



Method and system for authenticating and validating position information reported by a mobile device

The present invention relates to a method and a system for
5 authenticating and validating position information reported by a mobile
device. It applies notably to the field of highway, motorway and urban remote
toll systems and to any other geolocated payment device.

To determine the position of a vehicle, the known remote toll devices
use either signalling portals positioned at strategic places on roads subject to
10 a toll, or an onboard locating device on the vehicle periodically reporting its
position determined by a GNSS (Global Navigation Satellite System) satellite
positioning system, for example of GPS (Global Positioning System) or
Galileo type.

A satellite positioning system is ideal for the implementation of a
15 remote toll system for highways, motorways and urban applications but the
reliability of the position information that it delivers depends solely on
information transmitted by an onboard GNSS receiver in the vehicle and the
reliability of the billing produced by a position server depends directly on this
position information. Now, there are numerous sources of positioning error
20 than can compromise the validity of the position information uploaded to the
position server by a location device. A positioning error may be due to a
technical problem on reception of the GNSS signals, such as, for example, a
failure of the receiver or a failure of the information transmitted by the
constellation of satellites used. The error can also originate from the
25 deliberate use of a decoy by the owner of the vehicle to report information
corresponding to a place that is different from the place where the vehicle is
actually located, the decoy being able to use, for example, a programming of
a predefined trajectory or a generator of false GNSS signals.

A first known solution making it possible to detect and eliminate a
30 failure on one or more GNSS signals and for detecting a partial failure of the
GNSS receiver, on one or more reception channels, consists in using, within



the GNSS receiver, an algorithm known by the name of RAIM (Receiver Autonomous Integrity Monitoring).

A second known solution consists in analysing, in the position server, the trend of the time-stamped position information uploaded by the location
5 device. An error or failure is then detected and processed when a position becomes inconsistent relative to the preceding positions and it reveals a geographic jump between two successive position information items very much greater than the difference in position that the assumed dynamic of the vehicle can allow.

10 However, these two known solutions make it possible to resolve the problem of integrity due to an unintentional failure but they do not in any way make it possible to detect any intentional deception.

The aim of the invention is to resolve these problems and propose a method of authenticating and validating position information reported by a
15 mobile device that does not have the drawbacks of the known solutions and that makes it possible to effectively validate the position information in all circumstances, whether the information is in the form of coordinates or of measurements from which the coordinates of the mobile device can be deduced.

20 For this, the invention relates to a method of authenticating and validating position information reported by a mobile device consisting in determining, on board the mobile device, the position of the mobile device based on GNSS navigation signals emitted by a constellation of satellites and in transmitting the position information obtained to a position server via a
25 base station of a mobile communication cellular network, the base station having a coverage area, called a cell, in which the mobile device is located. The method also consists in transmitting to the position server position information concerning the cell in which the base station to which the mobile device is connected is located, in checking, in the position server, that the
30 position of the mobile device received is included in the cell of the base station corresponding to the cell position information received and, following the result of the check, in deciding whether the position determined by the

mobile device based on the navigation signals and transmitted to the position server is authentic or if there is fraud.

Advantageously, the method consists in transmitting to the position server a succession of position information items concerning the mobile device and a succession of position information items concerning the cells in which the base stations are located, in comparing the succession of positions of the mobile device to the succession of positions of the cells and in deciding whether the succession of positions transmitted by the mobile device corresponds to an authentic trajectory followed by the mobile device.

Advantageously, the cell position information is an identifier of the base station transmitted to the position server by the mobile device in a message containing the position information concerning the mobile and the identifier of the base station.

According to a variant of the invention, the cell position information for the base station is transmitted to the position server by a positioning node of the cellular network in response to an interrogation of the position server after reception of the message containing the position information concerning the mobile device transmitted by the mobile device. The cell position information for the base station can be an identifier of the base station or a geographic area obtained by processing measurements of receive mode power by a mobile communication transmitter-receiver placed on board the mobile device or a geographic area corresponding to the coverage area of the base station.

The invention also relates to a system for authenticating and validating position information reported by a mobile device, comprising:

- on board the mobile device, a location and broadcasting device for generating and sending a message containing position information concerning the mobile device,
- a cellular communication network comprising at least one base station having a geographic coverage area, called the cell, for transmitting the message containing the position information concerning the mobile device,

- a position server connected to the cellular network to receive and process the message containing the position information concerning the mobile device,

the cellular communication network also comprises means of locating
5 the cell of the base station in which the mobile is located for delivering and transmitting position information concerning said cell to the position server,

the position server comprises checking means for checking that the position of the mobile received is included in the cell of the base station corresponding to the cell position information received and, depending on the
10 result of the check, for deciding whether the position determined by the mobile device based on the navigation signals and transmitted to the position server is authentic or if there is fraud.

Advantageously, the location and broadcasting device comprises a receiver of GNSS navigation signals for determining the position of the
15 mobile device based on navigation signals emitted by a constellation of satellites, connected to a cellular communication transmitter-receiver for sending the message containing the position of the mobile device to the position server.

Advantageously, the location means of the cell of the base station in
20 which the mobile device is located comprise an identifier of the base station transmitted to the position server by the cellular communication transmitter-receiver with the message containing the position information concerning the mobile device.

Alternatively, the location means of the cell of the base station in
25 which the mobile device is located comprise a positioning node of the cellular network for transmitting to the position server position information concerning the base station corresponding to the cell in which the mobile is located. The cell position information for the base station can be an identifier of the base station or a geographic area obtained by processing measurements of
30 receive mode power performed on the base station by a mobile communication transmitter-receiver placed on board the mobile device or a geographic area corresponding to the coverage area of the base station.

Other features and benefits of the invention will become clearly apparent hereinafter in the description which is given by way of purely illustrative and nonlimiting example, with reference to the appended diagrammatic drawings which represent:

- 5 - Figure 1: an exemplary system for locating a mobile device, such as a vehicle, by satellite;
- Figure 2: an exemplary method of determining the position of a GNSS receiver in a mobile device, according to the invention;
- Figure 3: an example of transmission of the position information to
- 10 the position server 3 performed by a cellular network communication technique, according to the invention.

Figure 1 represents an exemplary system for locating a mobile device 1, for example a vehicle, by satellite. The location system comprises, on board the vehicle 1, a location and broadcasting device 2 intended to

15 determine the position and/or the speed of the vehicle and to transmit this location information to a position server 3 that is responsible for storing and/or analysing the information. The location and broadcasting device 2 comprises a receiver 4 of GNSS (Global Navigation Satellite System) navigation signals such as a GPS (Global Positioning System) or Galileo

20 receiver, emitted by a constellation of satellites 5a, 5b and a transmitter-receiver 6 for mobile communication by cellular network, for example of GSM (Global System for Mobile communications), UMTS (Universal Mobile Telecommunications System) or CDMA (Code Division Multiple Access) type. The position information is calculated by the GNSS receiver 4 by

25 analysing signals 13a and 13b emitted by the satellites 5a, 5b. The number of satellites must be at least equal to four to determine the four position coordinates of the vehicle in space x, y, z and in time t. This position information is then supplied to the mobile communication transmitter-receiver

30 6 which, according to a sequencing dependent on the application, the sequencing possibly being limited to following a predetermined periodicity, sends said position information to the position server 3 via a communication channel 12 and via a base station 7a covering a coverage area, also called a

cell, in which the mobile device 1 is located.

An exemplary method of determining the position of the GNSS receiver 4 is diagrammatically represented in Figure 2. The method consists, for the receiver 4, in determining the distances d_1 , d_2 , d_3 separating it from
 5 at least three satellites 5a, 5b, 5c of the constellation then in deducing therefrom the point of intersection 14 of the spheres whose centre is embodied by the position of the satellite itself and whose radius is supplied by the distances d_1 , d_2 , d_3 . The position of the GNSS receiver 4 corresponds to this point of intersection 14. The distances d_1 , d_2 , d_3 are
 10 measured in the receiver 4 by timing the arrival time of radiofrequency signals constituting a navigation message originating from the satellites 5a, 5b, 5c. The essential information originating from each satellite via the navigation message and that the receiver must process consists of the date of transmission of the message and the position of the satellite at the
 15 moment of transmission of the radiofrequency signal. The satellite transmits, in its navigation message, its ephemerides (Keplerian parameters) enabling the receiver 4 to calculate the position of the satellite within a system of coordinates linked to the earth. The ephemerides comprise, in the case of a GPS signal, 16 parameters repeated every 30 seconds in the navigation
 20 message.

With the position of the satellite having been obtained, it remains for the receiver to detect the time of transmission of the message in order to deduce the propagation time of the signal transmitted by the satellite and the distance separating it from the satellite, then the radius of one of the 4
 25 necessary spheres, and the position of the vehicle 1.

The method of transmitting position information to the position server 3 is performed by a cellular network communication technique as diagrammatically represented in Figure 3. The cellular communication network is based on a geographic mesh whose individual meshes constitute
 30 geographic coverage areas 8a, 8b, 8c, called cells. The geographic coverage areas 8a, 8b, 8c correspond respectively to radiofrequency coverage areas of the base stations 7a, 7b, 7c. A mobile communication transmitter-receiver

6 can communicate with the cellular network as soon as it is located in the radiofrequency coverage area of one of the base stations 7a, 7b, 7c and therefore as soon as it is located in one of the cells 8a, 8b, 8c.

Each base station is connected to a base station controller 9, referred to as a BSC (Base Station Controller) in GSM or an RNC (Radio Network Controller) in UMTS. The function of the base station controller 9 is to switch the calls from the mobile communication transmitter-receiver 6 but also to analyse a set of radiofrequency measurements reported by the mobile communication transmitter-receiver 6 in order to determine the geographic area 8a, 8b, 8c in which the transmitter-receiver 6 is located, and assign it a communication channel 12 with the most appropriate base station 7a, that is to say the one corresponding to the geographic area in which the mobile device 1 is located. The cellular communication networks of GSM and UMTS type are generally equipped with a positioning node 10, referred to as a GMLC (Gateway Mobile Location Centre), and each base station 7a, 7b, 7c is identified uniquely by a unique identifier, called cell id, in a GSM-type cellular network. The positioning node 10 is responsible, upon request from an application or from equipment external to the cellular network, for delivering either the identifier of the base station 7a to which the cellular transmitter-receiver 6 is connected, or, directly, position information concerning the mobile device 1 based on the geographic coverage area 8a of the base station 7a. A mobile device 1 knows perfectly the identifier of the base station to which it is connected.

According to the invention, the method consists in transmitting to the position server 3 the position information determined by the receiver 4 of GNSS navigation signals and the identifier of the base station to which it is connected and in checking, in the position server 3, that the position information received is included in the coverage area of the base station corresponding to the received identifier. The identifier of the base station can be transmitted in various ways to the position server 3.

According to a first embodiment of the invention, the method consists in analysing cell identifier information known to the mobile device 1 so as to

validate the position information reported by this mobile device. For this, the method consists in generating, in the location and broadcasting device 2, a message containing the position information and the identifier of the base station to which it is connected, and in sending this message to the position
5 server 3. On reception of the message, the position server 3 checks that the position information received is included in the coverage area of the base station corresponding to the identifier attached to the message sent. If it is not, then a fraud or a problem in the device is detected. Optionally, the method can include an additional step consisting in validating the identifier
10 transmitted in the message sent by the location and broadcasting device 2, this step consisting in checking, in the position server 3, the consistency between the succession of the different identifiers received. Advantageously, the succession of position information items concerning the mobile device 1 and the succession of position information items concerning the cells in
15 which the base stations are located and transmitted to the position server 3 are compared.

According to a second embodiment of the invention, the method consists in interrogating the positioning node 10 of the cellular network to obtain position information concerning the cell in which the base station to
20 which the transmitter-receiver 6 associated with the receiver 4 of GNSS navigation signals is connected is located. For this, the location and broadcasting device 2 sends a message containing the position information concerning the mobile device 1 determined by the receiver 4 of GNSS navigation signals, on reception of this message, the position server 3
25 interrogates the positioning node 10 of the cellular network to obtain position information concerning the cell in which the base station to which the transmitter-receiver 6 associated with the receiver 4 of GNSS navigation signals is connected is located. The position server 3 then checks that the position information received from the location and broadcasting device 2 is
30 included in the coverage area of the base station. This second embodiment of the invention can also be used as an optional additional step in the method according to the first embodiment.

The cell position information can be the identifier of the base station or a geographic area obtained by processing measurements of receive mode power performed by the transmitter-receiver 6 on at least the base station, or a geographic area corresponding to the coverage area of the base station
5 identified by its identifier.

Although the invention has been described in conjunction with particular embodiments, it is obvious that it is by no means limited thereto and that it includes all the technical equivalents of the means described and their combinations provided that they fall within the context of the invention.
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CLAIMS

1. Method of authenticating and validating position information reported by
5 a mobile device consisting in determining, on board the mobile device
(1), the position of the mobile device (1) based on GNSS navigation
signals emitted by a constellation of satellites (5a, 5b, 5c) and in
transmitting the position information obtained to a position server (3) via
10 a base station (7a, 7b, 7c) of a mobile communication cellular network,
the base station (7a, 7b, 7c) having a coverage area (8a, 8b, 8c), called
a cell, in which the mobile device (1) is located, characterized in that it
also consists in transmitting to the position server (3) position
information concerning the cell in which the base station (7a, 7b, 7c) to
15 which the mobile device (1) is connected is located, in checking, in the
position server (3), that the position of the mobile device (1) received is
included in the cell of the base station corresponding to the cell position
information received and, following the result of the check, in deciding
whether the position determined by the mobile device (1) based on the
20 navigation signals and transmitted to the position server is authentic or
if there is fraud.
2. Method according to Claim 1, characterized in that it consists in
transmitting to the position server (3) a succession of position
25 information items concerning the mobile device (1) and a succession of
position information items concerning the cells in which the base
stations are located, in comparing the succession of positions of the
mobile device (1) to the succession of positions of the cells and in
deciding whether the succession of positions transmitted by the mobile
30 device corresponds to an authentic trajectory followed by the mobile
device.

3. Method according to one of Claims 1 or 2, characterized in that the cell position information is an identifier of the base station (7a, 7b, 7c) transmitted to the position server (3) by the mobile device (1) in a message containing the position information concerning the mobile device (1) and the identifier of the base station (7a, 7b, 7c).
5
4. Method according to one of Claims 1 or 2, characterized in that the cell position information for the base station (7a, 7b, 7c) is transmitted to the position server (3) by a positioning node (10) of the cellular network in response to an interrogation of the position server (3) after reception of the message containing the position information concerning the mobile device (1) transmitted by the mobile device (1).
10
5. Method according to Claim 4, characterized in that the cell position information for the base station (7a, 7b, 7c) is an identifier of the base station.
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6. Method according to Claim 4, characterized in that the cell position information for the base station (7a, 7b, 7c) is a geographic area obtained by processing measurements of receive mode power by a mobile communication transmitter-receiver (6) placed on board the mobile device (1).
20
7. Method according to Claim 4, characterized in that the cell position information for the base station (7a, 7b, 7c) is a geographic area corresponding to the coverage area of the base station.
25
8. System for authenticating and validating position information reported by a mobile device, comprising:
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 - on board the mobile device (1), a location and broadcasting device (2) for generating and sending a message containing position information concerning the mobile device (1),

- a cellular communication network comprising at least one base station (7a, 7b, 7c) having a geographic coverage area (8a, 8b, 8c), called the cell, for transmitting the message containing the position information concerning the mobile device (1),
- 5 - a position server (3) connected to the cellular network to receive and process the message containing the position information concerning the mobile device (1),

characterized in that the cellular communication network also comprises means of locating the cell (8a, 8b, 8c) of the base station (7a, 7b, 7c) in
 10 which the mobile device (1) is located for delivering and transmitting position information concerning said cell to the position server (3) and in that the position server (3) comprises checking means for checking that the position of the mobile device (1) received is included in the cell of the base station corresponding to the cell position information received
 15 and, depending on the result of the check, for deciding whether the position determined by the mobile device (1) based on the navigation signals and transmitted to the position server is authentic or if there is fraud.

20 **9.** System according to Claim 8, characterized in that the location and broadcasting device (2) comprises a receiver (4) of GNSS navigation signals for determining the position of the mobile device (1) based on navigation signals emitted by a constellation of satellites, connected to a cellular communication transmitter-receiver (6) for sending the
 25 message containing the position of the mobile device (1) to the position server (3).

10. System according to one of Claims 8 or 9, characterized in that the location means of the cell (8a, 8b, 8c) of the base station (7a, 7b, 7c) in
 30 which the mobile device (1) is located comprise an identifier of the base station transmitted to the position server by the cellular communication transmitter-receiver (6) with the message containing the position

information concerning the mobile device (1).

- 5 **11.** System according to one of Claims 8 or 9, characterized in that the location means of the cell (8a, 8b, 8c) of the base station (7a, 7b, 7c) in which the mobile device (1) is located comprise a positioning node (10) of the cellular network for transmitting to the position server (3) position information concerning the base station corresponding to the cell in which the mobile device (1) is located.
- 10 **12.** System according to Claim 11, characterized in that the cell position information for the base station (7a, 7b, 7c) is an identifier of the base station.
- 15 **13.** System according to Claim 11, characterized in that the cell position information for the base station (7a, 7b, 7c) is a geographic area obtained by processing measurements of receive mode power by the mobile communication transmitter-receiver (6).
- 20 **14.** System according to Claim 11, characterized in that the cell position information for the base station (7a, 7b, 7c) is a geographic area corresponding to the coverage area of the base station.