the navigation server **114**.

The map display software **209** comprises methods for displaying, on display **212**, routes reconstructed from the optimal routing information provided by the server **114**.

The wireless transceiver **202** is used to send and receive data between the navigation computer **204** and the navigation server **114**. In addition, the wireless transceiver **202** is used to provide standard and enhanced telephony services via the telephonic device **210**. In one embodiment of the present invention, an enhanced telephony service that is provided is one that automatically displays the current time of day relative to a called party's location upon dialing out. This aspect of the present invention is described in detail below with reference to FIG. **11**.

The GPS receiver **206** is used to track the position, speed and bearing of the mobile unit **104**. As is well known, the GPS is a collection of 24 satellites owned by the US Government. Other similar systems can also be used in alternate embodiments of the present invention. One example of a similar system is the Russian GLONASS system.

In general, the GPS and other similar systems provide highly accurate positioning and navigational information.

Currently, the US GPS comprises 24 twenty-four NAVSTAR GPS satellites which orbit 12,000 miles above the earth and constantly transmit their individual positions as well as the current precise time-of-day. The current precise time-of-day is provided by one of four highly accurate on-board atomic clocks.

GPS receivers, such as the receiver **206**, listen to the information received from at least three satellites to determine the precise location of the receiver, as well as velocity and bearing information (if in motion). The GPS receiver **206** determines its distance from the satellite by using the travel time of the radio message from the satellite **110** to the receiver **206**. After calculating its relative position from at least three satellites **110**, the current position is calculated using well known triangulation techniques.

Accordingly, when the GPS receiver **206** is present, the navigation computer **102** uses data from the GPS to track the current location of the mobile unit **104**. The current location is overlaid on a map from the mapping database **208** and is displayed on the display screen **212**.

In one embodiment of the present invention, the precise location that is calculated by the GPS receiver **206** is used to determine current time zone information. This information can be used for example to set a highly accurate compensated local time in the navigation computer **204**. Details of this aspect of the present invention are subsequently described below with reference to FIGS. **8** and **9**.

FIG. **3** is a block diagram depicting some of the functional components of the navigation system in accordance with an embodiment of the present invention. The navigation computer **204** is provided with a web server interface component **302**. The web server interface component **302** is used to perform web browser-like functions for the navigation computer **204**. As shown, the web server interface is coupled with the navigation server **114**. This is generally accomplished through the use of the wireless transceiver **202**.

Accordingly, the web server interface module **302** interprets data streams from the server for displaying display text and/or graphics on the display screen **214**. Preferably, the data streams transmitted by the server **114** are in a standard format, such as HTML, a modified version of HTML or the like. In this fashion, generic web-browsing tools can be used to interface with the web navigation server **114** of the present invention.

The web server interface module **302** is also used to accept input **304** from the user and transmit such user input **304** to the server **114**. For example, users may request a route to be calculated by the server **114** by inputting route start and stop designations.

Route data that is calculated by the server **114** is downloaded to the navigation computer **204** via the web server interface **302**. The map reconstruction module **306** then processes the route data. In particular, the map reconstruction module interprets the route data and reconstructs, in the format required by the map display software **209**, the optimal route calculated by the server **114**, using the local mapping database **208**. As indicated by block **308**, the reconstructed mapping data is displayed, by the map display software **209**, on the display screen **214**.

FIG. **4** is a flowchart that depicts a process that can be used in an embodiment of the present invention. The process begins with step **404**, where the navigation computer **204** establishes a connection with the server **114**. Once a connection is established, the user inputs start and destination parameters for a requested route.

In step **408**, the server connects with other databases, as necessary to obtain real-time information that is to be used in calculating an optimal route for the user. For example, the server may connect with another server on the Internet **118** that provides current traffic or road conditions relevant to the proposed route. Alternatively, such information may reside in one or more resources directly controlled by the navigation server **114**, such as the database **116**, or the user profile **117**.

In any case, the Internet **118** is a preferred computer network used in an embodiment of the present invention because of the wide availability of information offered by governmental, educational and commercial sources. Thus, depending on the specific implementation of the present invention, real-time data provided by the present invention can originate from the navigation server **114**, or from other sources on the Internet **118**.

Accordingly, the knowledge base used by the navigation server **114** can be local or widely distributed, depending on each specific implementation of the present invention. On one end of the spectrum, the navigation server **114** provides all of the real-time information for the mobile navigation system **102**. On the other end of the spectrum, none of the real-time data is provided directly from navigation server **114**, but from other resources available on the Internet **118**. In a typical embodiment, the distribution of the knowledge base falls somewhere in-between these two extremes.

In step **408**, the server **114** optionally reads or requests user preference data for calculating the route. For example, the user may want to avoid toll roads, dirt roads or major highways. The server **114** can request this information from the user in real-time. Alternatively, such information may be pre-stored from previous sessions and is accessible by the server **114**, from the database **117**. Many known methods can be used to obtain user specific information, such as the use of cookies and the like. Such methods would be apparent to persons skilled in the relevant art(s).

In step **412**, the server calculates an optimal route based on the start and destination data from step **406**. the real-time data from step **408**, and the user information, if any, from step **410**. Next, in step **414**, the server **114** formats the routing data in accordance with a natural language specification. An example of a natural language specification that can be used to implement an embodiment of the present invention is described below with reference to FIG. **5**.

Next, in step **416**, the server downloads the calculated optimal route to the navigation computer **204**. Typically, this data is compressed prior to downloading in step **416**. Upon receipt of the compressed data, the client uses a decompression algorithm to expand the data to its original text format. The textual nature of the natural language specification of the present invention provides for highly compressible routing data to thereby reduce bandwidth requirements for the wireless connection.

In step **418**, the client interprets the routing data, queries the mapping database **208**, and reconstructs the optimal route in terms that are native to the mapping database **208** and/or the map display software **209**. In step **420** the route is displayed, by the map display software **209**, on the display screen **212**, as indicated by block **308**.

FIG. **5** is a block diagram describing a natural language format that can be used to specify routes in accordance with an embodiment of the present invention. A generic designation for the natural language description is depicted in block **502**. This is followed by a specific example of a formatted calculated route as shown in block **508**.

The natural language description **502** preferably consists of start and end route designations **504**. These designations

are described using a natural language specification and generally include such information as street names and city names, etc. In addition, in a typical embodiment. the start/end route designation includes a start direction.

The start and end route designations are followed by a number of links **505***a,* **505***b* . . . **505***n* (generally **505**). Each link **505** is described using a natural language description. This can include m any variables such as a street name, a distance, a turning orientation, a landmark designation, a turning distance from the landmark, etc. Many variations can be used in different embodiments of the present invention in accordance with desired features.

In a preferred embodiment, a minimal amount of information is used to describe each link to minimize bandwidth requirements. The route table **508** depicts a specific example of a calculated route that begins on Sea World Drive in San Diego Calif. and ends on South Rodeo Drive in Beverly Hills Calif.

As stated above, the natural language routing description **502** begins with the start/end route designations **504**. An example of a start/end route designation is shown in block **510**. These designations can be as simple as the name of the start and end streets as well as the city and state of such streets. In this example, the start/end route designation is defined as "Sea World Drive, San Diego Calif. to South Rodeo Drive, Beverly Hills Calif. The meaning of these terms is self-explanatory.

The first link **514** describes information about the next turn. In particular, the link **514** lists the name of the next road ("Interstate 8"), the orientation of the turn at Interstate 8 ("90 Deg.") and the distance to the turn at Interstate 8 ("1.4 miles"). Similarly, Link **515** lists the name of the next road ("Interstate 5"), the orientation of the turn ("0 Deg.") and the distance ("127.3 miles"). The next link **518** lists the name of the next road ("Santa Monica Highway 2"), the orientation of the turn ("45 Deg.") and the distance to the turn("2.9 miles"). Finally, the last link **520** lists the next turn ("South Rodeo Drive"), the turning orientation ("180 Deg.") and the distance to the turn ("1 mile").

As described below, this information is processed by the navigation computer **204** to reconstruct and display the route **508** using the local mapping database **208**. As stated, the local mapping database **208** can be different from the mapping database **116** used by the server **114** to calculate the route. Specifically, the map reconstruction module **306** reads the natural language routing description **508** and reconstructs the route in step **418**.

A method that can be used by the map reconstruction module **306** to reconstruct the route (as shown in step **418** from FIG. **4**) will now be described with reference to FIG. **6**. The map reconstruction process **600** begins with step **602**. In step **602**, the process finds the starting point of the route. Typically, this starting point is listed in the first entry **504** in the natural language description **502**. It should be noted that there are many ways in which to specify a start location. For example, in one embodiment, the start location is specified in accordance with the current GPS location. In another embodiment, the start location is specified by specific user input. In yet another embodiment, preprogrammed user information, such as a home or work address is stored in either the navigation computer **204** or the user profile database **117**. In any case, various methods for specifying a start location that can be used in specific embodiments of the present invention would be apparent to persons skilled in the relevant art(s).

Accordingly, in step **602**, the start location is found within the local mapping database **208**. Specific methods for searching the local mapping database **208** depend on the actual mapping database being used in each specific implementation of the present invention. Typically, standard map data accessing function calls are used in accordance with requirements of a predefined application-programming interface (API). Specific method steps for searching various types of mapping databases **208** would be apparent to persons skilled in the relevant art(s).

Once the starting point is found on the mapping database **208**, the process continues with step **604**. In step **604**, the next link is extracted from the natural language description **505**. As stated, this includes at least the street name of the next turn ("next turn street") and the type of the next turn ("turn type"). It should be noted the turn type could be specified in various ways. For example, the turn type could be specified in terms of absolute degrees, as shown in FIG. **5** or as directional indicators, such as N, NE, E, SE, S, SW, W and NW. Alternatively, the turn type could be specified as a left turn or a right turn, a left bear or a right bear, etc. Any method for describing turns can be used in alternative embodiments of the present invention.

Next, in step **606**, the current road in the mapping database **208** is followed in the indicated direction. The indicated direction is determined by the start/end route designations **504**, or from the last turn. Next, in step **608** the process determines if the last link **505***n* has been processed. If so, the map is highlighted in accordance with the reconstructed routing information determined from the previous steps. Typically, the highlighted map is displayed on the display screen **212**.

If the last link **505***n* has not been reached in step **608**, control passes to step **610**. In step **610** the current road in the mapping database **208** is searched for the next occurrence of a cross street. The goal is to determine the exact location (i.e. the latitude and longitude) of each maneuver. This is accomplished by finding the intersection of the two streets before and after a maneuver under consideration. In one embodiment, it is assumed that the street names and the city name of the streets have been extracted from the turn-by-turn text instructions provided by the server.

This task can be achieved by using standard map data accessing function calls. A node ID of the maneuver point (intersection) can thus be obtained. Once the maneuver point is identified, the road segment corresponding to the next cross street can be determined.

Next, in step **612**, the process adds the map information to the reconstructed route. Control next passes to step **614**. The objective is to construct a route data structure or "link list" which consists of all the shape points along the route. Given two nodes (i.e. maneuver points) and the name of the road between them, the process traces through the segments that connect the two nodes. From each segment, a series of shape points can be obtained. The result of step **612** is link list of shape points, which define part of the route.

Next, in step **614**, the process double checks if the found cross street matches the turn street. In a preferred embodiment, fuzzy logic is used to implement the street name comparison in step **614** to account for differences in spelling and for differences in street names such as "road" verses "drive", "street", or "circle" and abbreviations and the like. If an exact match is not found, heuristic techniques can be used to determine the best match. Typically, this involves additional searching in the current direction to determine if other candidates exist.

If in step **614**, a match between the cross street and the turn street is found, control passes to step **616**. In step **616**,

the process makes the turn as indicated in the link information. Control next passes back to step **604**, where the next link is read. The process represented by steps **604–616** continues until step **608** determines that the last link has been processed, as described above.

The outcome of this algorithm depicted by flowchart **600** is a link list of shape points, which define the optimal route downloaded from the server **114**. A subset of the link list of shape points is the actual maneuver points. This reconstructed route data can then be used to display and route track a vehicle progression along the route. The navigational computer **204** can then issue guidance instructions to the user at appropriate times (e.g. when the automobile **104** approaches a turn).

An enhanced user-interface data-entry feature will now be described with reference to FIGS. **7**A, **7**B and **7**C. This feature is preferably used in embodiments of the present invention that include the use of data entry fields similar to the type shown in FIG. **7**C. This type of data entry field is hereinafter referred to as a "keypad data entry field." A keypad data entry field provides the capability for inputting alphanumeric characters with the use of a keypad device, rather then a keyboard device. Keypad data entry fields can be found, for example, in Microsoft's CE Auto PC operating system.

The keypad input device **214** used in one embodiment of the present invention consists of five keys that are arranged as shown in FIG. **7**A. In this example, the central key **711** is used to perform an "Enter" function and is hereinafter referred to as the "enter-key **711**." The four directional keys **705**, **707**, **709**, and **703** are generally used to alter the position of a screen object, such as a cursor or the like. In addition, the directional keys are used to scroll data as described below.

FIG. **7**C represents a single keypad data entry field shown at different points in time. In particular, in this example, the elapsed time increases as the reference numerals **712–720** increase. In this example, different character positions are highlighted (as indicated by darkened triangles) at each point in time **712–720**. That is, the first character is highlighted at time **712**, the second at time **714**, the third at time **716**, the forth at time **718** and the fifth at time **720**.

The highlighted character position indicates the active character position. When a particular character position is active, users can manipulate the data within that position by using the up and down arrow keys **703** and **707**, respectively. Typically, pressing the up arrow key **703** scrolls data in the data in the active character position in a descending alphabetical order. Similarly, pressing the down arrow key **707** scrolls the data in the active character position in an ascending alphabetical order.

Further, users select which character position in the data entry field is active by manipulating the left **709** and right **705** arrow keys. The enter-key **711** is generally depressed to indicate that data should be entered and accepted by the program.

The enhanced user interface feature of the present invention anticipates the contents of data being entered by the user and fills-in the data entry field with the anticipated characters to the right of the active character position. In this fashion, if the anticipated data is correct, the user need not enter data into the remaining character positions, but instead, immediately presses the enter-key **711**.

In addition, the method constantly determines a valid character set for each character position. Therefore, when user presses up arrow key or down arrow key for scrolling characters, only valid characters appear in the keypad data entry field in accordance with the set of allowable entries. This feature of the present invention is especially useful in a mobile environment such as an automobile, where data entry is not only cumbersome, but can also be dangerous.

The enhanced user-interface feature of the present invention functions as follows. FIG. **7**B represents a portion of a database comprising allowable cities that can be specified by a user, for example, when specifying the start and/or stop route designations in step **406**. In this example, the cities are listed in alphabetical order, but any order can be used in alternate embodiments.

As shown by the data entry field at time **712**, the user enters an "S" in the first character position by manipulating the up and down arrow keys (**703** and **707**, respectively). In response to this user input, all of the character positions to the right of the active character position are completed with anticipated data. In this example, the city "Sacramento" **704** is selected as the anticipated data entry item.

In this example, "Sacramento" **704** is selected from the table **702**, because it is the first entry found in the table **704** that conforms to the entered data at the time **712**. That is, "Sacramento" is the first city in the table **702** that begins with the letter "S".

It is important to note that in other embodiments, different criteria can be used to select a particular item from the set of conforming data items. In this example, the set of conforming data items is all items in the table that begin with the letter "S". Further, in this example, the criterion used for selecting a particular conforming data item is that it appears first in the list, alphabetically.

In another embodiments, different criteria can be used, such as frequency of use and most recent use. For example in one embodiment, a frequency of use counter is maintained for each data item in the list **702**. Accordingly, a data item having the highest frequency of use is selected from the set of conforming data items. In another embodiment, a date counter is maintained for each item in the list **702**. In this example, the most recently used data item is selected from the set of conforming data items. Any method can be used to select the anticipated data item from the set of conforming data items at each point in time during the data entry process. Such methods would be apparent to persons skilled in the relevant art(s).

Next, as indicated by the time **714**, the user selects the letter "A" in the second character position. At this point, the set of conforming data items is all items in the list **702** beginning with the letters "SA". This includes the data items **704–710**. Using the alphabetical criterion as described above, the data item "Sacramento" is selected as the anticipated data entry.

Next, as indicated by the time **716**, the user selects the letter "N" in the third character position. This letter can be quickly selected by the user because the scrollable character set at each position is limited in accordance with the allowable entry list **702**. In this example, if the allowable data entry list **702** represents the entire list, then the allowable characters in the third character position is limited by to the letters "C" and "N".

When the "N" is selected, the set of conforming data items is all items in the list **702** beginning with the letters "SAN", namely **706–710**. Again, using the alphabetical criterion as described above the data item "San Diego" is selected as the anticipated data entry.

Next, as indicated by the time **718**, the user selects a space in the forth character position. At this point, the set of

conforming data items remains the same. Therefore, the data item "San Diego" is selected as the anticipated data entry.

Next, as indicated by the time **720**, the user selects the letter "F" in the fifth character position. At this point, the set of conforming data items is all items in the list **702** beginning with the letters "SAN F." The set of conforming data items that meets this criterion is "San Francisco" **78**. Accordingly, "San Francisco" **708** is selected as the anticipated data entry.

As stated above, in one embodiment of the present invention, the precise location that is calculated by the GPS receiver **206** is used to determine the current time zone. This information can be used for example to set the clock **219** coupled to the navigation computer **204** to a highly accurate compensated local time, based on current position. This feature avoids the problem found in current systems where a local clock is not updated with a time zone is crossed.

FIG. **8**A is a flowchart depicting a process that can be used to implement an enhanced feature for determining current time zone information in accordance with an embodiment of the present invention. In step **804** time zone division lines are input into the navigation computer system **204**. One way to accomplish this is to digitize time zone division lines. In step **806** three sets of time zone division lines are stored in the computer system **204**. Preferably, these lines are stored as three sets of polygons having an increasing level of accuracy, as indicated by step **806**.

Accordingly, three sets of time zone division lines are stored, ranging in accuracy from course to medium to fine. The course time zone division lines are wider and not as accurate as the medium division lines, which in turn are wider and not as accurate as the fine division lines. As the level of accuracy increases, so does the number and complexity of the polygons that comprise the different sets of time zone lines. In other words, the course and medium time division lines are approximations that are used to quickly determine whether a current position is close to an actual time zone. If so, a more precise set of lines is used. The fine time zone division lines very accurately depict the shape and position of the actual time zone division lines. The fine set of lines is much more complex and requires more polygons than the less accurate course and medium sets of lines. This concept is illustrated in FIG. **8**B.

In FIG. **8**B, a portion of a course, medium and fine set of time zone lines are depicted. The actual time zone is coincident with the fine set of time zone lines that are represented by the line **826**. In this example the fine set of division lines **826** exactly matches the width and shape of the actual time zone. The medium set of time zone division lines **824** represent a close approximation that encompasses the time zone line **826**.

Note that the medium set of lines **824** can be represented with much fewer polygons than the fine set of lines **826**. In this fashion, searches using the medium set of lines **824** for determining whether a current position is coincident with the time zone lines **824** can occur much faster than using the fine set of lines **826**.

The course set of time zone division lines **822** represent a gross approximation of the time zone line **826**. Note that the course set of lines **822** can be represented with fewer polygons than the medium set of lines **824**. In this fashion, searches using the course set of lines **822** for determining whether a current position is coincident with the time zone lines **822** can occur much faster than using the medium set of lines **824**. Accordingly, as shown below, searches are made first with the course set of lines **822**, followed by the medium set of lines **824**, followed by the fine set of lines **826**.

Referring back now to FIG. **8**A, in step **808**, the process determines the current position from the GPS receiver **206** in terms of latitude and longitude. Next, in step **810**, the process determines if the current position intersects with the course set of time division lines. It should be noted that comparing the position using the course set of time zone division lines is faster than using the medium set of time zone division lines. Similarly, the comparison using the medium set of time zone division lines is faster than using the fine set of time zone division lines. In this fashion, the medium and fine sets are used only when required (i.e. when the navigation system **102** gets closer to an actual time zone division line.)

When the navigation system **102** gets close to a time zone, the compare using the course approximation location information will indicate that an intersection between the current location and the course set of lines exist. This indicates that a higher resolution compare is required using a finer set of time zone division lines.

Accordingly, in step **810**, a comparison is made between the current position and the course set of time zone division lines. In step **812**, the process determines if the current position intersects with the time zone division lines in accordance with the comparison. If it does, the process determines if the most accurate set of division lines have been used in step **812**. If so, control passes to step **818**, where the new time zone is set. If not, the next finer set of division lines are used for another comparison, as indicated by steps **814** and **812**.

If it is determined in step **812** that an intersection between the current position and the time zone lines do not exist, control passes back to step **808** and the process repeats. Note that an embodiment of the present invention may include a delay between steps **812** and **808**. For example, it may be desirable to save CPU cycles by checking for a new time zone at specified intervals, rather than continuously.

FIG. **9** is a flowchart depicting a process that can be used to calibrate a real-time clock in the navigation computer **204**. The process begins with step **904**. In step **904** the process determines the current time in Greenwich Mean Time (GMT) from the GPS receiver **206**. Next, in step **906**, the process determines the current time zone information. This can be accomplished using the process **800** as described above.

Next, in step **908**, the process coverts the GMT to local time in accordance with the current time zone and daylight savings time and like. A database that is accessible to the navigation computer **204** is used for this purpose. In step **910** the process sets the local time of the navigation computer **204** in accordance with the time calculated in step **908**. The process ends as indicated by step **912**.

As stated above, the display screen **212** is used to display geographical maps from the mapping database **208**. In addition, the current position of the automobile **102** is superimposed on the geographical map to indicate the current position and bearing. In this example, the display screen **212** is a liquid crystal display that conforms to the Auto PC platform specification maintained by Microsoft Corporation. In this example embodiment, the navigation system conforms to the Auto PC platform and thus **102** fits into a standard 1-DIN unit in the dash of the automobile **104**. It is assumed that in accordance with this standard, the display screen **212** is on the order of 256 pixels wide by 64 pixels tall. An method for displaying a navigational mapping system on such a display will now be described with reference to FIG. **10**.

A "head-right" map display **1002** is shown in FIG. **10**A. In this example, the automobile **104** is represented by the triangle **1004**. In this example the automobile is heading from left to right. In the head-right display **1002**, the map is continuously rotated such that the direction of the vehicle **1004** always points to the right. This method is much preferred over the current method of displaying maps such that the vehicle always points up. Using a head-right display is preferred due to the fact that the display screen **212** is significantly wider than it is tall. In this fashion, by using a head right display, more look-ahead space of the route is provided.

Alternatively, a "head-left" map display **1006** as shown in FIG. **10**B can be used. This may be the preferred method for automobiles equipped with a steering wheel on the right side. In this example, the automobile **104** is represented by the triangle **1008** and is heading from right to left. In the head-left display **1006**, the map is continuously rotated such that the direction of the vehicle **1004** always points to the left. This method is much preferred over the current method of displaying maps such that the vehicle always points up.

In one embodiment of the present invention, a database is maintained that maps time zone information to telephone numbers. This database is used to provide an enhanced user-interface feature of the present invention. In particular, the database is used to display the current local time of a called party, when dialing out on the telephonic device **210**. The database used to implement this feature matches country codes, city codes, area codes, and local exchange information that comprise telephone numbers to time zone information.

FIG. **11** is a flowchart depicting a process that can be used to implement this feature of the present invention. In step **1104**, the telephone number input by the user is parsed to extract a country and city code, or an area code and three-digit exchange. Once this information is extracted, it is used in step **1106** to query a database that matches such information with time zone information. The time zone information is generally relative to universal time or GMT, and typically ranges from GMT −12 hours to GMT +12 hours. Once this information is retrieved from the database, the current time in GMT is obtained as indicated in step **1108**.

After the current GMT is obtained, it is adjusted in accordance with the time zone information as indicated in step **1110**. Finally, in step **1112**, the adjusted time is displayed to the user.

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

1. A method for providing an optimal route using real-time information for a navigation system comprising a client and a server, said server coupled to a computer network, said method comprising the steps of:

establishing a wireless connection between the client and the server;

transmitting start and end route designations from the client to the server;

accessing real-time information by the server;

calculating the optimal route by the server, based on the real-time information and said start and end route designations;

formatting the optimal route into a non-proprietary, natural language description;

downloading said non-proprietary, natural language description to the client;

reconstructing the optimal route by the client using a local mapping database; and

displaying said optimal route on a display system coupled to the client.

2. The method of claim **1**, wherein said step of formatting includes the step of dividing the optimal route into one or more links, wherein each link includes at least a street name and a turning orientation.

3. The method of claim **2**, wherein said step of reconstructing includes the steps of:

searching said local mapping database for a closest match of said street name and said turning orientation for each of said links; and

building the optimal route by combining each of said closest matches from said searching step.

4. The method of claim **1**, wherein said accessing step comprises the step of accessing a traffic database comprising current traffic conditions; and

querying said traffic database for determining current traffic conditions between locations defined by said start and end route designations.

5. The method of claim **1**, wherein said real-time information includes one or more from the set of:

current traffic conditions;

highway ramp configurations;

current weather conditions;

constriction information;

road restrictions;

detour information; and

event traffic information.

6. The method of claim **1**, wherein said wireless connection is accomplished using a cellular network.

7. The method of claim **1**, wherein said transmitting step includes the step of entering into a keypad data entry field, said start and stop route designations including a name for one or more of:

a city;

a state;

a country; and

a street.

8. The method of claim **7**, wherein said step of entering comprises the steps of:

comparing data entered into the keypad data entry field with a database of allowable entries;

determining a set of conforming data items associated with said entered data;

applying a criterion to said set of conforming data items to determine an anticipated data item; and

displaying said anticipated data item in the data entry field.

9. The method of claim **8**, wherein said criterion defines a data item in said set of conforming data items that appears first alphabetically.

10. The method of claim **8**, wherein said criterion defines a data item in said set of conforming data items that is used most frequently.

11. The method of claim **8**, wherein said criterion defines a data item in said set of conforming data items that is used most recently.

12. The method of claim 1, wherein said downloading step comprises the step of compressing said natural language description.

13. The method of claim 1, wherein said calculating step further comprises the step of reading user-specific data in calculating the optimal route.

14. The method of claim 1, wherein said computer network is the Internet.

15. A mobile navigation system comprising:

a navigation computer;

a wireless transceiver coupled to said navigation computer for connecting with a navigation server, said navigation server for calculating optimal routes based on real-time information, said optimal routes being formatted using a non-proprietary, natural language description;

a mapping database coupled to said navigation computer for reconstructing said optimal route from said non-proprietary, natural language description; and

a display screen coupled to said navigation computer for displaying said optimal route using said mapping database.

16. The mobile navigation system of claim 15, further comprising:

a GPS receiver coupled to said navigation computer for monitoring position;

a telephonic device coupled to said wireless transceiver and said navigation computer for making and receiving telephone calls; and

a keypad coupled to said navigation computer for entering start and end route designations.

17. The mobile navigation system of claim 15, wherein said display screen is used to display the mapping database in a head right configuration.

18. The mobile navigation system of claim 15, wherein said display screen is used to display the mapping database in a head left configuration.

19. The mobile navigation system of claim 16, further including a clock coupled to said navigation computer, wherein said navigation computer is programmed to set said clock to an accurate local time in accordance with a time from said GPS receiver and a current time zone.

20. The mobile navigation system of claim 15, further including a clock coupled to said navigation computer, and said telephonic device, wherein said navigation computer is programmed to indicate from said clock a local time of a called party based on a dialed number.

21. A method for providing an optimal route using real-time information from a server of a navigation system, the navigation system also comprising a client and said server coupled to a computer network, said method comprising the steps of:

establishing a wireless connection with the client;

receiving at the server start and end route designations from the client;

calculating at the server the optimal route based on real-time information at the server and said start and end route designations;

formatting at the server the optimal route into a non-proprietary, natural language description;

downloading from the server said non-proprietary, natural language description to the client so that the client can reconstruct the optimal route using a local mapping database and display said optimal route on a display system coupled to the client.

22. A method for providing an optimal route using real-time information at client of a navigation system, the navigation system also comprising a client and said server coupled to a computer network, said method comprising the steps of:

establishing a wireless connection with the server;

transmitting start and end route designations from the client to the server;

receiving from the server an optimal route formatted in a non-proprietary, natural language description and calculated based on real-time information and said start and end route designations;

reconstructing the optimal route using a local mapping database; and

displaying said optimal route on a display system coupled to the client.

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