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(54) HYBRID LOCATING METHOD AND SYSTEM FOR LOCATING A MOBILE TERMINAL IN A WIRELESS COMMUNICATIONS NETWORK

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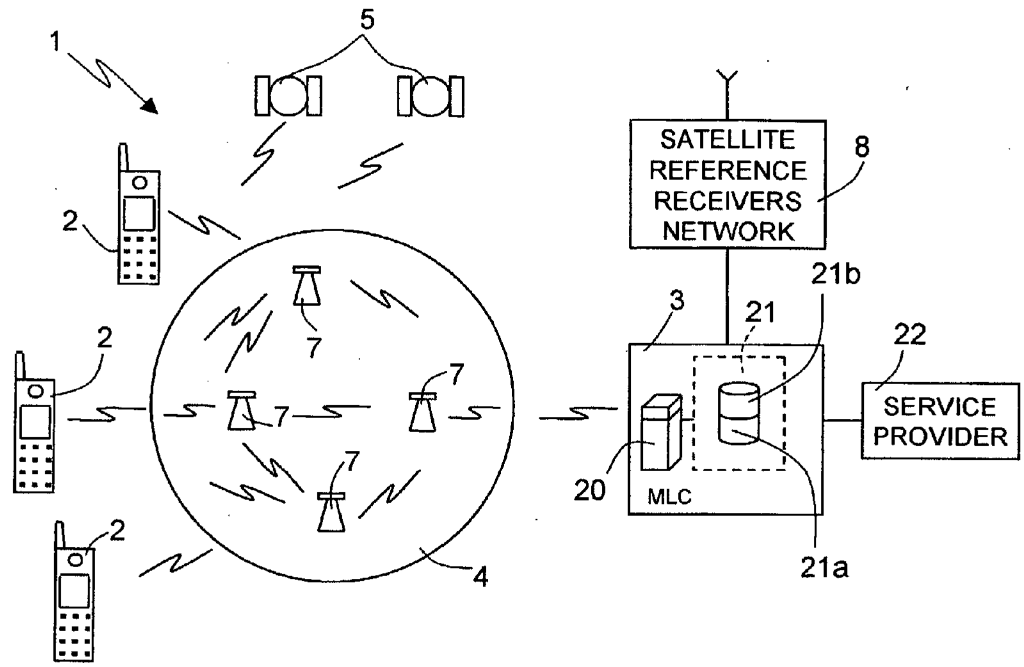
(57) **ABSTRACT**

Method of hybrid location in a wireless system includes a terminal having both a satellite receiving section and a cellular receiving section operating according to at least a first and a second locating mode; a locating center having a position calculation module and a wireless communication channel between said terminal and said locating center. The server performs the steps of: receiving a locating request; analyzing available resources and locating requirements associated with the locating request; selecting at least one locating mode according to the locating requirements and the available resources; setting instructions including locating measures to be acquired and response triggering conditions; sending the instructions to the terminal through the wireless communication channel; receiving acquired locating measures from the terminal; and calculating a position information from the locating measures.



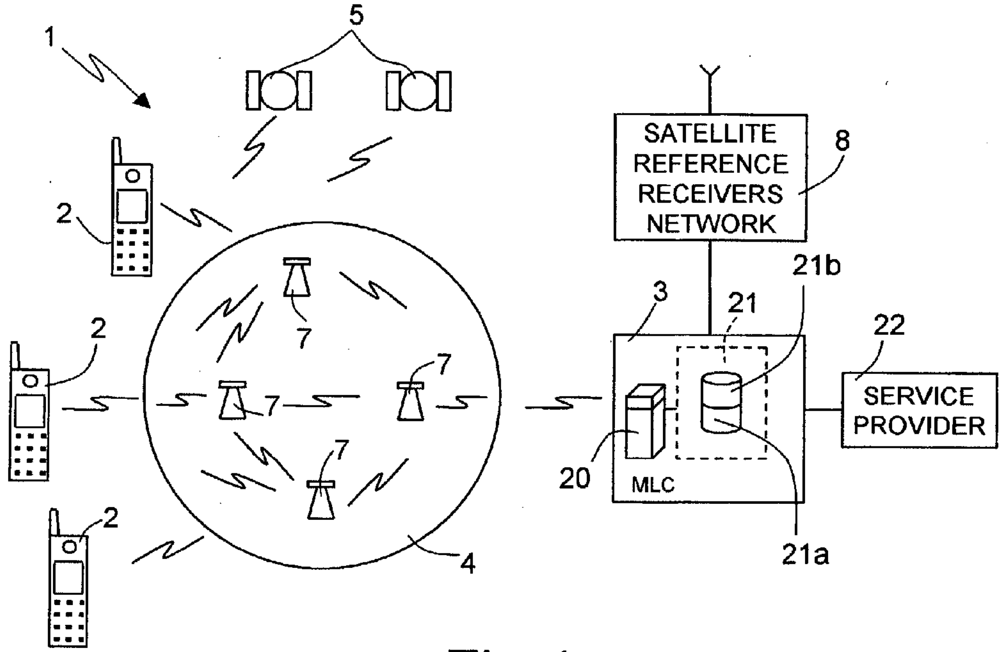

1
5
2
2
2
7
7
7
7
4
SATELLITE REFERENCE RECEIVERS NETWORK
8
21b
3
21
22
SERVICE PROVIDER
20
MLC
21a

Fig.1

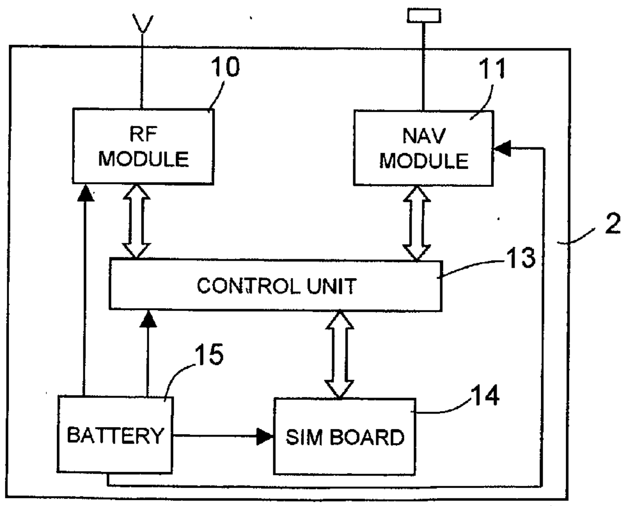

10
11
RF MODULE
NAV MODULE
2
13
CONTROL UNIT
15
14
BATTERY
SIM BOARD

Fig.2

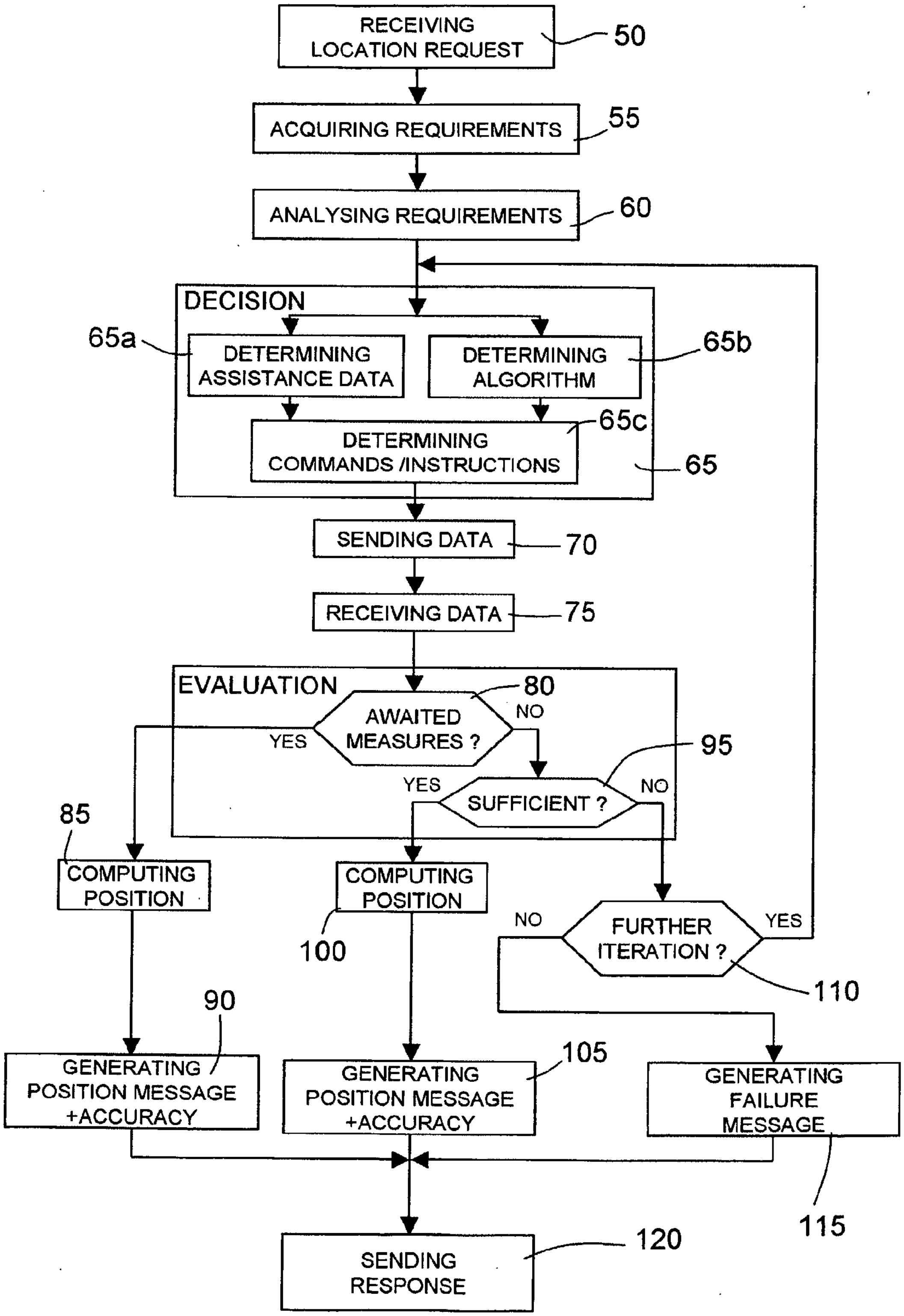

RECEIVING LOCATION REQUEST
50
ACQUIRING REQUIREMENTS
55
ANALYSING REQUIREMENTS
60
DECISION
65a
DETERMINING ASSISTANCE DATA
DETERMINING ALGORITHM
65b
65c
DETERMINING COMMANDS /INSTRUCTIONS
65
SENDING DATA
70
RECEIVING DATA
75
EVALUATION
80
AWAITED MEASURES ?
YES
NO
95
YES
SUFFICIENT ?
NO
85
COMPUTING POSITION
COMPUTING POSITION
100
NO
FURTHER ITERATION ?
YES
110
90
GENERATING POSITION MESSAGE +ACCURACY
105
GENERATING POSITION MESSAGE +ACCURACY
GENERATING FAILURE MESSAGE
115
SENDING RESPONSE
120

Fig.3

HYBRID LOCATING METHOD AND SYSTEM FOR LOCATING A MOBILE TERMINAL IN A WIRELESS COMMUNICATIONS NETWORK

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to the field of wireless communications systems, and more particularly to a method and system for locating a mobile terminal according to different modes.

BACKGROUND ART

[0002] Hybrid location methods are known to exploit different localization techniques, such as satellite measures (using e.g. the GPS-Global Positioning System—navigation system) and cellular measures (e.g. based on the measure of the electromagnetic field). These known methods use suitable algorithms that, based upon two or more pluralities of measures acquired by the terminal, are intended to globally improve the performance of the positioning, in terms of accuracy, availability, and so on.

[0003] The estimation of the position of the mobile terminal is carried out either at the terminal itself or at a network server, also called mobile location center (MLC). In the latter case, the MLC receives the measures from the mobile terminal and, if necessary, uses additional data such as a network database (including data about the physical environment around the mobile terminal) and/or data received from reference GPS receivers.

[0004] U.S. Pat. No. 6,249,245 discloses a system combining GPS and cellular technology, wherein the mobile terminal calculates its position using GPS data and information sent by a cellular network. Information can include differential GPS error correction data. When the requisite number of GPS satellites are not in view of the GPS receiver, the system utilizes a GPS pseudosatellite signal that is generated by one or more base stations of the cellular network independent of the GPS. When the requisite number of GPS satellites is temporarily not in view, position is calculated using the cellular network infrastructure. In the alternative, cellular signals already transmitted from a base station are used to calculate a round trip delay and then a distance between the base station and the terminal, which replaces a missing GPS satellite signal.

[0005] WO 01/86315 discloses a system, wherein a mobile unit compiles a set of positioning data based on the signals received from GPS satellites and from a cellular communication network. The positioning data are then transferred to a calculation center where the most precise location calculation possible is performed.

[0006] Applicant has noted that these known systems have the inherent shortcoming of assuming that the cellular and/or satellite measures are available to the base station.

[0007] Other GPS solutions provide for an "assisted GPS", wherein the network server sends suitable data for improving the receiver performances.

[0008] For example, U.S. Pat. No. 6,389,291 discloses a GPS system that can operate in different modes, including a standalone mode, wherein a mobile communications device computes its position; an autonomous mode, where the mobile communications device transmits the computed position to another component of the communications network; a

system, the selective switching of the GPS receiver is performed either automatically or manually at the wireless communications device in either local or remote control.

[0009] Applicant has noted that this system has the inherent shortcoming that it does not take into account the terminal resources which thus cannot be efficiently managed. For example, this system may decide to use an autonomous or standalone mode (i.e. where the mobile device computes its position) and thus decide to wait until a position calculation has been done; but this choice could be not optimal when the battery level is too low (and thus does not enable data to be acquired within the provided acquisition time). Furthermore, the choice at the terminal's end does not take into account the calculation power existing at the server. In fact, Applicant has observed that the performances of a GPS/AGS (Assisted Global Positioning System) mainly do not depend upon the operation mode (i.e. with or without assistance data transmission), but they mainly depend upon the local conditions of the mobile terminal and are generally unpredictable.

[0010] In general, the only choice of the operation mode is not sufficient to have an efficient localization procedure and does not ensure the optimal trade-off between requirement compliance and resource management. For example, for preset accuracy requirements, it may be not efficient to wait for the terminal to calculate the position, when the network server has a suitable algorithm able to process a subset of measures that can be acquired in a shorter time.

[0011] US 2002/0019698 describes a solution wherein a positioning method selecting device automatically determines the best possible positioning method available for use by the terminal's applications, based on requirements specifying the quality of service.

[0012] US 2003/0045303 describes a system wherein the terminal receives assistant information from a positioning server and measures signals based onto the received information; in case the positioning information collected is sufficient, it displays the location computed by the positioning server; otherwise it displays a corresponding message.

[0013] EP-A-1 418 439 discloses a portable telephone aimed at reducing power consumption and shortening positioning time, by selecting a method for determining the location according to the distance from an objective point or a reception level of a downlink signal. The telephone automatically switches a positioning method according to the distance between its location and the objective point. In detail, the portable telephone receives the location of the base station when in a distant place from the objective point, regards it as the location of the telephone and exerts control to gradually increase the number of times the GPS positioning is selected as it come closer to the objecting point.

[0014] US-A-2003/0144042 discloses a method wherein the rate at which position information is transmitted may be adjusted based upon the battery strength and/or whether the mobile station is operating in the emergency mode. The mobile station determines whether the battery is low and transmits this information to the network. The mobile station may also transmit whether it is currently operating in an emergency mode. Based on this information, the network may adjust the rate.

OBJECT AND SUMMARY OF THE INVENTION

[0015] The aim of the present invention is therefore to on the server side, so as to manage in an efficient way the different variables affecting the performance of the localization process.

[0016] Advantageously, these variables include the battery charge of the mobile terminal, type and requirements of the service; available resources; calculation power at the server, and so on.

[0017] The present invention efficiently allows picking up measures from the terminal, in accordance with the service requirements or the available resources.

[0018] According to the present invention, there are provided a method and a system of hybrid location as defined in claims **1** and, respectively, **15**.

[0019] The present system uses a hybrid location method and is based on the observation that in a hybrid location method, it is advantageous that the position detection is carried out at the network server. In fact, the network server knows its own processing and calculation potential and the service requirements and, moreover it can know the available resources, since:

- **[0020]** it receives the localization request from a user (e.g., an external service provider or an LCS-LoCal Service client which may be the terminal) together with various requirements; and
- **[0021]** the server knows the requirements and the potential of the available location algorithm; generally the results and the performance depend upon the used algorithm and the available measures and data. Therefore, the server is able to determine which data should be sent to the terminal and which data and measures (satellite, cellular) should be gathered from the terminal to satisfy the service requirements; and
- **[0022]** the server can know the available resources both at the network side (e.g. bandwidth) and/or at the terminal side (e.g. battery charge level). Resources of the terminal can be in fact communicated to the server on request (or periodically).

[0023] In one embodiment, the server decides which measures/data should be acquired from the terminal; i.e. the server decides the trade-off between cellular and satellite measures/data. In this way, the server may acquire only the data that are necessary to satisfy the accuracy requirements; thereby the localization procedure may be optimized as regards e.g. the time needed by the terminal to send the acquired measures, the number of transmitted bytes, or terminal battery consumption.

[0024] In another embodiment, the server controls the navigation module integrated in or connected to the mobile terminal based on events that cause switching on and off and/or based on the on and off times of the GPS module. In this way, the navigation management logics can be decided and adjusted not only based on the service requirements but also taking into account the available algorithm capability, which in general is variable with time.

[0025] Preferably, the navigation management logic takes into account also the terminal resources.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] For a better understanding of the present invention, a preferred exemplary non-limitative embodiment will now

[0027] FIG. **1** shows a block diagram of a communications network according to an embodiment of the present invention;

[0028] FIG. **2** shows a block diagram of a mobile terminal of the communication network according to FIG. **1**;

[0029] FIG. **3** shows a flow-chart of an embodiment of the present localizing method.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0030] FIG. **1** shows the block diagram of a communication system **1** using a hybrid location method. The communication system **1** comprises a plurality of wireless devices or terminals **2**, e.g. cellular handphones, each having at least some of the functions typical of a satellite positioning (e.g., GPS) receiver/processor (as explained in greater detail hereinbelow). The terminals **2** are spread randomly in an area inside which the position of the single terminal **2** is to be determined. The communication network **1** further comprises a server **3** (mobile localization center MLC); a wireless communications network **4**, for example a GSM network, including a plurality of base stations **7** (e.g. BTS or Base Transceiver Stations, in a GMS network) and arranged between the terminals **2** and the server **3**. The network is adopted to receive signals emitted by a plurality of satellites **5**.

[0031] Preferably, a MLC **3** is connected to a satellite reference receiver (e.g., a GPS receiver) or a network of reference receivers **8**. The presence of one or more reference receivers is preferred especially in case of transmission of assistance data. Furthermore, in the final phase of the location process when the server collects the measures from the terminal (as explained below more in detail), it can be advantageous that the server can infer the position of the satellites (e.g. through the ephemerides parameters) at the times when measures were taken. Although, it is envisaged that the server can request the terminal to provide the satellite positions, it can be more efficient that the server takes this information from the satellite receiver(s) which it is connected to.

[0032] Each terminal **2** (FIG. **2**) comprises an RF module **10** (e.g. operating according to the GSM, the GPRS—General Packet Radio System—or the UMTS—Universal Mobile Telecommunications System—standard), a navigation or NAV module **11** (e.g. operating according to the GPS, the AGPS or the GALILEO standard), a control unit **13**, connected to the RF module **10** and to the NAV module **11**; a SIM (Subscriber Identity Module) **14**, connected to the control unit **13**; and a battery **15**, connected to all the other units of the terminal **2**.

[0033] The NAV module **11** is of standard type and comprises a satellite receiver (e.g. a GPS receiver) that is kept on only when measures are to be acquired, as below discussed. The terminal may include other modules to enable other functions of the wireless network, such as voice, video or data communication.

[0034] The control unit **13**, the implementation whereof may be of a known type and thus not described in detail, e.g. including a client software developed in Symbian OS or in other manner, has the function of controlling the activities of the terminal **2**, based on programs stored in the control unit **13** itself. In particular, the control unit **13** controls the RF module **10** so as to periodically measure the electromagnetic field (RF measures) within a preset number of frequency channels, in a

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