

METHOD AND APPARATUS FOR LOCATING A MOBILE STATION BY COMPARING CALCULATED LOCATION AREA WITH GPS COORDINATES

This application is a continuation-in-part of copending U.S. patent application Ser. No. 08/472,082 (attorney docket no. MacDonald 1), filed Jun. 7, 1995, entitled Method And Apparatus For Determining The Location Of A Mobile Telephone.

FIELD OF THE INVENTION

The present invention relates generally to mobile telephone systems. More particularly, the present invention relates to determining the location of a mobile telephone within the geographic serving area of a mobile telephone system.

BACKGROUND OF THE INVENTION

Mobile telephone systems, also called cellular telephone systems, are becoming increasingly popular. These systems are generally made up of cell sites, each of which serves a coverage area, or cell. The cell site is the location within a cell which contains the required hardware (e.g. antenna(s) and radio base station) to communicate with the mobile telephones. A mobile telephone operating within a particular cell in the system communicates with the mobile telephone system through the cell site covering that cell. The various cell sites are connected to a mobile switching center which connects the mobile telephone system to the land-line telephone network.

One reason for the popularity of mobile telephones is that they can be used for emergencies when outside the home. For example, a motorist could use the mobile telephone to call for assistance in case of a disabled vehicle. Many areas provide a special emergency cellular telephone number. In other areas, users can dial 911, just as they would from a conventional land-line telephone.

One of the problems with using the mobile telephone for emergencies stems from the mobility of the telephone. Public service providers, such as police, do not know the location of the mobile telephone calling the emergency number. In addition, users who call the emergency number often cannot provide enough location information to allow the public service provider to find them. Thus, it is desirable to provide a mobile telephone system which can determine the location of a mobile telephone and provide that information to public service providers, for example the police.

Such a mobile telephone location service would be desirable in other contexts besides emergency responses. For example, a mobile telephone user who is lost may request location information from the mobile telephone system provider. The location information could be passed to the user from the system. Yet another user for such a system would be companies which operate fleets of vehicles. A home base for company operations could keep track of the locations of its vehicles by using a mobile telephone location service. Of course, there are many other applications for such a system.

In known techniques for mobile telephone location, the distance between a mobile telephone and a mobile telephone system antenna in a cell site can be determined by analyzing the signal strength of a communication signal between the cell site antenna and the mobile telephone. If the distance between the mobile telephone and a number of cell site antennas is calculated, the approximate location of the

mobile telephone can be determined by a geometric process such as triangulation.

U.S. Pat. No. 4,891,650 describes a vehicle location system which determines an approximate vehicle location using a cellular telephone system. The location function is initiated when a vehicle transmits an alarm signal to nearby cell sites. The cell sites receiving this alarm signal analyze the received alarm signal to determine its signal strength. The cell sites then send signal strength information through the mobile telephone system to an alarm central station. The alarm central station then uses the signal strengths reported from various cells to determine an approximate location of the vehicle. A more accurate location is achieved by sending out actual tracking vehicles to the approximate location calculated by the central station. A disadvantage of this system is that each of the cell sites requires additional components which will generate and send an appropriate signal strength report message to a mobile telecommunications switching office. The mobile telecommunications switching office also needs special functionality to send appropriate information to a central tracking station which will determine an approximate location of the vehicle using the signal strengths.

U.S. Pat. No. 5,218,367 describes a vehicle tracking system which uses signal strengths received from nearby cells to calculate an approximate vehicle location. In this system, a special purpose mobile telephone determines signal strengths being received from nearby cells and generates and sends an appropriate alarm message, including signal strength information, to a central station via the mobile telephone system. The central station then uses this information to determine an approximate location of the vehicle. The system can improve upon the accuracy of the approximate location if the cells are divided into sectors and particular information about the antennas in these sectors is used. Once an approximate location is found, a more accurate location is achieved by sending out actual tracking vehicles to the approximate location calculated by the central station.

The technique described in U.S. Pat. No. 4,891,650 requires additional components in each of the cell sites in order to generate and send appropriate signal strength report messages. Since there are many such cells in a mobile telephone system, such additional components are undesirable. Thus, there is a need for a mobile telephone location system which does not require additional components at each cell site.

Further, the location techniques described in the above patents does not calculate an accurate location of the mobile telephone. The accuracy of the location is improved by sending out actual tracking vehicles. However, the need for such vehicles makes these techniques very expensive. Thus, there is a need for a technique which will improve the accuracy of a location estimate calculated with signal strengths.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for accurately determining the location of a mobile telephone within a mobile telephone system serving area.

In accordance with one embodiment of the invention, the location of a mobile telephone is determined using a geometric location technique in combination with GPS location coordinates produced by a GPS processor/receiver within the mobile telephone. A mobile location module within the mobile telephone system receives data representing the