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(54) Title: SYSTEMS AND METHODS FOR ROUTING AND SCHEDULING

(57) Abstract: The present invention provides systems, methods and computer program- product for calculating and storing time and distance information in an economical and efficient manner. The time and distance information may be used in the development of traversable networks for the delivery and retrieval of items from multiple locations in a timely and efficient manner.

SYSTEMS AND METHODS FOR ROUTING AND SCHEDULING

BACKGROUND OF THE INVENTION

When routing delivery vehicles between a large number of delivery locations, current routing and scheduling systems often utilize stored time and distance data in conjunction with routing and scheduling algorithms to create routes. Calculating the shortest path between each location within a delivery region is often an expensive and time consuming process, with the task becoming exceedingly more difficult as the delivery area expands. In fact, performing shortest path calculations between a large number of delivery locations or over an extended area of land is often beyond the processing and memory capabilities of some computers. For those computers that do possess the capacity to perform such calculations, the process is still entails a time consuming process. Accordingly, improved logistics systems are needed that calculate and store time and distance data in a more economical and efficient format.

BRIEF SUMMARY OF THE INVENTION

Embodiments of the present invention provide a system, method and computer program product for calculating and storing time and distance information in an economical and efficient manner.

One aspect of the invention is a computer program product for controlling a computing device having at least a memory, a processor and a display device. The computer program product is for calculating and storing shortest path information between two or more delivery locations, and comprises a computer-readable storage medium that stores computer-readable program code portions. The computer-readable program code portions include a grid partitioning module that divides an overall delivery region into multiples of a defined number of grids. For example, the grid partitioning module may be a quad grid partitioning module that divides the delivery region into a number of grids that is a multiple of four. Two or more delivery locations are located within at least one of the defined number of grids. Another program code portion is an initial friend selection module that selects one of the defined number of grids and for each particular delivery location within the selected grid a friends list is created that is comprised of a set of delivery locations that are most likely to appear on the same route as the particular delivery location. The computer program product also includes a super matrix creation module that creates a traversable network comprised of nodes and arcs for the selected grid, calculates time/distance data from each delivery location within the selected grid to every node within the traversable network, and populates a super matrix containing time/distance data from each particular delivery location within the selected grid to each delivery location in that location's friends list and any in-range depots.

Another aspect of the present invention is a system for delivering items to two or more delivery locations. The system is comprised of a delivery vehicle capable of transporting one or more items for delivery at each of said two or more delivery locations. The delivery items are obtained at a depot. The system further includes the computer program product described above. The delivery vehicle utilizes said shortest path information determined by the computer program product to determine a route for obtaining the one or more items for delivery at each of the two or more delivery locations and transporting the one or more items for delivery at each of the two or more delivery locations to each delivery location.

Yet another aspect of the present invention is a computer system for calculating and storing shortest path information between two or more potential delivery locations. The computer system comprises at least a processor that is configured to partition a delivery region into multiples of one or more discrete geographic areas, and each of the geographic areas includes a first set of one or more potential delivery locations. The processor is configured to select a first geographic area and creates a unique second set of potential delivery locations for each potential delivery location geographically located within the first geographic area. The processor is also configured to create a traversable network. The traversable network comprises a set of nodes and arcs and further includes a set of two or more nodes comprising at least the potential delivery locations geographically located within the first geographic area and all potential delivery locations included within any of the unique second sets of potential delivery locations created above. The processor is configured to calculate shortest path information from each of the potential delivery locations geographically located within the first geographic area to every node contained within the traversable network and select particular shortest path information and store the particular shortest path information for future lookup by a routing and scheduling system.

Another aspect of the present invention is a computer system for calculating and storing shortest path information between two or more potential delivery locations. The computer system is comprised of at least a processor that is configured to create a unique set of potential delivery locations for each potential delivery location geographically located within a geographic area. The processor is also configured to create a traversable network uniquely associated with the geographic area. The traversable network comprises a set of nodes and arcs and further includes a set of two or more nodes comprising at least the potential delivery locations geographically located within the geographic area and all potential delivery locations included within the unique set of potential delivery locations created above. The processor is configured to calculate shortest path information from each of the potential delivery locations geographically located within the geographic area to every node contained within the traversable network, and select particular shortest path information and store the selected particular shortest path information for future lookup by a routing and scheduling system.

Another aspect of the present invention is a method for calculating and storing shortest path information between two or more potential delivery locations. This method comprises the steps of partitioning a delivery region into multiples of one or more discrete geographic areas. Each of the geographic areas includes a first set of one or more potential delivery locations. Another step is selecting a first geographic area and creating a corresponding unique second set of potential delivery locations for each potential delivery location geographically located within the selected geographic area. A traversable network is created that comprises a set of nodes and arcs and further includes a set of two or more nodes comprising at least the potential delivery location geographically located within the selected geographic area and all potential delivery locations included within the unique second set of potential delivery locations that correspond to the potential delivery locations geographically located within the selected geographic area. Shortest path information from the delivery location geographically located within the selected geographic area to every node contained within the traversable network is calculated and stored. The above steps are repeated as necessary for each potential delivery location geographically located within the selected geographic area, and for every geographic area created above.

These and other aspects of the present invention are described more fully herein.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. 1 illustrates a schematic diagram of a super matrix computer system according to one embodiment of the invention.;

FIG. 2 is a flowchart that illustrates various steps executed by a super matrix computer system according to one embodiment of the present invention;

FIG. 3 is a flowchart that illustrates various steps executed by a quad grid partitioning module according to one embodiment of the present invention;

FIG. 4 is a flowchart that illustrates various steps executed by an initial friends selection module according to one embodiment of the present invention;

FIG. 5 is a flowchart that illustrates various steps executed by a geo-balancing module according to one embodiment of the present invention;

FIG. 6 is a flowchart that illustrates various steps executed by a super matrix creation module according to one embodiment of the present invention;

FIG. 7 is a flowchart that illustrates additional steps executed by a super matrix creation module for calculating times/distances from each in-range depot to all in-grid, in-range locations, according to one embodiment of the present invention;

FIG. 8 (A) is a flowchart that illustrates various steps executed by a drop off handling module where time and distances are created using XY/ Pythagorean theorem calculations, according to one embodiment of the present invention;

FIG 8 (B) is a flowchart that illustrates various steps executed by a drop off handling module where times and distances are compiled through the creation of a "mini-travnet," according to one embodiment of the present invention;

FIG. 9 is a graphical representation of various unique delivery locations located within an exemplary delivery region and displayed by a visual display screen of a super matrix computer system according to one embodiment of the invention;

FIG. 10 illustrates the exemplary delivery region of FIG. 9 after 50 locations have been plotted;

FIG. 11 illustrates the exemplary delivery region of FIG. 9 after 501 locations have been processed;

FIG. 12 illustrates the exemplary delivery region of FIG. 9 after 1000 locations have been plotted;

FIG. 13 illustrates a close up view of the exemplary delivery region shown in FIG. 12; FIG. 14 illustrates the complete quad grid decomposition for the various delivery locations of FIG. 9;

FIG. 15 illustrates the quad grid decomposition of the highest density location grids after all of the various locations have been processed;

FIG. 16 illustrates one method of determining the order for processing delivery locations.;

FIG. 17 graphically illustrates the locations included within a particular origin location's friends list;

FIG. 18 is a graphical illustration of the steps performed by the geo-balancing module in a hypothetical case in which the maximum friends parameter is set at 2500;

FIG. 19 is a graphical illustration of an origin location's friend list, including locations that were added through geo-balancing;

FIG. 20 graphically illustrates a travnet according to one embodiment of the invention;

FIG. 21 illustrates an exemplary super matrix created from a hypothetical delivery region containing ten locations;

FIG. 22 graphically illustrates a travnet in which one location (location Z) is excluded from the grid containing locations A, B, and C; and

FIG. 23 graphically illustrates a "mini-travnet" created between locations C and Z of FIG. 22.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, this invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

As will be appreciated by one skilled in the art, the present invention may be embodied as a method, a data processing system, or a computer program product. Accordingly, the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment, or an embodiment combining software and hardware aspects. Furthermore, the present invention may take the form of a computer program product on a computer-readable storage medium having computer-readable program instructions (e.g., computer software) embodied in the storage medium. More particularly, the present invention may take the form of web-implemented computer software. Any suitable computer-readable storage medium may be utilized including hard disks, CD-ROMs, optical storage devices, or magnetic storage devices.

The present invention is described below with reference to block diagrams and flowchart illustrations of methods, apparatuses (i.e., systems) and computer program products according to an embodiment of the invention. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create a means for implementing the functions specified in the flowchart block or blocks.

These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including computer-readable instructions for implementing the function specified in the flowchart block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

Accordingly, blocks of the block diagrams and flowchart illustrations support combinations of means for performing the specified functions, combinations of steps for performing the specified functions and program instructions for performing the specified functions. It will also be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, can be implemented by special purpose hardware-based computer systems that perform the specified functions or steps, or combinations of special purpose hardware and computer instructions.

System Architecture

FIG. 1 illustrates a schematic diagram of a super matrix computer system **10** according to one embodiment of the invention. As may be understood from this figure, in this embodiment, the super matrix computer system **10** includes a processor **65** that communicates with other elements within the super matrix computer system **10** via a system interface or bus **90**. Also included in the super matrix computer system **10** is a display device/input device **70** for receiving and displaying data. This display device/input device **70** may be, for example, a touch screen monitor, a keyboard, or any other device known to those skilled in the art. The super matrix computer system **10** further includes memory **11**, which preferably includes both read only memory (ROM) **14** and random access memory (RAM) **12**. The server's ROM **14** is used to store a basic input/output system **85** (BIOS), containing the basic routines that help to transfer information between elements within the super matrix computer system **10**.

In addition, the super matrix computer system **10** includes at least one storage device **13** such as a hard disk drive, a floppy disk drive, a CD Rom drive, or optical disk drive, for storing information on various computer-readable media, such as a hard disk, a removable magnetic disk, or a CD-ROM disk. As will be appreciated by one of ordinary skill in the art, each of these storage devices is connected to the system bus **90** by an appropriate interface. The storage devices and their associated computer-readable media provide nonvolatile storage for a computer such as a personal computer. It is important to note that the computer-readable media described above could be replaced by any other type of computer-readable media known in the art. Such media include, for example, magnetic cassettes, flash memory cards, digital video disks, and Bernoulli cartridges.

A number of program modules may be stored by the various storage devices and within RAM **12**. Such program modules include an operating system **60**, a routing and scheduling module **800**, a quad grid partitioning module **100**, an initial friend selection module **200**, a geo-balancing module **300**, a super matrix creation module **500**, and a drop-off handling module **700**. The routing and scheduling module **800**, quad grid partitioning module **100**, initial friend selection module **200**, geo-balancing module **300**, super matrix creation module **500**, and drop-off Handling module **700** each control certain aspects of the operation of the super matrix computer system **10**, as is described in more detail below, with the assistance of the processor **65** and an operating system **60**.

Also located within the super matrix computer system **10** is a network interface **75**, for interfacing and communicating with other elements of a computer network **80**. Furthermore, one or more of the components may be combined, and additional components performing functions described herein may be included in the super matrix computer system **10**.

<u>Exemplary Flow of Super Matrix Computer System</u>

FIG. 2 depicts the exemplary flow of a super matrix computer system **10** according to one embodiment of the invention. As may be understood from this figure, the system begins at Step **15** by executing the quad grid partitioning module **100**. As discussed in greater detail below, the overall function of the quad grid partitioning module **100** according to one embodiment of the invention is to divide the overall delivery region into smaller and more manageable grids. Next, the system proceeds to Step **20** and selects a first grid (created by the quad grid partitioning module **100**) for processing. After a grid is selected, the super matrix computer system **10** executes the initial friend selection module **200** at Step **25** and then executes the geo-balancing module **300** at Step **30**. In various embodiments of the invention, the execution of the initial friend selection module **200** and geo-balancing module **300** results in the creation of individual friends lists for each location within the selected grid. As used in this application, the term "friends list" is used to define the set of locations that are most likely to appear on the same route as a particular location.

Next, the system proceeds to Step **50** where it executes the super matrix creation module **500**. Generally described, in certain embodiments of the invention, the super matrix creation module **500** creates a traversable network ("travnet") for the selected grid, calculates time/distance data from each in-grid location to every node within the travnet, and populates a super matrix containing time/distance data from each in-grid location to that location's friends and in-range depots, which are depositories for items to be delivered to the delivery locations.

Next, the system advances to Step **60**, where it determines whether any grids remain unprocessed. If so, the system advances to Step **70** where it selects the next grid for processing. If not, the system advances to Step **55**, where it competes processing.

Detailed Discussion of Various System Modules

The various modules referenced in FIG. 2 will now be described in greater detail.

Quad Grid Partitioning Module

FIG. 3 depicts a quad grid partitioning module **100** according to one embodiment of the invention. As may be understood from this figure, the system begins at Step **105** where a user (e.g., a routing and scheduling technician) defines a set of unique delivery locations within a designated delivery region. For example, for a particular day, the user may be responsible for routing and scheduling one or more delivery vehicles to 100 unique delivery locations (e.g., homes, apartments, or businesses). In this situation, the user would define the set of unique delivery locations at Step **105** to include these 100 unique locations.

After completing Step **105**, the system proceeds to Step **110** where it creates a first grid that contains all of the specified unique delivery locations. The initial grid is created by the system such that its geographic boundary encompasses the extent of all of the delivery locations within the delivery region. In another embodiment, the system allows the user to define the first grid's boundaries by presenting a map to the user (e.g., via a computer display screen) and allows the user to select or define the geographical area encompassed by the grid. For example, if all of the unique delivery locations were located in the State of California, the user could potentially set the first grid to include California and portions of surrounding states.

Next, at Step **120**, the system selects a first location for processing. At Step **130**, the system then adds the selected location to the grid that geographically contains the selected location. In one embodiment of the invention, adding (e.g., "plotting") the location to a grid requires location-specific data relating to the location's longitude and latitude coordinates. For example, for a first location located at 35° Latitude and 119° Longitude, the system would enter 35/119. In one embodiment, after the latitude/longitude data is entered, the system displays (e.g., via a computer display screen) a graphical representation of the selected location. For example, the selected location may be represented by an orange dot or some other symbol such as, for example, a "+.".

After the system plots the first location at Step **130**, the system determines (at Step **150**) whether the grid to which the location was added exceeds a pre-determined "maximum number of locations per grid" parameter. This "maximum number of locations per grid" parameter is pre-defined within the system. In one embodiment, the "maximum number of locations per grid parameter" is configurable and defined by the user. In other embodiments, the system includes a default value for the maximum number of locations per grid parameter. For example, the default "maximum number of locations per grid" parameter in one embodiment of the invention is 500.

If, at Step **150**, the system determines that the "maximum number of locations per grid" parameter is exceeded within any particular grid, the system proceeds to Step **170**, where the grid identified as having excess locations is partitioned into four equally sized grids. For example, in an embodiment of the invention where a grid is substantially square shaped, the grid is partitioned into four equally dimensioned grids that are also substantially square shaped. It is to be appreciated that partitioning the grid having excess locations into four equally-sized grids is one embodiment according to the present invention, and in other embodiments, the grid may be partitioned into other numbers of equally-sized grids such as, for example, two. For example, in an embodiment of the invention where a grid is substantially square shaped, the grid is partitioned into four equally dimensioned grids that are also substantially square shaped.

After the grid having excess locations is partitioned at Step **170**, the system proceeds to Step **160** and determines whether any unplotted delivery locations remain in the set of unique delivery locations.

Referring back to Step **150**, if the system determines that no grids include an excess number of locations, the system proceeds directly to Step **160**. If at Step **160**, the system determines that no unplotted delivery locations remain, the system proceeds to Step **180**, where it completes the quad grid partitioning module **100**. However, if additional unplotted delivery locations remain, the system proceeds to Step **140**, where it advances to process the next delivery location.

As shown in FIG. 3, in this embodiment, the system performs a continuous loop, in which the system determines whether any particular grid needs to be partitioned after each delivery location is plotted. The system repeats Steps **130**, **150**, **160**, and/or **170** until every delivery location in the set defined at Step **105** has been processed.

For illustrative purposes, FIGS. 9-15 graphically illustrate the steps performed by the quad grid partitioning module **100** in various embodiments of the invention. More particularly, FIGS. 9-15 illustrate a hypothetical example in which the system is to route and schedule delivery vehicles to various locations within a pre-determined set of 21,937 unique delivery locations. FIG. 9 shows a graphical representation of the 21,937 unique delivery locations. In this embodiment, the majority of delivery locations are located in the State of California. However, locations are also sporadically located in Washington, Idaho, Virginia and Texas. In this example, the "maximum number of delivery locations per grid" parameter is set at 500.

FIG. 10 illustrates the delivery region after 50 locations have been plotted. (Because FIG. 9 shows the entire delivery region, it is difficult to discern each of the 21,937 individual delivery locations.) As shown in this figure, the entire delivery region is included in a single grid **77**. FIG. 11 illustrates the delivery region after 501 locations have been plotted. Because the maximum number of locations per grid was set at 500, the grid is partitioned into four equally-sized grids following the plotting of the 501st location within the initial grid.

FIGS. 12 and 13 illustrate the delivery region after 1000 locations have been plotted. In this example, the highest density location grids are found in the Los Angeles area (See FIG. 13). FIG. 14 shows the complete quad grid decomposition for the 21,937 delivery locations. Finally, FIG. 15 illustrates the quad grid decomposition of the various highest density location grids after all 21,937 locations have been processed.

FIG. 16 illustrates one method of determining the order for processing delivery locations. In this embodiment, the locations are processed (e.g., selected at Steps **120** and **140** and plotted at Step **130**) based on their latitude and longitude coordinates. In this example, the set of locations having the smallest latitude value are processed first. The latitude value is determined by taking the absolute value of the location's latitude coordinate. In this embodiment, any set of locations having identical latitude values are processed in order of their respective longitude value, from smallest to largest. Therefore, the first location to be processed will be the location having the combination of the smallest latitude coordinate and the smallest longitude coordinate. FIG. 16 shows a particular example that includes 5 delivery locations. Locations 1 and 2 are processed first because they have the smallest latitude value. As between locations 1 and 2, location 1 is processed first because location 1 has the smallest longitude value. All five locations are processed one at a time according to the rules above until all locations within the set have been plotted.

Initial Friend Selection Module

After the quad grid partitioning module **100** has divided the overall delivery region into smaller and more manageable grids, the next objective of the super matrix computer system **10** is to compile individual friends lists for each unique delivery location. Returning briefly to FIG. 2, the system performs this process on a grid-by-grid basis by selecting a first grid at Step **20** and subsequently selecting one grid after another (Step **70**) until every grid has been processed.

FIG. 4 depicts an initial friend selection module **200** according to one embodiment of the invention. The initial friend selection module **200** begins at Step **205**, where a first in-grid origin location is selected for which to create an initial friends list. Once an origin location is selected at Step **205**, the system proceeds to Step **215** where it creates a list of all of the delivery locations that are within a pre-determined "maximum friend radius" of the selected origin location. In one embodiment, the maximum friend radius is a configurable parameter. At Step **218**, each location within the maximum friends radius is assigned a quadrant identifier, which may, for example, indicate the general direction a neighboring location is geographically located in relation to the origin location. In one embodiment, the area surrounding the selected origin location is divided into four separate and equal quadrants. As illustrated in FIG. 13, which will be discussed in greater detail below, the four quadrants are formed by two intersecting lines passing horizontally and vertically through the selected origin location. Returning to FIG. 4, at Step **220**, the system sorts the list compiled at Step **215** from the closest neighboring location to the selected origin location, to the most distant neighboring location from the selected origin location.

After the list has been sorted at Step **220**, the system proceeds to Step **225** where it selects the closest location to be a candidate for addition to the friends list. Once the candidate neighboring location has been selected, the system proceeds to Step **255** where it determines whether the addition of the candidate neighboring location to the origin location's friends list would exceed the "maximum number of friends" parameter. As with the maximum friends radius parameter described above, one embodiment of the invention includes a configurable "maximum number of friends" parameter. If at Step **255**, the maximum number of friends would not be exceeded with the addition of the candidate neighboring location, the system proceeds to Step **270** where it adds the neighboring location to the origin location's friends list.

After the neighboring location is added, the system proceeds to Step **227**, where it uses the neighboring location's quadrant identifier to increment a counter corresponding to the neighboring location's quadrant. In this embodiment, in which the area surrounding the origin location is divided into four quadrants, four distinct counters are used to track the number of friends. (The tally of the individual counters can be aggregated for purposes of determining whether the maximum number of friends has been exceeded at Step **255**. For example, in one embodiment, when the first candidate selected at Step 225 is processed, the counters would total zero neighbors. Assuming the maximum number of friends parameter is set at a number greater than zero, the first candidate will never exceed the maximum.) Next, at Step **227**, the counter associated with the added location's quadrant is incremented.

Next, the system advances to Step **230** where it determines whether any locations remain from the sorted list compiled at Step **220.** If so, the system proceeds to Step **245** where it selects the next closest location on the sorted list as a candidate for addition to the origin location's friends list. The system then repeats Steps **255, 270,** and **227** until either (1) the maximum number of friends parameter has been exceeded, or (2) all locations from the list compiled at Step **215** have been processed.

If the system determines, at Step **255**, that the maximum number of friends parameter would be exceeded with the addition of the candidate neighboring location, the system advances to Step **260** where it excludes the neighboring location from the friends list. The system then proceeds to Step **265** and adds all depots within the maximum depot radius of the selected in-grid origin location to the friends list. Next, at Step **235**, the system finalizes the initial friends list. When the initial friends list is finalized at Step **235**, the system proceeds to Step **280** where it determines whether any in-grid locations remain within the grid selected. If so, the system proceeds to Step **285** and selects a new in-grid location for processing. The system then advances to Step 215 and continues as described above until all in-grid locations have been processed.

FIG. 17 graphically illustrates the locations included within a particular origin location's friends list. In this hypothetical example, the "+" **1700** represents the origin location for which a friends list will be computed. The area bounded within the circle **1702** represents locations that were included within the origin location's friends list following the execution of the initial friend selection module **200** and includes locations added to the origin location's friends list following the execution of the geo-balancing module (discussed in greater detail below). The dots outside the circle **1702** represent delivery locations that are not included within the origin location's friends list.

Geo-Balancing Module

After creating the initial friends list for each in-grid location via the initial friends selection module **200**, the system's next objective is to avoid having friends lists that are overloaded with friends located in a highly populated area. For example, if a selected origin location is on the edge or outskirt of a city, a majority of the locations on the initial friends list might be located in the same general direction from the origin location (e.g., toward the city). In other words, the maximum number of friends parameter might be exceeded before locations in rural or sparsely populated areas can be included within the selected origin location's friends list.

Referring again to FIG. 2, through the execution of the geo-balancing module **300,** the system attempts to include locations from all areas surrounding the origin location within the friends list. As shown in FIG. 5, the geo-balancing module **300** begins at Step **305** with the selection of a first in-grid location. Next, at Step **310**, the system selects a first neighboring location from the list that was compiled at Step **215** of the initial friend selection module **200**. In one embodiment, the selection at Step **310** is based on the order in which the neighboring locations were sorted at Step **220** of the initial friends selection module **200**, (e.g., closest to farthest.) Once a neighboring location has been selected, the system proceeds to Step **315** where it determines the quadrant in which the selected neighboring location is geographically located. In one embodiment, the system uses the quadrant identifiers assigned at Step **218** of the initial friends selection module **200** to determine the selected neighboring location's quadrant location.

Next, at Step **320**, the system determines whether the quadrant containing the selected neighboring locations contain greater than or equal to one fourth the maximum number of friends parameter. For example, if the maximum number of friends parameter is set at 400 friends, then the system determines whether the selected quadrant contains 100 (400/4) or more friends. In one embodiment, the counters used to keep track of the maximum number of friends parameter in the initial friends selection module **200** are used to determine whether each quadrant contains greater than or equal to (maximum number of friends parameter)/4 friends, or just "maximum/4" friends. If the selected quadrant contains greater than or equal to maximum/4 friends, the system proceeds to Step **340**, where it excludes the neighboring location from the friends list.

Next, at Step **345**, the system determines whether the list compiled and sorted at Steps **215** and **220** from the initial friends selection module **200** contains any additional locations. If so, the system proceeds to Step **350**, where the next closest neighboring location is selected for processing and the above described steps are repeated.

If at Step **320**, the system determines that the quadrant containing the selected neighboring location has less than maximum/4 friends, the system proceeds to Step **325** where it adds the neighboring location to the origin location's friends list. Following the addition of the neighboring location to the friends list, the system advances to Step **330** where it increments the counter corresponding to the quadrant to which the added neighboring location was geographically located. In an embodiment in which the area surrounding the origin location is divided into four discrete quadrants, the system will utilize four different counters to track (or tally) the number of friends within each quadrant. For example, in one embodiment, when a neighboring location geographically located quadrant two is added to the friends list at Step **325**, the counter corresponding to quadrant two is incremented by one.

Following Step **330**, the system proceeds to Step **333**, where it determines whether the list compiled and sorted at Steps **215** and **220** from the initial friends selection module **200** contains additional locations. Also at Step **333**, the system determines whether any quadrants still need geo-balancing. If at Step **333**, the system determines that either (1) no quadrants need geo-balancing or (2) the list of locations within the maximum radius from the selected origin location is exhausted, the system proceeds to Step **355** where it finalizes the friends list for the selected in-grid location. Otherwise, the system proceeds to Step **335**, where it selects the next closest neighboring location within the maximum radius for processing. Once the system has and finalized the friends list for the selected in-grid location at Step **335**, the system advances to Step **360**, where it determines whether any unprocessed in-grid locations remain. If so, the system proceeds to Step **370** where it selects a new in-grid location for processing. Once all in-grid locations have been processed, the system advances to Step **375**, where it completes processing.

As stated above, FIG. 18 is a graphical illustration of the steps performed by the geo-balancing module **300** in a hypothetical case in which the maximum friends parameter is set to 2500. The point **1800** at which the vertical and horizontal lines intersect represents an in-grid location selected at either Step **301** or Step **370**. In this example, the two intersecting lines create four equally sized quadrants. The numbers 1500, 700, 200, and 100 represent the number of locations (from the friends list) that are geographically located within each quadrant and within the area encompassed by the inner circle **1802**. As such, the northeast quadrant contains 100 locations, the southeast quadrant contains 700 locations, the southwest quadrant contains 1500 locations, and the northwest quadrant contains 200.

As illustrated in FIG. 18, the quadrants containing 1500 and 700 friends dominate the friends list. In fact, 2200 out of the 2500 total friends are located in these two quadrants alone. In one embodiment, the geo-balancing module **300** attempts to balance the northwest and northeast quadrants of FIG. 18 by expanding the arcs **1804, 1806** within these quadrants and adding neighboring locations until each quadrant includes at least one fourth of the maximum friends parameter or until the list of neighboring locations within the maximum radius is exhausted, whichever comes first. In this example, neighboring locations located within the northwest and northeast quadrants will be added until each quadrant contains at least 625 friends. Ultimately, geo-balancing will expand the friends list from 2500 to 3450 locations, with 1500 friend in the southwest quadrant, 700 locations in the southeast quadrant, 625 locations in the northwest quadrant, and 625 locations in the northeast quadrant, assuming that the maximum area limitation (i.e., maximum radius) is not exceeded before 625 locations are found in each of the northwest an northeast quadrants.

FIG. 19 is a graphical illustration of an origin location's friend list, including locations that were added through geo-balancing. In this hypothetical example, the "+" **1900** represents the origin location for which a friends list will be computed. Locations shown within the first bounded area **1902** represent the set of friends determined by either the maximum number of friends parameter or the maximum radius. It is to be appreciated that both, the maximum friends parameter and the maximum radius are configurable parameters and in this hypothetical example of FIG. 19, the maximum friends parameter is set at 2500 and the maximum radius is 250 miles. Locations shown within the second bounded area **1904** represent the set of friends obtained using the geo-balancing module. In FIG. 19, the second bounded area, 1904, represent locations added to the upper left and upper right quadrants of the coordinate system formed with the center at the "plus sign" (the origin location). No locations are added in the lower left and right, because these quadrants are already fully represented in the friends list (initial friends selection). If not for geo-balancing, a super matrix for the origin location

1900 would likely include only times and distances to locations in the highly dense area proximal to the origin location **1900**, but not the sparser outlying locations within the second bounded area **1904**.

Super Matrix Creation Module

Referring again to FIG. 2, the super matrix computer system **10** executes the super matrix creation module **500** following the execution of the geo-balancing module **300**. As shown in FIG. 6, the super matrix creation module **500** begins at Step **505**, with the creation of a travnet derived from (1) all in-grid locations, (2) all friends of any in-grid location, and (3) any in-range depots. In various embodiments, a "travnet" is a set of arcs and nodes. More specifically, in this embodiment, the set of nodes includes a set of "travnet locations" comprising all in-grid locations, all friends of in-grid locations, and all depots within the maximum radius of any in-grid location. The travnet's arcs include all "necessary" street segments that connect the travnet locations listed above. In addition, intersecting street segments connecting travnet locations are also included within the set of nodes. The set of arcs includes a combination of local roads, secondary roads, and interstate/primary roads.

In one embodiment, the total number of street segments (which may be represented by one or more arcs) is reduced via a reduction in the amount of local roads used to connect travnet locations. The reduction of local roads is accomplished by connecting travnet locations using mainly secondary or interstate/primary roads. In this embodiment, local roads are used only to the extent that they connect a travnet location to a secondary road or interstate. By reducing the number of local road (and total street segments) included with the travnet, the total number of arcs and nodes are reduced. Because the processing time required to perform shortest path computation is based principally on the number of arcs and nodes, reducing the number of street segments ultimately reduces the time required to compute the shortest path between travnet locations. A travnet maybe derived from existing map data, available from a variety of third party sources.

FIG. 20 graphically illustrates a travnet according to one embodiment of the invention in which a grid contains three in-grid locations (Loc A **2002**, Loc B **2004**, and Loc C **2006**). Each in-grid location is a friend of the other two in-grid locations as well as location Loc D **2008**. In this hypothetical example, the maximum number of friends is set to three. Therefore, location A's **2002** friends list includes B **2004**, C **2006**, and D **2008**; location B's **2004** friends list includes A **2002**, C **2006**, and D **2008**; and location C's **2006** friends list includes locations A **2002**, B **2004**, and D **2008**. Finally, Depot 1 **2010** is within the maximum depot radius of A **2002**, B **2004**, and C **2006**. Under this example, the travnet locations include A **2002**, B **2004**, and C **2006** (the in-grid locations), D **2008** (a friend of an in-grid location) and Depot 1 **2010** (a depot within the maximum radius of an in-grid location).

Using these travnet locations, a travnet is derived (using map data known in the art) which comprises connected arcs/nodes of the local roads that surround each travnet location, the arcs/nodes of surrounding secondary roads, and finally, arcs/nodes corresponding to interstate and primary roads.

Returning to FIG. 6, once the travnet for a selected grid has been created, the system advances to Step **510**, where it selects a first in-grid location for processing. Next, at Step **515**, the system calculates the shortest times and distances from the selected in-grid location to every node within the travnet. As stated above, in various embodiments, the travnet nodes include not only the in-grid locations, friends, and depots, but also street intersections that connect the in-grid locations, friends, and depots. The algorithms used to calculate the shortest times and distances are well known within the art.

Once times and distances from the selected in-grid location to every node has been calculated, the system proceeds to Step **520**, where it selectively picks off certain times and distances. The times and distances that are picked off include the time/distances from the selected in-grid location to that location's friends. Next, at Step **525**, the times and distances picked off at Step **520** are populated as a row of a super matrix. One embodiment of a super matrix is show in FIG. 21, described in greater detail below.

Once the times and distances from the selected in-grid location to that location's friends are populated into a row of a super matrix, the system advances to Step **530** where it determines whether any in-grid locations remain unprocessed. If so, the system selects a next in-grid location (at Step **545**) for processing. As illustrated in FIG. 21, each in-grid location corresponds to a specific row of the super matrix. Rows representing each in-grid location are continually added until all in-grid locations have been processed. Once all in-grid locations have been processed, the system advances to Step **570**, where it finishes processing.

FIG. 7 illustrates additional steps performed by the super matrix creation module **500.** In addition to calculating time and distance data between in-grid locations and locations included within friends list, in various embodiments, the super matrix creation module **500** is also designed to process shortest path times and distances from every depot located within a grid's travnet to all other in-grid, in-range locations and in-range depots. Much like the process described in FIG. 6, the system beings at Step **550** by selecting a first in-range depot. Next, at Step **555**, the system calculates shortest path computations (using known shortest path algorithms) from the selected depot to every node within the travnet. Following Step **555**, the system proceeds to Step **560**, where selected data corresponding to the times and distances from the selected depot to all in-grid, in-range locations and in-range depots are populated within the super matrix at Step **565**. As shown in FIG. 21, each selected depot is represented by a single row within the super matrix. At Step **575**, the system determines if any unprocessed depots (within the travnet) remain. If so, the system selects a next depot (at Step **580**) and repeats Steps **555**, **560**, and **565.** Once all depots within the grid's travnet have been processed, the system advances to Step **585**, where it completes processing.

As stated above, FIG. 21 illustrates a sample super matrix. The super matrix as shown in FIG. 21 is derived from a group of 9 locations and 1 location/depot. In this hypothetical, the maximum number of friends parameter is set at four. However, as a result of geo-balancing, many locations have more than four friends (e.g., locations 3, 5, 6, 7, 8, and 9). As illustrated by FIG. 21, Row #1 contains times and distances from Location #1 to four different locations. As shown in FIG. 21, each column represents a different location. The location is identified, in this embodiment, using latitude (in millionths of degrees), and longitude (in millionths of degrees) coordinates. Following the latitude and longitude coordinates are time and distance data. In this embodiment, time is shown in seconds and distance in 100ths of a mile. Therefore, referring now Row 1 of FIG. 21, the time/distance from location 1 to the location geographically located at 30180600, -81551600 is 303 seconds (time) and 3 hundredths of a mile (distance). As illustrated in Row 4, location 4 is also a depot and therefore has time/distance data for each in-range location. In this hypothetical, because all nine locations are in-range of the depot, Row 4 has time/distance data to all nine locations.

As illustrated in FIG. 21, in various embodiments, the super matrix does not contain times and distances from each location to every other location. Instead, in such embodiments, the super matrix only contains time and distance data from each in-grid location to that location's friends, including all in-range depots.

Drop-Off Handling Module

In some instances, the algorithms performed within the routing and scheduling algorithm **800** may require time and distance data between two locations that were not included within each other's friends lists. As a result, the super matrix will not contain time and distance data. When such an event occurs, the system may compute time and distance data by executing a drop-off handling module **700**.

FIGS. 8 (A) and 8 (B) depict two different drop-off handling modules **700** according to various embodiments of the invention. Referring now to FIG. 8 (A), the drop-off handling module **700** begins at Step **705** where the system receives a call from a Routing/Scheduling module **800** requesting time and/or distance data between locations A & B. At Step **710**, the system determines whether the super matrix contains time/distance data from A to B. If so, the system advances to Step **715** where it provides the Routing/Scheduling module **800** with data contained in the super matrix. However, if the super matrix does not contain time/distance data from A to B, the system proceeds to Step **720** where it computes the time and distance from A to B using XY distance computation (e.g., using the Pythagorean theorem). Once the time/distance data is determined at Step **720**, the system sends the data to the Routing/Scheduling module **800** and advances to Step **735**, where the processing ends.

In the embodiment depicted in FIG. 8 (B), the drop-off handling module **700** begins by performing the same basic steps shown in FIG. 8 (A). For example, at Step **705** the system receives a call from a Routing/Scheduling module **800** requesting time and/or distance data between locations A & B. At Step **710**, the system determines whether the super matrix contains time/distance data from A to B. If so, the system advanced to Step **715** where it provides the Routing/Scheduling module **800** with data contained in the super matrix.

However, if the super matrix does not contain time/distance data from A to B, the system proceeds to Step **725** where it creates a "mini-travnet" connecting locations A & B. Following the creation of the mini-travnet, the system performs shortest path time and distance calculations between A & B. At Step **740**, the time and distance data is saved (e.g., cached) for future lookup.

FIGS. 22 and 23 illustrate a scenario in which the time and distance from one location to another is calculated using the drop-off handling module **700** of FIG. 8 (B). This scenario assumes that during the quad grid partitioning module **100**, locations A, B, and C were placed in one grid, illustrated in FIG. 22. In addition, the maximum number of friends parameter is set at two. Following the execution of the initial friends selection module **200** and the geo-balancing module **300**, locations A, B, and C only include each other as friends. For example, location A's friends are B and C, location B's friends are A and C and location C's friends are A and B. This hypothetical does not include depots. When the travnet for this particular grid is created, it will only include street networks that connect locations A, B, and C. Therefore, the super matrix will not include time and distance data from either A, B, or C to location Z.

Assume that later, after the super matrix has been created, a user creates a route consisting of locations A, B, and C. For this route, regardless of sequence, the super matrix can provide street network times and distances, because the super matrix contains time/distances between any two locations. Now assume that the route sequence is A - B - C, and that the user then decides that they want stop Z to be placed after stop C, making the route A – B – C – Z. However, we now have a situation where the super matrix does not provide a time and distance between C and Z. When such a situation occurs, the drop-off handling module **700** provides real-time time/distance calculations by first creating a "mini-travnet", illustrated in FIG. 23, connecting locations C and Z. From this "mini-travnet," the system computes the shortest path time and distance between C and Z. (This time and distance is then cached so that the "mini-travnet" does not have to be recreated and times / distances recomputed, in the event the system needs the time/distance between C and Z again during the same routing session).

Conclusion

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

THAT WHICH IS CLAIMED:

1. A computer program product for controlling a computing device having at least a memory, a processor and a display device, the computer program product is for calculating and storing shortest path information between two or more delivery locations, and comprises a computer-readable storage medium having computer-readable program code portions stored therein, said computer-readable program code portions comprising:

a first executable portion comprising a grid partitioning module that is executable on said processor, wherein said grid partitioning module divides an overall delivery region into multiples of a defined number of grids and said two or more delivery locations are located within at least one of said defined number of grids;

a second executable portion comprising an initial friend selection module that is executable on said processor, wherein one of said defined number of grids is selected and for each particular delivery location within said selected grid a friends list is created, said friends list is comprised of a set of delivery locations that are most likely to appear on the same route as said particular delivery location; and

a third executable portion comprising a super matrix creation module that is executable on said processor, wherein said super matrix creation module creates a traversable network comprised of nodes and arcs for the selected grid, calculates time/distance data from each delivery location within said selected grid to every node within the traversable network, and populates a super matrix containing time/distance data from each particular delivery location within the selected grid to each delivery location in that location's friends list and any in-range depots.

2. The computer program product of claim 1, further comprising:

a fourth executable portion comprising a geo-balancing module that is executable on said processor, wherein said geo-balancing module balances each delivery location's said friends list by selecting each delivery location, dividing the delivery region about the selected delivery location into four quadrants such that the selected delivery location forms an origin for the four quadrants and expanding an arc in each of the four quadrants equidistant from the origin to form a bounded substantially circular area about the origin until a defined number of delivery locations in said selected delivery location's friends list are located within said bounded substantially circular area, determining the number of delivery locations in said selected delivery location's friends list that are in each quadrant, and if said number of delivery locations in said selected delivery location's friends list is less than a ((defined number of delivery locations in said selected delivery location's friend list)/4) in any quadrant then marking such quadrant as a deficient quadrant and expanding the arc in any deficient quadrant until at least the ((defined number of delivery locations in said selected deliver location's friend list)/4) delivery locations that are in the selected delivery location's friends list are contained within the are bounded by the arc and axes forming the quadrant, or until a maximum distance from the origin is achieved.

3. The computer program of claim 2, wherein said ((defined number of delivery locations in said selected delivery location's friend list)/4) is 625 and said maximum distance from the origin is 250 miles.

4. A system for delivering items to two or more delivery locations comprising:

a delivery vehicle capable of transporting one or more items for delivery at each of said two or more delivery locations, wherein said one or more items for delivery are obtained at a depot;

a computer program product for controlling a computing device having at least a memory, a processor and a display device, the computer program product is for calculating and storing shortest path information between said two or more delivery locations, and comprises a computer-readable storage medium having computer-readable program code portions stored therein, said computer-readable program code portions comprising:

a first executable portion comprising a grid partitioning module that is executable on said processor, wherein said grid partitioning module divides an overall delivery region into multiples of a defined number of grids and said two or more delivery locations are located within at least one of said defined number of grids;

a second executable portion comprising an initial friend selection module that is executable on said processor, wherein one of said defined number of grids is selected and for each particular delivery location within said selected grid a friends list is created, said friends list is comprised of a set of delivery locations that are most likely to appear on the same route as said particular delivery location; and

a third executable portion comprising a super matrix creation module that is executable on said processor, wherein said super matrix creation module creates a traversable network comprised of nodes and arcs for the selected grid, calculates time/distance data from each delivery location within said selected grid to every node within the traversable network, and populates a super matrix containing time/distance data from each particular delivery location within the selected grid to each delivery location in that location's friends list and any in-range depots,

wherein said delivery vehicle utilizes said shortest path information in determining a route for obtaining said one or more items for delivery at each of said two or more delivery locations and transporting said one or more items for delivery at each of said two or more delivery locations to each delivery location.

5. The system of claim 4, wherein said computer program product is further comprised of:

a fourth executable portion comprising a geo-balancing module that is executable on said processor, wherein said geo-balancing module balances each delivery location's said friends list by selecting each delivery location, dividing the delivery region about the selected delivery location into four quadrants such that the selected delivery location forms an origin for the four quadrants and expanding an arc in each of the four quadrants equidistant from the origin to form a bounded substantially circular area about the origin until a defined number of delivery locations in said selected delivery location's friends list are located within said bounded substantially circular area, determining the number of delivery locations in said selected delivery location's friends list that are in each quadrant, and if said number of delivery locations in said selected delivery location's friends list is less than a ((defined number of delivery locations in said selected delivery location's friend list)/4) in any quadrant then marking such quadrant as a deficient quadrant and expanding the arc in any deficient quadrant until at least the ((defined number of delivery locations in said selected deliver location's friend list)/4) delivery locations that are in the selected delivery location's friends list are contained within the are bounded by the arc and axes forming the quadrant, or until a maximum distance from the origin is achieved.

6. The system of claim 5, wherein said ((defined number of delivery locations in said selected delivery location's friend list)/4) is 625 and said maximum distance from the origin is 250 miles.

7. A computer system for calculating and storing shortest path information between two or more potential delivery locations, wherein said computer system comprises:

a processor configured to;

(1) partition a delivery region into multiples of one or more discrete geographic areas, wherein each of the geographic areas includes a first set of one or more potential delivery locations;

(2) select a first geographic area;

(3) create a unique second set of potential delivery locations for each of said first set of one or more potential delivery locations;

(4) create a traversable network, wherein the traversable network comprises a set of nodes and arcs and further includes a set of two or more nodes comprising at least the potential delivery locations geographically located within the first geographic area and all potential delivery locations included within any of the unique second sets of potential delivery locations created at Step (3);

(5) calculate shortest path information from each of the potential delivery locations geographically located within the first geographic area to every node contained within the traversable network;

(6) select particular shortest path information and store the particular shortest path information for future lookup by a routing and scheduling system.

8. The system of claim 7, wherein the traversable network includes at least one node that corresponds to a depot.

9. The system of claim 7, wherein creating a unique second set of potential delivery locations for each potential delivery location geographically located within the first geographic area further comprises:

balancing the unique second set of potential delivery locations for each potential delivery location in said first set of one or more deliver locations by selecting each potential delivery location in said first set of one or more delivery locations, dividing the delivery region about the selected delivery location into four quadrants such that the selected delivery location forms an origin for the four quadrants and expanding an arc in each of the four quadrants equidistant from the origin to form a bounded substantially circular area about the origin until a defined number of second set of potential delivery locations for said selected delivery location are located within said bounded substantially circular area, determining the number of delivery locations in said selected delivery location's second set of potential delivery locations that are in each quadrant, and if said number of delivery locations in said selected delivery location's second set of potential delivery locations is less than a ((defined number of delivery locations in said selected deliver location's second set of potential delivery locations)/4) in any quadrant marking such quadrant as a deficient quadrant, and expanding the arc in any deficient quadrant until at least the ((defined number of delivery locations in said selected deliver location's second set of potential delivery locations)/4) delivery locations that are in the selected delivery location's second set of potential delivery locations are contained within the area bounded by the arc and axes forming the quadrant or until a maximum distance from the origin is achieved.

10. The system of claim 9, wherein said ((defined number of delivery locations in said selected delivery location's friend list)/4) is 625 and said maximum distance from the origin is 250 miles.

11. A computer system for calculating and storing shortest path information between two or more potential delivery locations, wherein said computer system comprises:

a processor configured to;

(1) create a unique set of potential delivery locations for each potential delivery location geographically located within a geographic area;

(2) create a traversable network uniquely associated with the geographic area, wherein the traversable network comprises a set of nodes and arcs and further includes a set of two or more nodes comprising at least the potential delivery locations geographically located within the geographic area and all potential delivery locations included within the unique set of potential delivery locations created at Step (1);

(3) calculate shortest path information from each of the potential delivery locations geographically located within the geographic area to every node contained within the traversable network;

(4) select particular shortest path information and store the selected particular shortest path information for future lookup by a routing and scheduling system.

12. The system of claim 11, wherein the traversable network includes at least one node that corresponds to a depot.

13. A method for calculating and storing shortest path information between two or more potential delivery locations comprising the steps of:

(A) partitioning a delivery region into multiples of one or more discrete geographic areas, wherein each of the geographic areas includes a first set of one or more potential delivery locations;

(B) electing a first geographic area;

(C) creating a corresponding unique second set of potential delivery locations for each potential delivery location geographically located within the selected geographic area;

(D) creating a traversable network, wherein the traversable network comprises a set of nodes and arcs and further includes a set of two or more nodes comprising at least the potential delivery location geographically located within the selected geographic area and all potential delivery locations included within the unique second set of potential delivery locations that correspond to the potential delivery locations geographically located within the selected geographic area;

(E) calculating shortest path information from the delivery location geographically located within the selected geographic area to every node contained within the traversable network;

(F) selecting particular shortest path information and storing the selected particular shortest path information for future lookup by a routing and scheduling system;

(G) repeating steps (D) through (F) for each potential delivery location geographically located within the selected geographic area; and

(H) repeating steps (B) through (G) for every geographic area created at step (A).

14. The method of claim 13, wherein creating a traversable network comprises creating a traversable network that includes at least one node that corresponds to a depot.

15. The method of claim 13, wherein creating a corresponding unique second set of potential delivery locations for each potential delivery location geographically located within the first geographic area further comprises balancing the unique second set of potential delivery locations for each potential delivery location geographically located within the first geographic area by selecting each potential delivery location in said first set of one or more delivery locations, dividing the delivery region about the selected delivery location into four quadrants such that the selected delivery location forms an origin for the four quadrants and expanding an arc in each of the four quadrants equidistant from the origin to form a bounded substantially circular area about the origin until a defined number of second set of potential delivery locations for said selected delivery location are located within said bounded substantially circular area, determining the number of delivery locations in said selected delivery location's second set of potential delivery locations that are in each quadrant, and if said number of delivery locations in said selected delivery location's second set of potential delivery locations is less than a ((defined number of delivery locations in said selected deliver location's second set of potential delivery locations)/4) in any quadrant marking such quadrant as a deficient quadrant, and expanding the arc in any deficient quadrant until at least the ((defined number of delivery locations in said selected deliver location's second set of potential delivery locations)/4) delivery locations that are in the selected delivery location's second set of potential delivery

locations are contained within the area bounded by the arc and axes forming the quadrant or until a maximum distance from the origin is achieved.

16. The method of claim 15, wherein said ((defined number of delivery locations in said selected delivery location's friend list)/4) is 625 and said maximum distance from the origin is 250 miles.

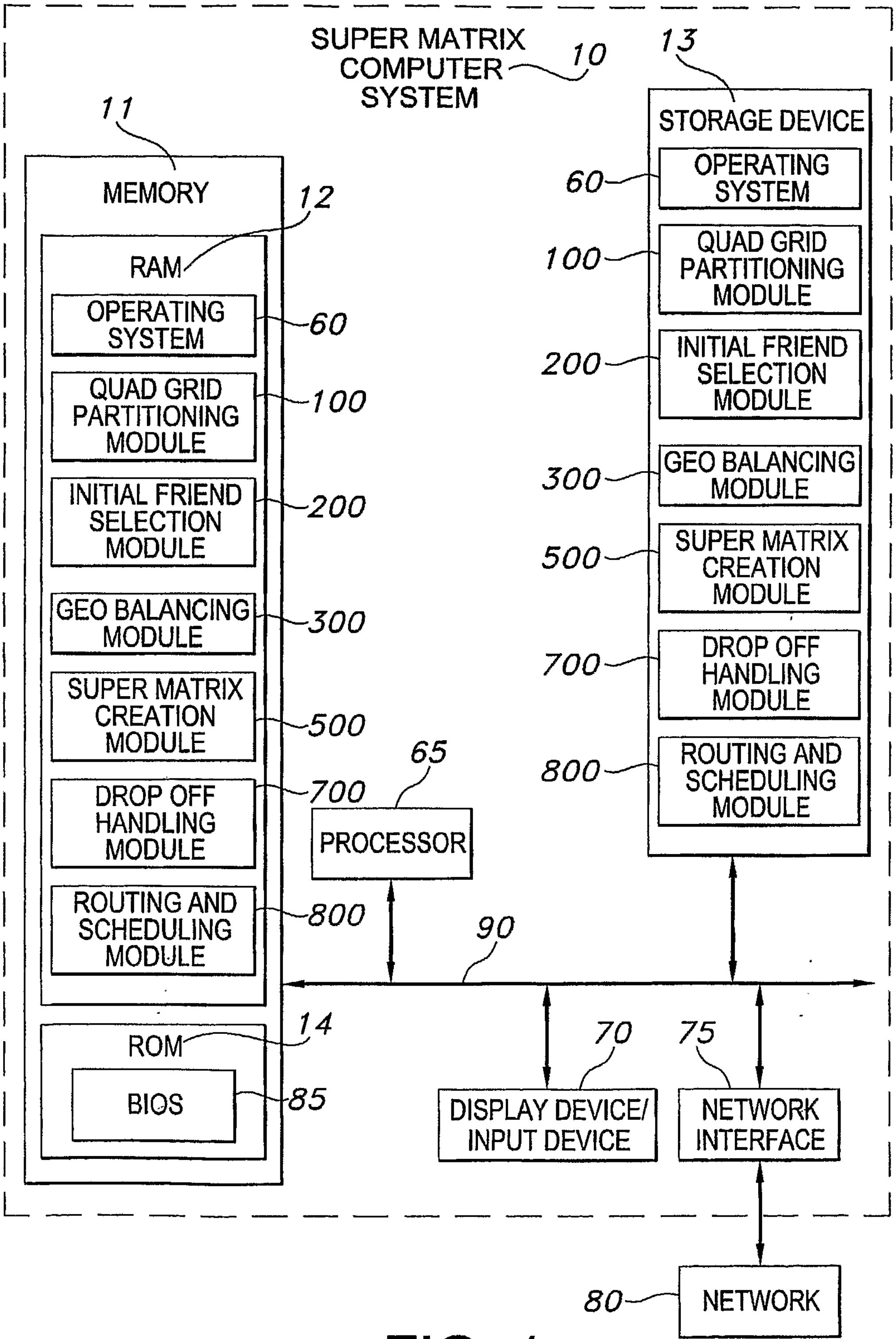

SUPER MATRIX COMPUTER SYSTEM
10
11
MEMORY
12
RAM
OPERATING SYSTEM
60
QUAD GRID PARTITIONING MODULE
100
INITIAL FRIEND SELECTION MODULE
200
GEO BALANCING MODULE
300
SUPER MATRIX CREATION MODULE
500
DROP OFF HANDLING MODULE
700
ROUTING AND SCHEDULING MODULE
800
14
ROM
BIOS
85
65
PROCESSOR
90
13
STORAGE DEVICE
OPERATING SYSTEM
60
QUAD GRID PARTITIONING MODULE
100
INITIAL FRIEND SELECTION MODULE
200
GEO BALANCING MODULE
300
SUPER MATRIX CREATION MODULE
500
DROP OFF HANDLING MODULE
700
ROUTING AND SCHEDULING MODULE
800
70
DISPLAY DEVICE/ INPUT DEVICE
75
NETWORK INTERFACE
80
NETWORK

FIG. 1

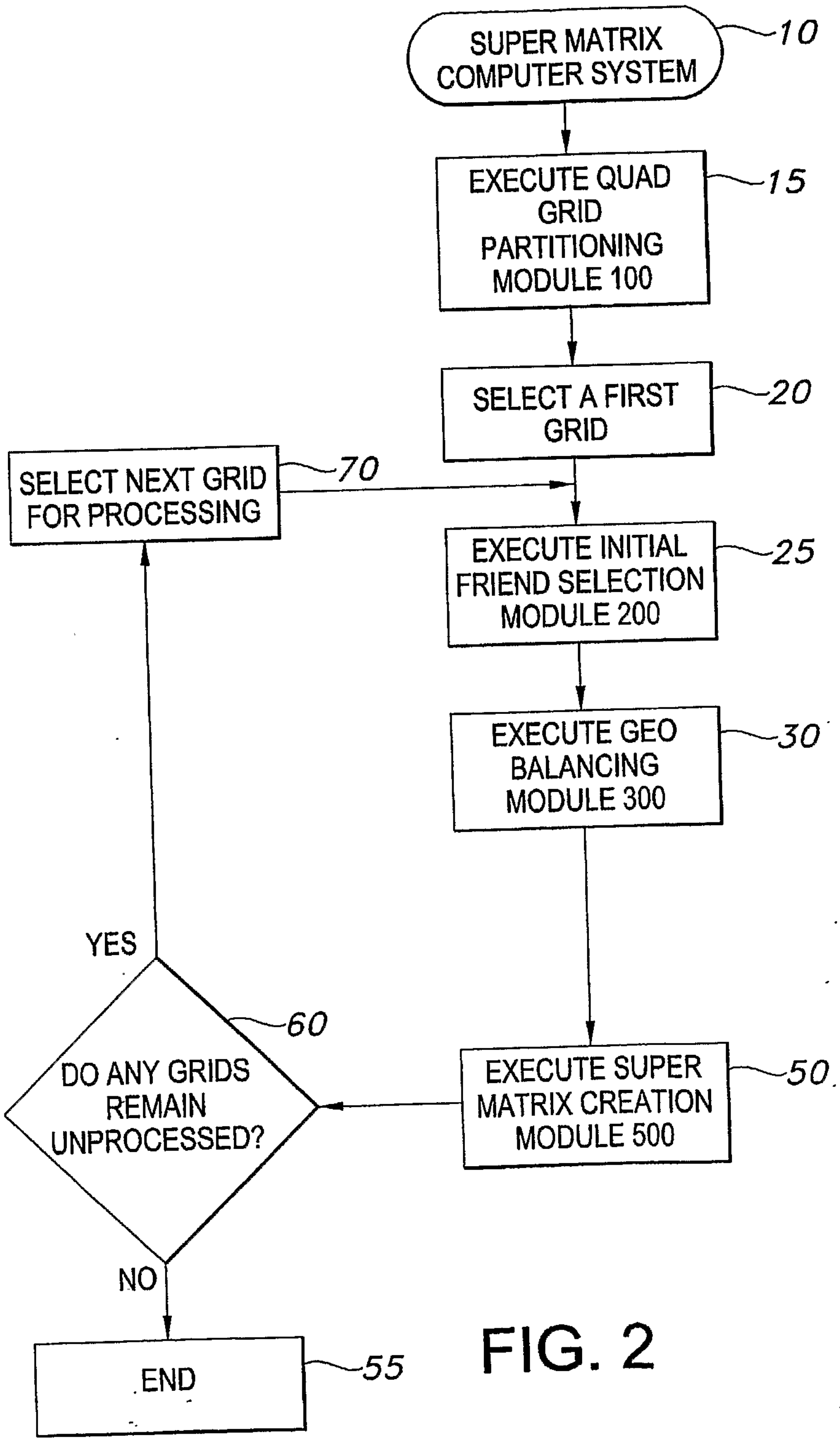

SUPER MATRIX COMPUTER SYSTEM
10
EXECUTE QUAD GRID PARTITIONING MODULE 100
15
SELECT A FIRST GRID
20
SELECT NEXT GRID FOR PROCESSING
70
EXECUTE INITIAL FRIEND SELECTION MODULE 200
25
EXECUTE GEO BALANCING MODULE 300
30
YES
DO ANY GRIDS REMAIN UNPROCESSED?
60
EXECUTE SUPER MATRIX CREATION MODULE 500
50
NO
END
55

FIG. 2

3/24

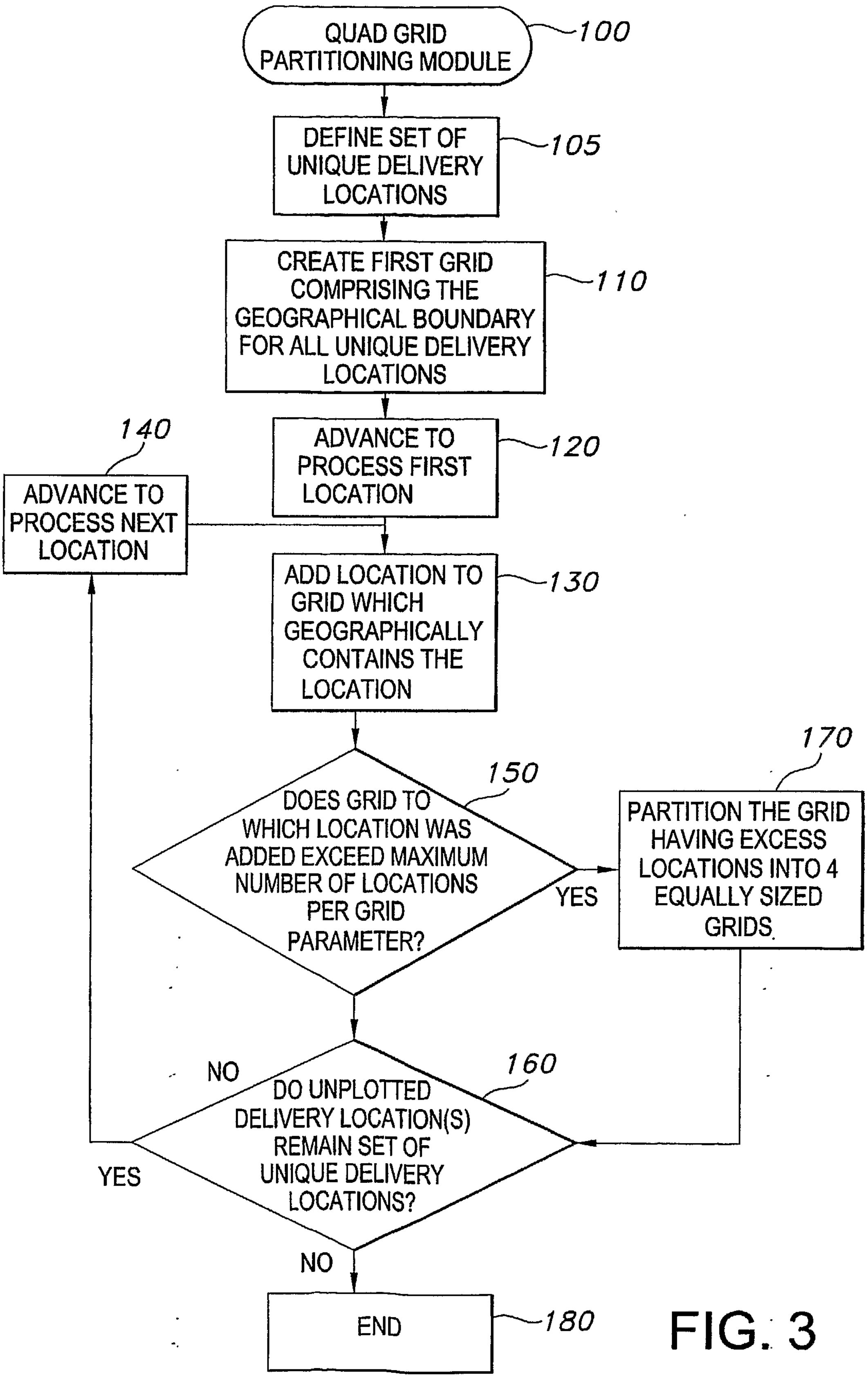

QUAD GRID PARTITIONING MODULE
100
DEFINE SET OF UNIQUE DELIVERY LOCATIONS
105
CREATE FIRST GRID COMPRISING THE GEOGRAPHICAL BOUNDARY FOR ALL UNIQUE DELIVERY LOCATIONS
110
ADVANCE TO PROCESS FIRST LOCATION
120
140
ADVANCE TO PROCESS NEXT LOCATION
ADD LOCATION TO GRID WHICH GEOGRAPHICALLY CONTAINS THE LOCATION
130
DOES GRID TO WHICH LOCATION WAS ADDED EXCEED MAXIMUM NUMBER OF LOCATIONS PER GRID PARAMETER?
150
YES
170
PARTITION THE GRID HAVING EXCESS LOCATIONS INTO 4 EQUALLY SIZED GRIDS
NO
DO UNPLOTTED DELIVERY LOCATION(S) REMAIN SET OF UNIQUE DELIVERY LOCATIONS?
160
YES
NO
END
180

FIG. 3

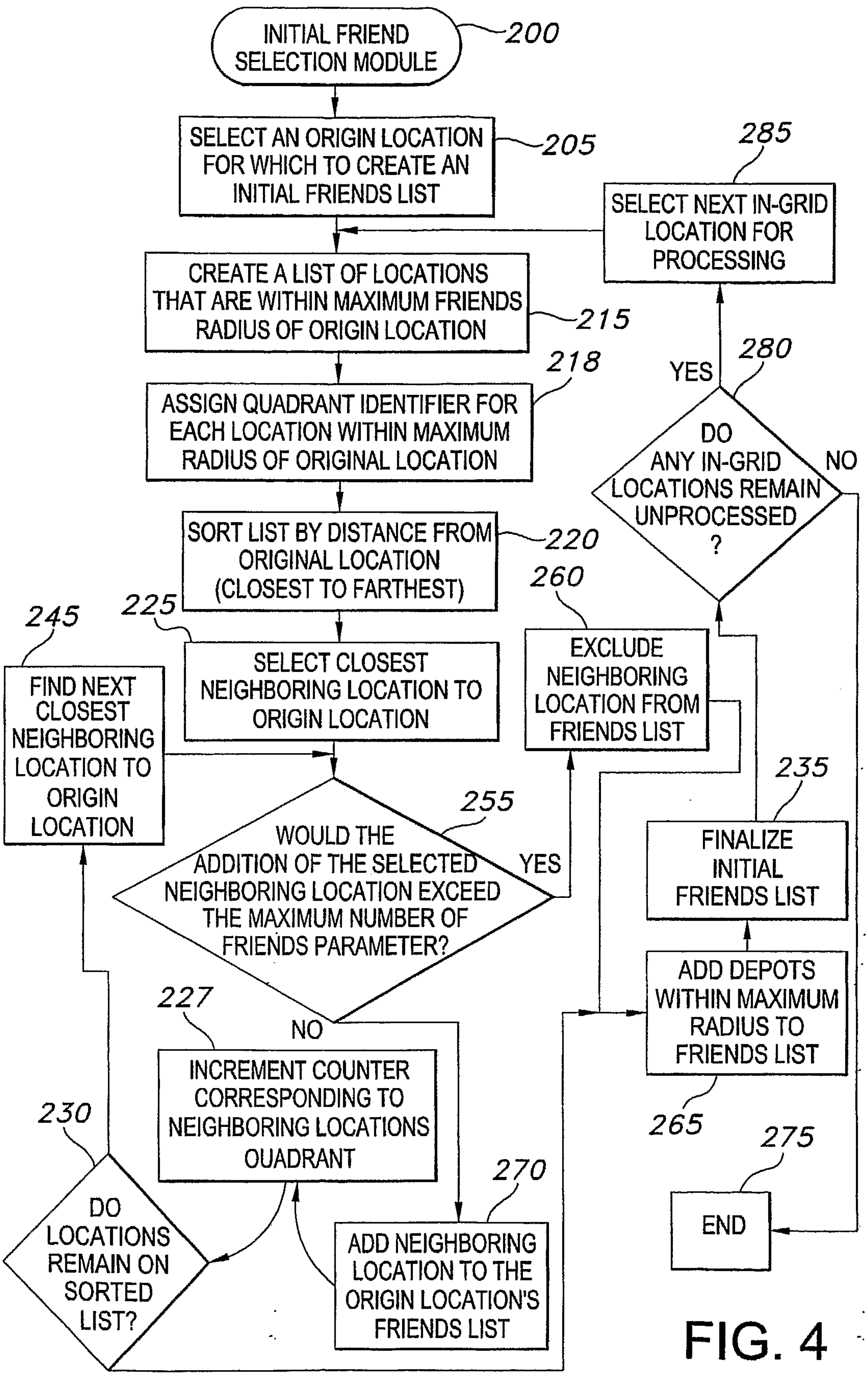

INITIAL FRIEND SELECTION MODULE
200
SELECT AN ORIGIN LOCATION FOR WHICH TO CREATE AN INITIAL FRIENDS LIST
205
CREATE A LIST OF LOCATIONS THAT ARE WITHIN MAXIMUM FRIENDS RADIUS OF ORIGIN LOCATION
215
ASSIGN QUADRANT IDENTIFIER FOR EACH LOCATION WITHIN MAXIMUM RADIUS OF ORIGINAL LOCATION
218
SORT LIST BY DISTANCE FROM ORIGINAL LOCATION (CLOSEST TO FARTHEST)
220
SELECT CLOSEST NEIGHBORING LOCATION TO ORIGIN LOCATION
225
FIND NEXT CLOSEST NEIGHBORING LOCATION TO ORIGIN LOCATION
245
WOULD THE ADDITION OF THE SELECTED NEIGHBORING LOCATION EXCEED THE MAXIMUM NUMBER OF FRIENDS PARAMETER?
255
YES
NO
EXCLUDE NEIGHBORING LOCATION FROM FRIENDS LIST
260
INCREMENT COUNTER CORRESPONDING TO NEIGHBORING LOCATIONS QUADRANT
227
DO LOCATIONS REMAIN ON SORTED LIST?
230
ADD NEIGHBORING LOCATION TO THE ORIGIN LOCATION'S FRIENDS LIST
270
SELECT NEXT IN-GRID LOCATION FOR PROCESSING
285
DO ANY IN-GRID LOCATIONS REMAIN UNPROCESSED ?
280
YES
NO
FINALIZE INITIAL FRIENDS LIST
235
ADD DEPOTS WITHIN MAXIMUM RADIUS TO FRIENDS LIST
265
END
275

FIG. 4

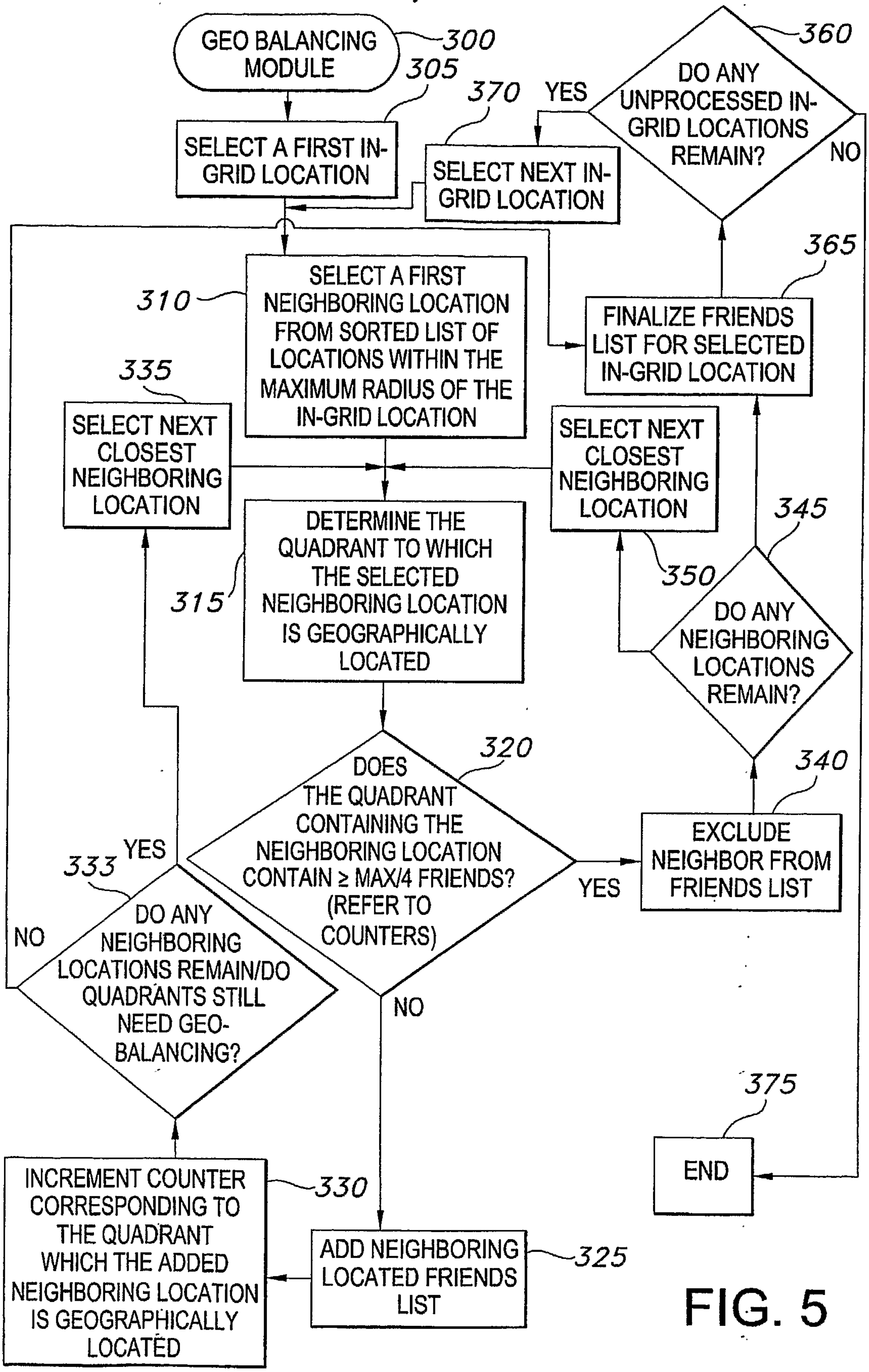

GEO BALANCING MODULE
300
305
SELECT A FIRST IN-GRID LOCATION
370
YES
SELECT NEXT IN-GRID LOCATION
360
DO ANY UNPROCESSED IN-GRID LOCATIONS REMAIN?
NO
365
310
SELECT A FIRST NEIGHBORING LOCATION FROM SORTED LIST OF LOCATIONS WITHIN THE MAXIMUM RADIUS OF THE IN-GRID LOCATION
FINALIZE FRIENDS LIST FOR SELECTED IN-GRID LOCATION
335
SELECT NEXT CLOSEST NEIGHBORING LOCATION
SELECT NEXT CLOSEST NEIGHBORING LOCATION
345
315
DETERMINE THE QUADRANT TO WHICH THE SELECTED NEIGHBORING LOCATION IS GEOGRAPHICALLY LOCATED
350
DO ANY NEIGHBORING LOCATIONS REMAIN?
320
340
DOES THE QUADRANT CONTAINING THE NEIGHBORING LOCATION CONTAIN ≥ MAX/4 FRIENDS? (REFER TO COUNTERS)
YES
EXCLUDE NEIGHBOR FROM FRIENDS LIST
333
YES
NO
DO ANY NEIGHBORING LOCATIONS REMAIN/DO QUADRANTS STILL NEED GEO-BALANCING?
NO
375
END
INCREMENT COUNTER CORRESPONDING TO THE QUADRANT WHICH THE ADDED NEIGHBORING LOCATION IS GEOGRAPHICALLY LOCATED
330
ADD NEIGHBORING LOCATED FRIENDS LIST
325

FIG. 5

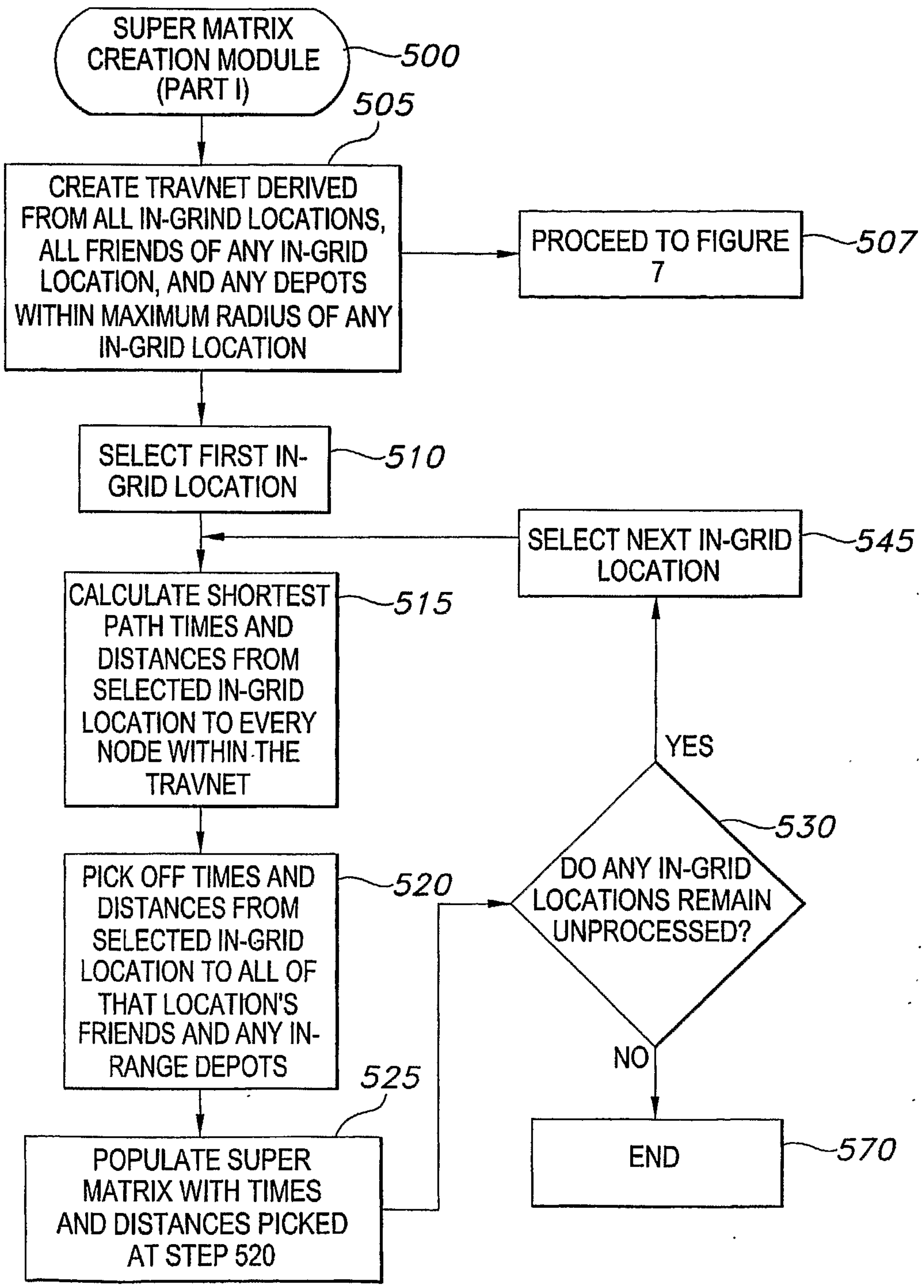
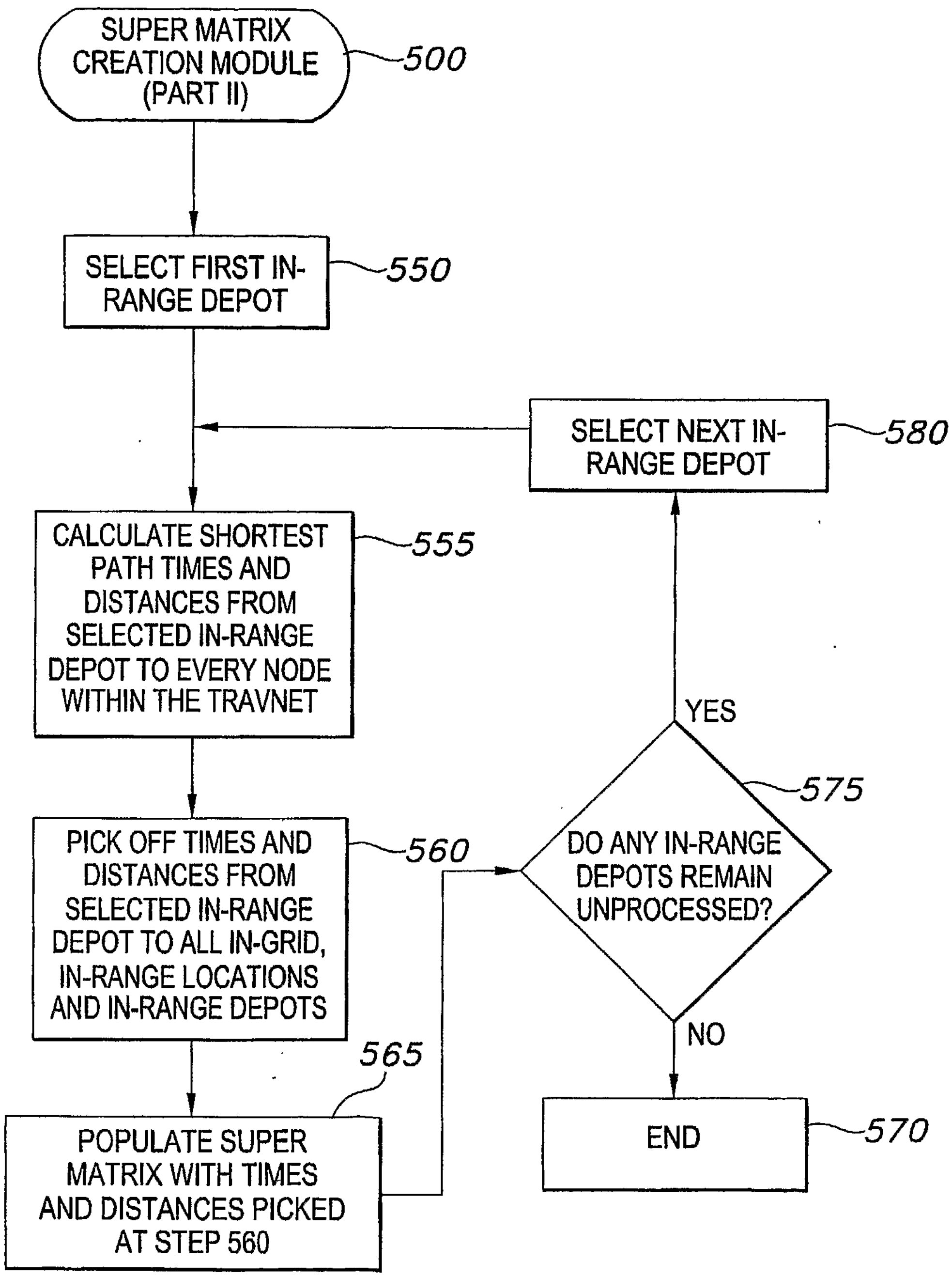

SUPER MATRIX CREATION MODULE (PART I)
500
505
CREATE TRAVNET DERIVED FROM ALL IN-GRIND LOCATIONS, ALL FRIENDS OF ANY IN-GRID LOCATION, AND ANY DEPOTS WITHIN MAXIMUM RADIUS OF ANY IN-GRID LOCATION
PROCEED TO FIGURE 7
507
SELECT FIRST IN-GRID LOCATION
510
SELECT NEXT IN-GRID LOCATION
545
CALCULATE SHORTEST PATH TIMES AND DISTANCES FROM SELECTED IN-GRID LOCATION TO EVERY NODE WITHIN THE TRAVNET
515
YES
530
PICK OFF TIMES AND DISTANCES FROM SELECTED IN-GRID LOCATION TO ALL OF THAT LOCATION'S FRIENDS AND ANY IN-RANGE DEPOTS
520
DO ANY IN-GRID LOCATIONS REMAIN UNPROCESSED?
NO
525
POPULATE SUPER MATRIX WITH TIMES AND DISTANCES PICKED AT STEP 520
END
570

FIG. 6



SUPER MATRIX CREATION MODULE (PART II)
500
SELECT FIRST IN-RANGE DEPOT
550
SELECT NEXT IN-RANGE DEPOT
580
CALCULATE SHORTEST PATH TIMES AND DISTANCES FROM SELECTED IN-RANGE DEPOT TO EVERY NODE WITHIN THE TRAVNET
555
YES
575
PICK OFF TIMES AND DISTANCES FROM SELECTED IN-RANGE DEPOT TO ALL IN-GRID, IN-RANGE LOCATIONS AND IN-RANGE DEPOTS
560
DO ANY IN-RANGE DEPOTS REMAIN UNPROCESSED?
NO
565
POPULATE SUPER MATRIX WITH TIMES AND DISTANCES PICKED AT STEP 560
END
570

FIG. 7

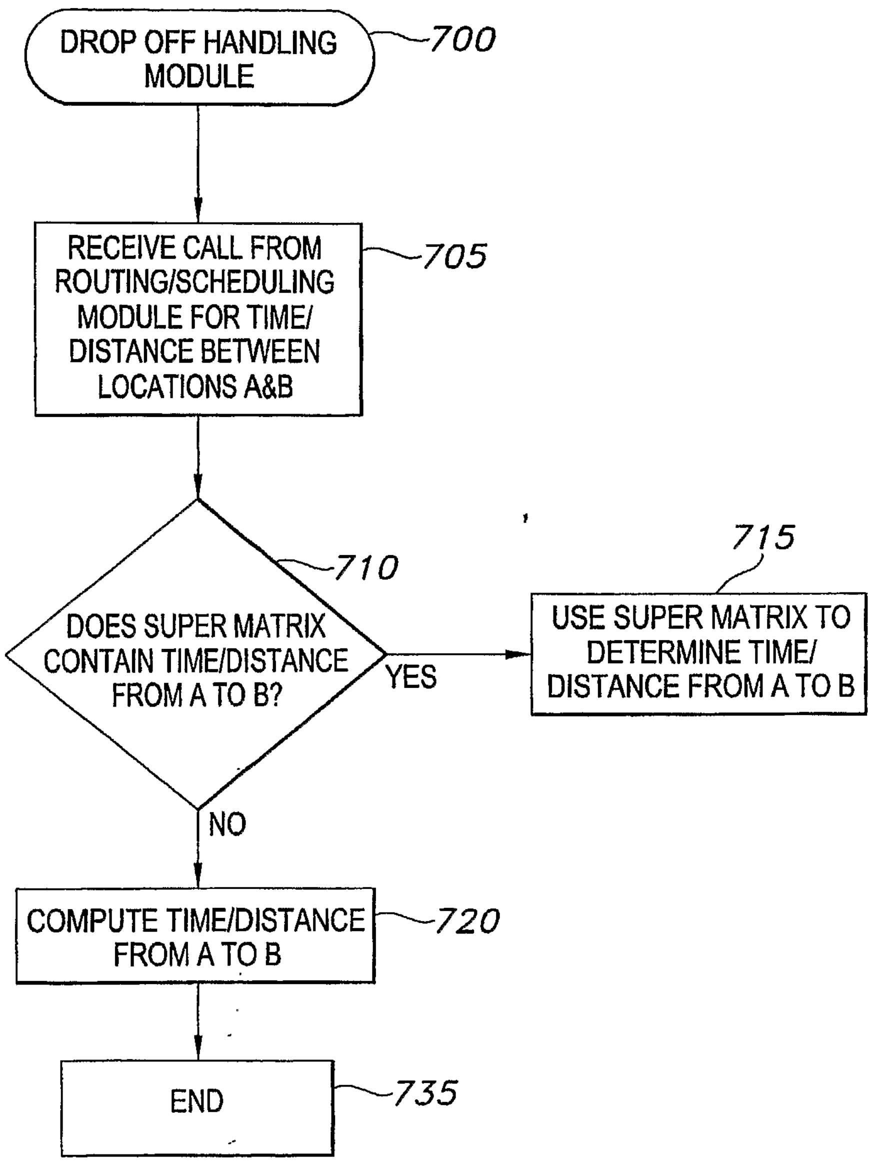
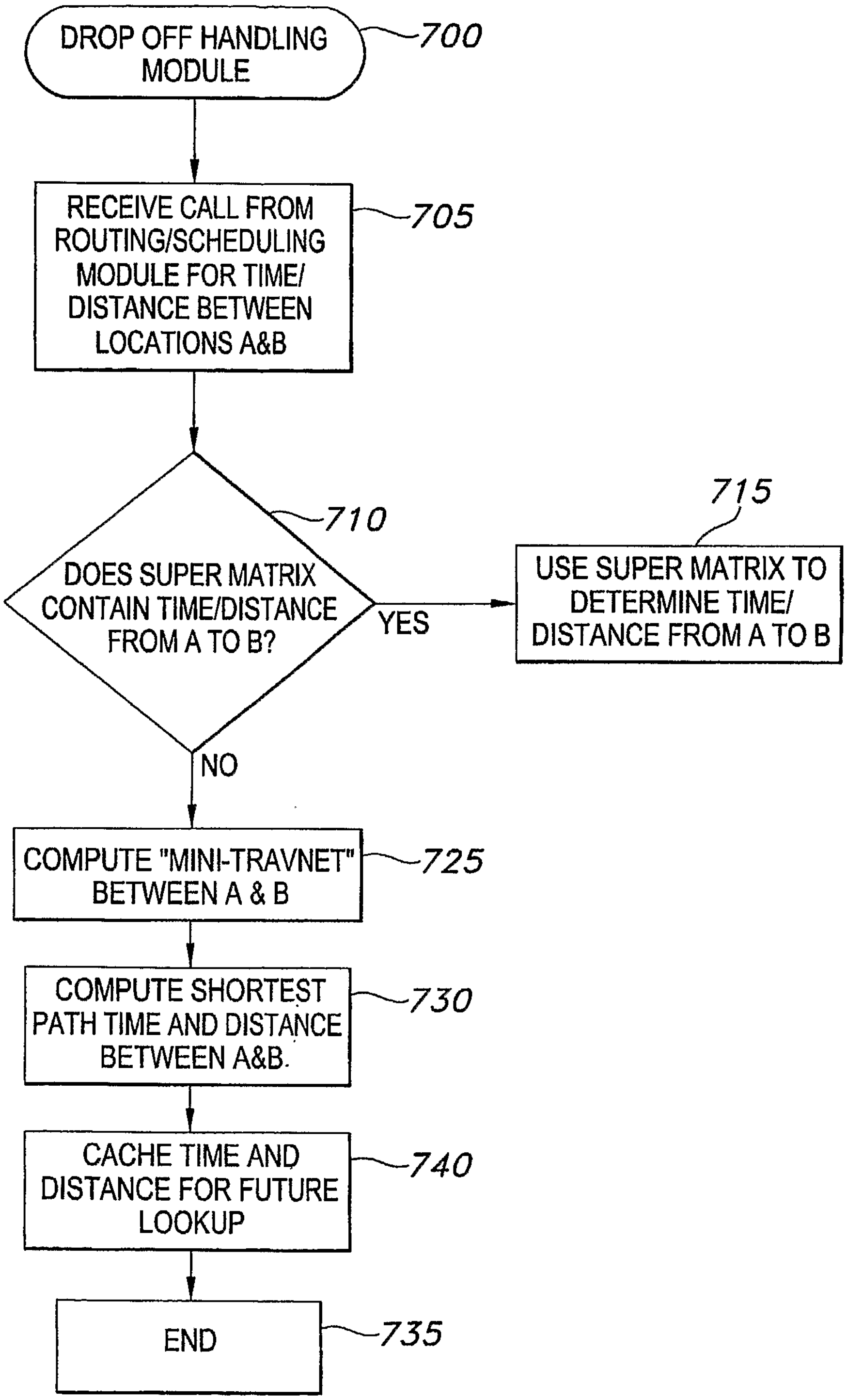

DROP OFF HANDLING MODULE
700
RECEIVE CALL FROM ROUTING/SCHEDULING MODULE FOR TIME/ DISTANCE BETWEEN LOCATIONS A&B
705
DOES SUPER MATRIX CONTAIN TIME/DISTANCE FROM A TO B?
710
YES
USE SUPER MATRIX TO DETERMINE TIME/ DISTANCE FROM A TO B
715
NO
COMPUTE TIME/DISTANCE FROM A TO B
720
END
735

FIG. 8A



DROP OFF HANDLING MODULE
700
RECEIVE CALL FROM ROUTING/SCHEDULING MODULE FOR TIME/ DISTANCE BETWEEN LOCATIONS A&B
705
DOES SUPER MATRIX CONTAIN TIME/DISTANCE FROM A TO B?
710
YES
USE SUPER MATRIX TO DETERMINE TIME/ DISTANCE FROM A TO B
715
NO
COMPUTE "MINI-TRAVNET" BETWEEN A & B
725
COMPUTE SHORTEST PATH TIME AND DISTANCE BETWEEN A&B.
730
CACHE TIME AND DISTANCE FOR FUTURE LOOKUP
740
END
735

FIG. 8B

SET OF UNIQUE DELIVERY LOCATIONS WITHIN A REGION

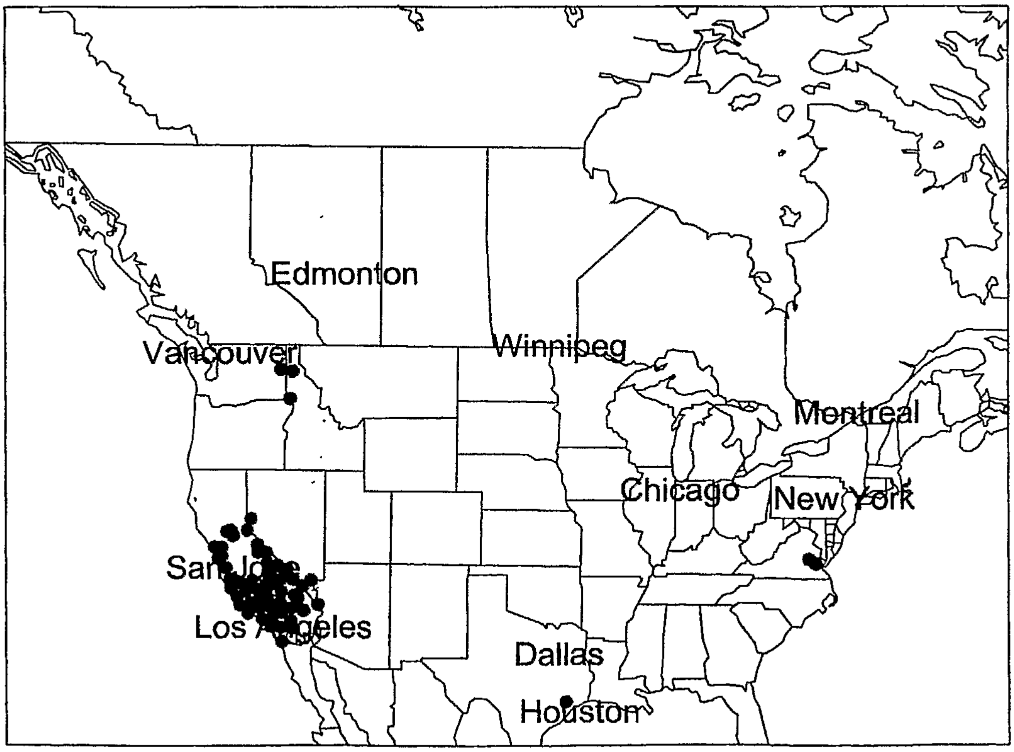


FIG. 9

QUAD GRID PROCESSING AFTER 50 LOCATIONS

FIG. 10

QUAD GRID PROCESSING AFTER 5011 LOCATIONS

FIG. 11

QUAD GRID PROCESSING AFTER 1000 LOCATIONS

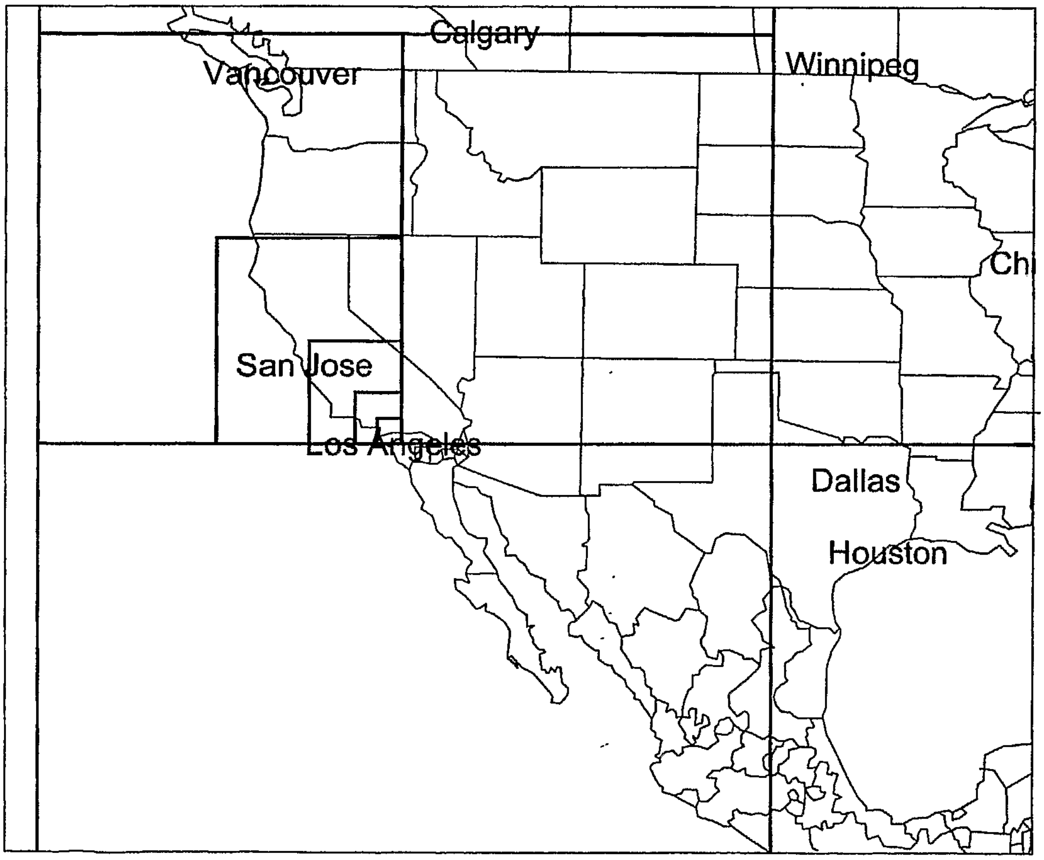


FIG. 12

1000 LOCATIONS ZOOMED ON
HIGHEST DENSITY LOCATION GRIDS

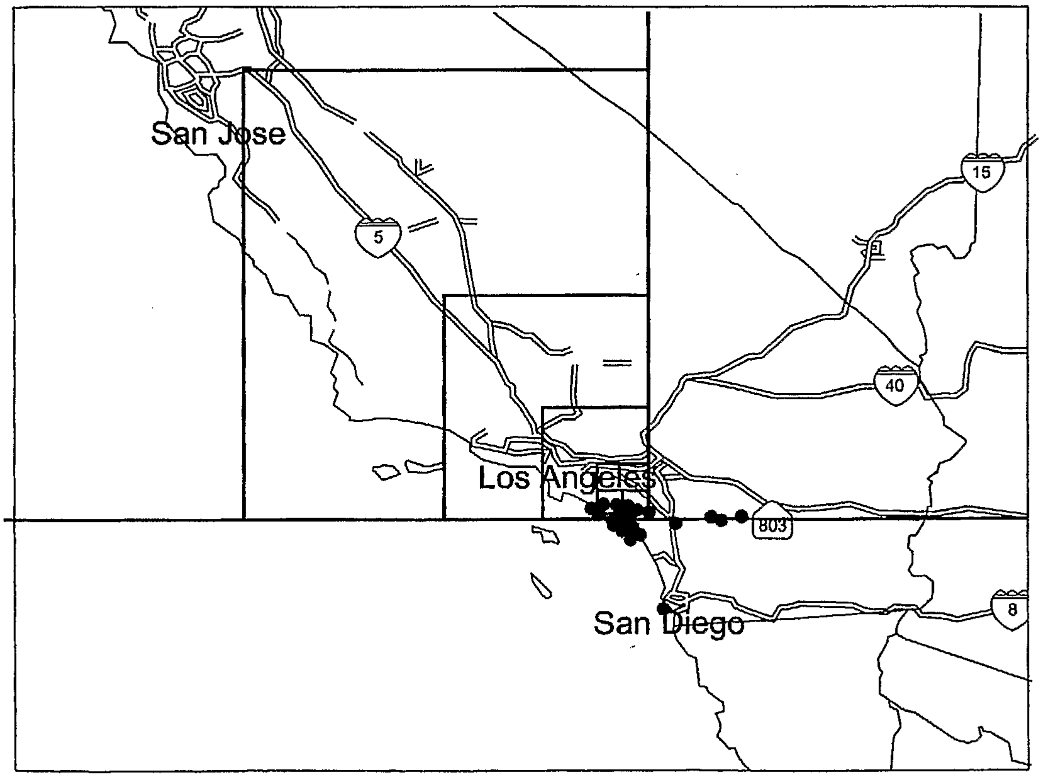


FIG. 13

COMPLETE QUAD GRID DECOMPOSITION

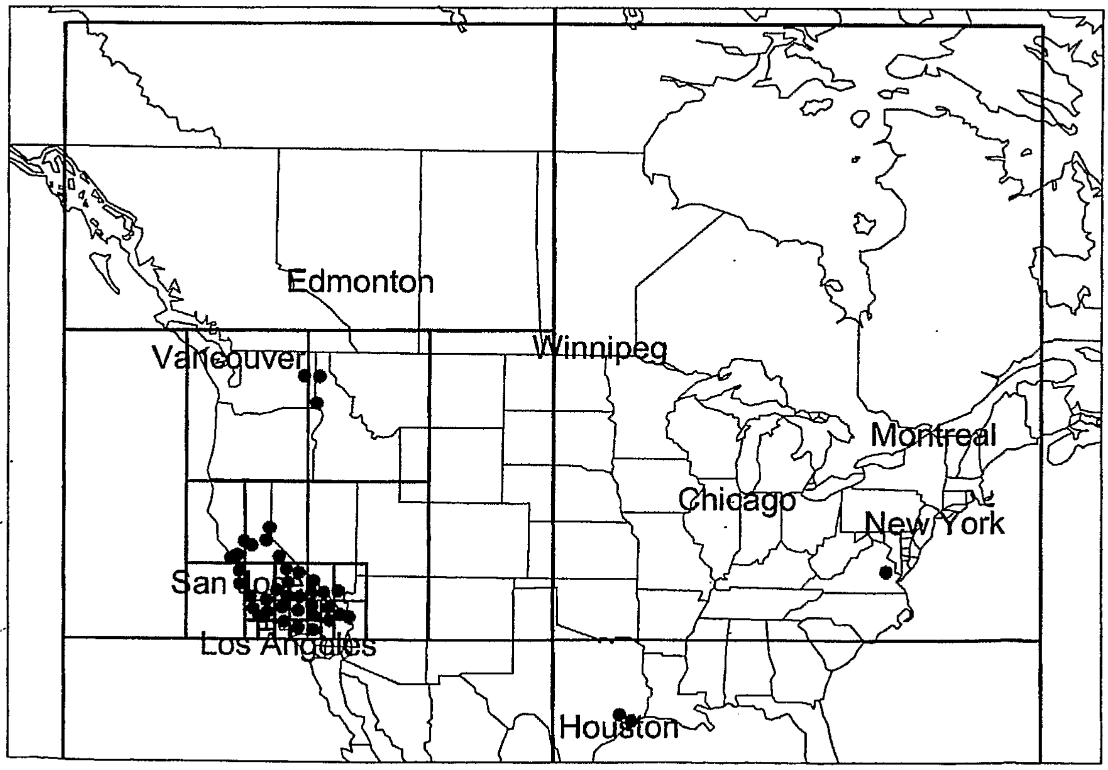


FIG. 14

GRID PORTIONING FOR DENSE AREA

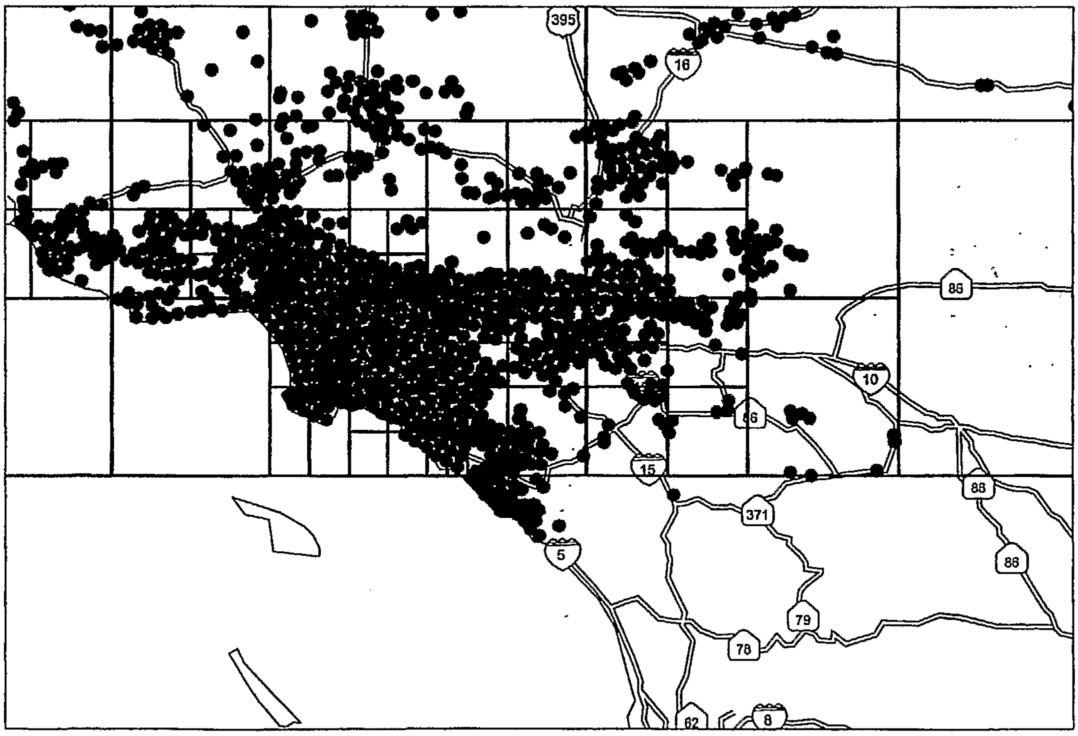


FIG. 15

ORDER OF LOCATION INPUT TO QUAD GRID PROCESSING

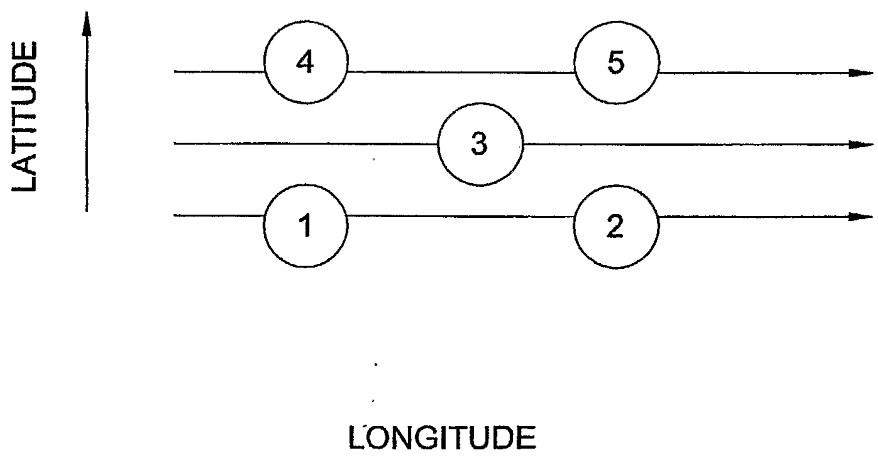


FIG. 16

FRIEND SELECTION

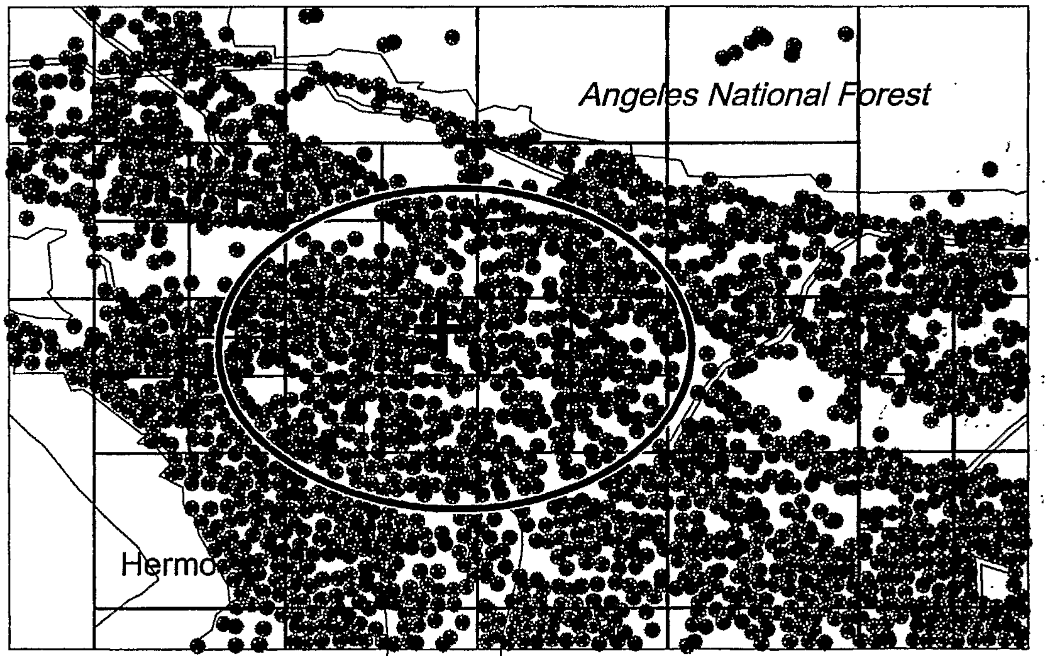


FIG. 17

GEO-BALANCING

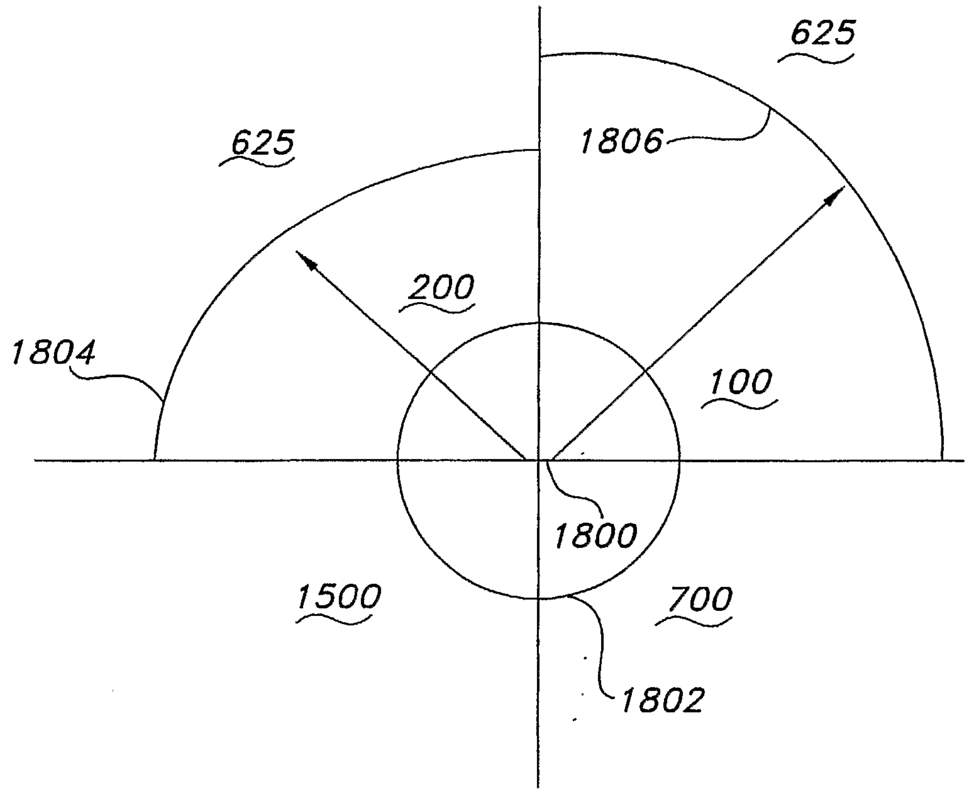


FIG. 18

FRIEND SELECTION WITH GEO-BALANCING

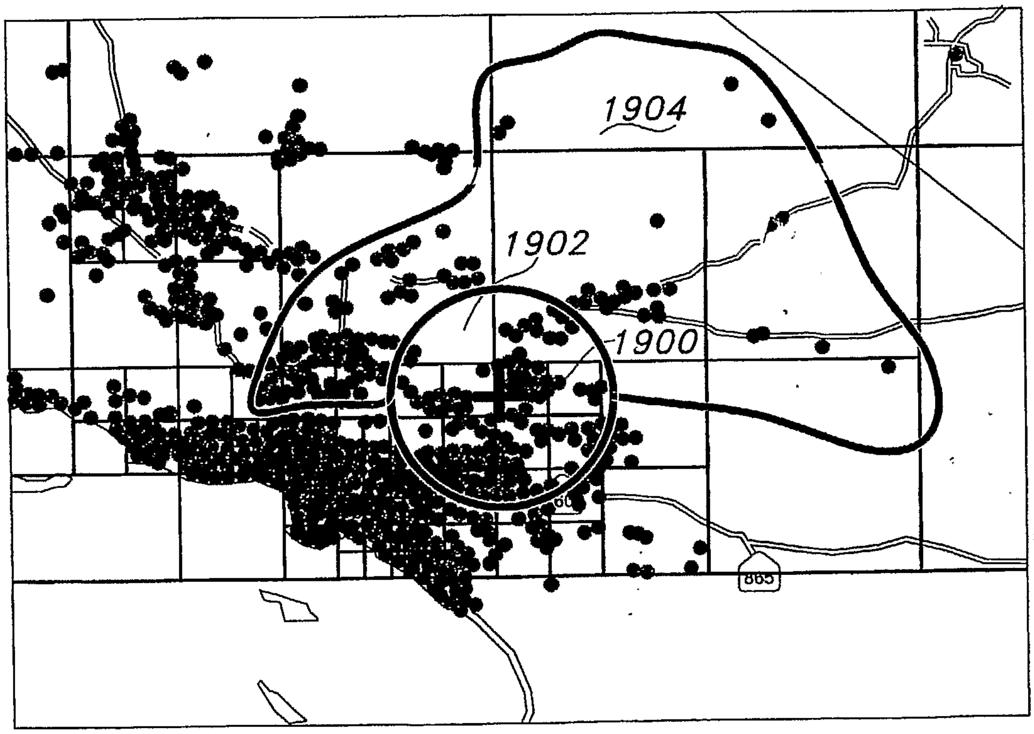


FIG. 19

TRAVNET POPULATION

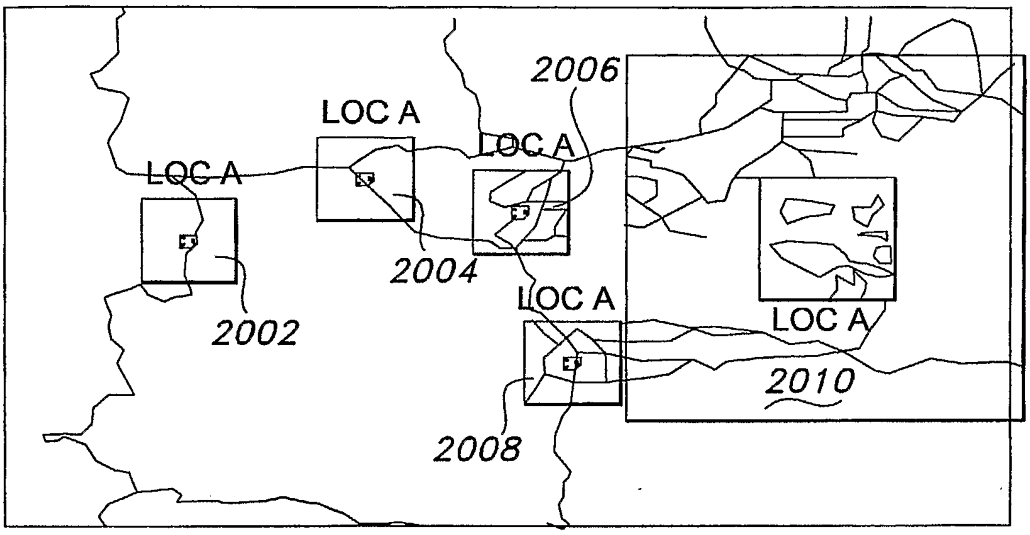


FIG. 20

SUPER MATRIX

	Lat.Long.Time.Distance	Lat.Long.Time.Distance	Lat.Long.Time.Distance	Lat.Long.Time.Distance
LOC #1	30180600.-81551600.303.3	30182800.-81556200.332.45	30186000.-81571200.423.178	30196500.-81556200.332.45
LOC #2	30180200.-81551600.332.45	30182800.-81556200.331.44	30186000.-81571200.392.132	30196500.-81556200.438.200
LOC #3	30180200.-81551600.332.45	30180600.-81551600.303.3	30186000.-81571200.423.178	30196500.-81556200.332.45
LOC #4	30180200.-81551600.303.3	30182800.-81556200.332.45	30180600.-81551600.303.3	30196500.-81556200.332.45
LOC #5	30180200.-81551600.303.3	30186000.-81571200.423.178	30205300.-81551800.145.166	30206200.-81577000.786.432
LOC #6	30180200.-81551600.303.3	30180600.-81551600.303.3	30182800.-81556200.331.44	30186000.-81571200.423.178
LOC #7	30180200.-81551600.303.3	30180600.-81551600.303.3	30182800.-81556200.331.44	30186000.-81571200.423.178
LOC #8	30186000.-81571200.423.178	30196500.-81556200.332.45	30205300.-81551800.145.166	30205300.-81551800.469.244
LOC #9	30180200.-81551600.332.45	30180600.-81551600.303.3	30182800.-81556200.332.45	30186000.-81571200.423.178
LOC #10	30186000.-81571200.423.178	30196500.-81556200.332.45	30205300.-81551800.145.166	30206200.-81577000.786.432

Latitude (millionths degrees)
Longitude (millionths degrees)
Time (secs)
Distance (100ths miles)

FIG. 21A

Lat.Long.Time.Distance	Lat.Long.Time.Distance	Lat.Long.Time.Distance	Lat.Long.Time.Distance	Lat.Long.Time.Distance
30205300.-81551800.145.166				
30205300.-81551800.145.166	30205500.-81551800.464.237	30206200.-81577000.786.432	30206300.-81551800.469.244	30206900.-81577400.448.214
30206900.-81577400.448.214				
30205500.-81551800.464.237	30206200.-81577000.786.432	30206300.-81551800.469.244		
30205300.-81551800.145.166	30206200.-81577000.786.432	30206300.-81551800.469.244		
30206900.-81577400.448.214				
30205300.-81551800.145.166	30205500.-81551800.464.237	30206900.-81577400.448.214		

FIG. 21B

DROPOFF HANDLING

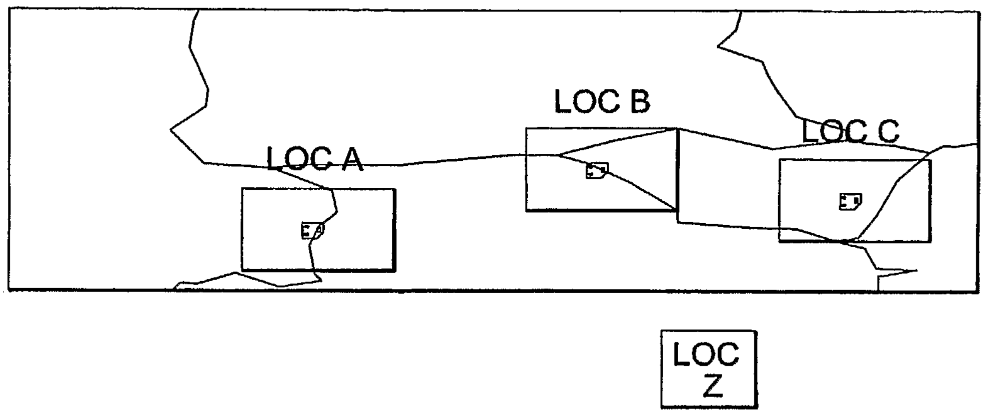


FIG. 22

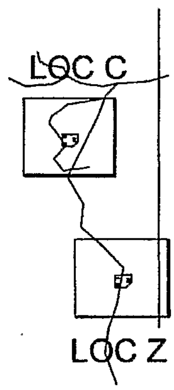


FIG. 23