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(54) Mobile telemetry apparatus

(57) Mobile telemetry apparatus for use in a vehicle, comprising a processor and a data storage unit containing a map database, the apparatus configured to store in a long term storage unit or to transmit to an external back-office system output data representative of the position or speed of the vehicle, the processor being programmed to respond to measured parameters indicative of vehicle motion and to access the map database representative of possible vehicle positions, to generate the output data; wherein the map database comprises a plurality of zones and a set of data reporting parameters associated with each zone, and the processor is programmed to determine in which zone the vehicle is positioned and to transmit the output data in accordance with the reporting parameters associated with that zone.

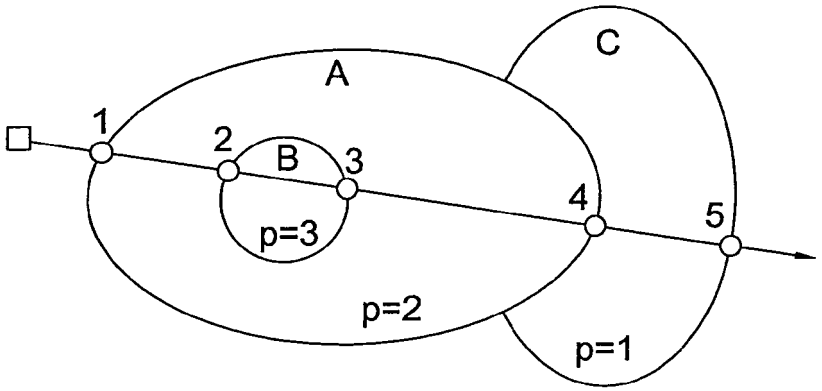

Fig. 1

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Description

[0001] This invention relates to mobile telemetry apparatus for use in a vehicle, and to a method of mobile telemetry. It is particularly useful in relation to Global Navigation Satellite System, GNSS, or other positioning systems, and is particularly useful for road vehicle user charging.

[0002] Existing mobile telemetry systems typically transmit a superset of data over mobile data networks such as the GSM, and these can incur significant operational charges that could be avoided if only the required data were transmitted. Alternatively the storage of this superset of data may require prohibitive amounts of on-device memory (e.g. flash memory) compared to only recording the data required at a particular location.

[0003] Typically, the amount of data, or the frequency of data, that are required to be transmitted to a back-office system, for example for road user charging, varies significantly as a function of the position of the vehicle, for example in an urban or suburban or motorway road scheme. Existing telemetry systems are unable to adapt to the transmission of only what is required at a given time.

[0004] Accordingly, the present invention provides mobile telemetry apparatus for use in a vehicle, comprising a processor and a data storage unit containing a map database, the apparatus configured to store in a long term storage unit or to transmit to an external back-office system output data representative of the position or speed of the vehicle, the processor being programmed to respond to measured parameters indicative of vehicle motion and to access the map database representative of possible vehicle positions, to generate the output data; wherein the map database comprises a plurality of zones and a set of data reporting parameters associated with each zone, and the processor is programmed to determine in which zone the vehicle is positioned and to transmit the output data in accordance with the reporting parameters associated with that zone.

[0005] The apparatus may have a transmitter configured for data communication with road-side apparatus, and the processor then may be configured to determine that the vehicle has moved to a new zone based on the data received from the road-side apparatus.

[0006] The vehicle position is preferably determined using a GNSS receiver. Where a GNSS receiver is used, the vehicle position data it provides are used as the measured parameters from which to derive the zone in which the vehicle is located.

[0007] Preferably, the map database comprises data indicative of a priority level for each zone, some at least of the zones partially overlapping each other, and the processor is programmed to determine that the appropriate set of data reporting parameters is that set associated with the zone with the higher or the highest priority level in the event that it determines the vehicle position to be in plural zones.

[0008] Preferably, the data reporting parameters comprise: the frequency of data reporting events, or the number of data reporting events for a given distance travelled, or the triggering of a data reporting event by a vehicle heading change of at least a predetermined angle or by a speed change of at least a predetermined speed difference, or an authentication key for the transmission, or more than one of the aforesaid parameters.

[0009] The invention also provides a method of mobile vehicle telemetry comprising transmitting to an external back-office system or storing in a long term storage unit output data representative of the position or speed of the vehicle, responding to measured parameters indicative of vehicle motion and accessing a map database representative of possible vehicle positions, to generate the output data; wherein the map database comprises a plurality of zones and a set of data reporting parameters associated with each zone; the method comprising determining in which zone the vehicle is positioned and transmitting the output data in accordance with the reporting parameters associated with that zone.

[0010] The implementation of location "awareness" in a mobile telemetry device in accordance with the invention allows the reporting or other behaviour of a road user charging or telemetry system to be changed to satisfy the operational requirements of the device at its current location.

[0011] Mobile telemetry equipment embodying the invention is made location-aware to behave correctly in multiple different operational scenarios. For example, in the road user charging domain the in-vehicle telemetry device may need to provide different access credentials for communication with road-side equipment according to its current location. Alternatively the device may need to change its reporting interval or reported parameter set according to location to meet the operational requirements of different charging schemes while minimising communicated data volumes and therefore operational cost.

[0012] Such changes in operational behaviour may be required when moving between different road user charging systems with different security, privacy, or enforcement legislation, for example when crossing international borders. Other examples include changing the reporting frequency in driver behaviour monitoring or "pay as you drive" insurance schemes as the vehicle moves between motorway, suburban, and urban road environments.

[0013] Location awareness in the telemetry unit is also beneficial in so-called back-office systems as it can significantly reduce computational load and therefore the cost of equipment and the related power consumption by allowing the elimination of data that is not relevant to the current operational scenario.

[0014] Preferably, the mobile telemetry device can dynamically modify its behaviour according to its current location in a collection of multiple potentially overlapping geographical regions as the zones. These regions may be defined arbitrarily as any geometric shape, such as a polygon or circle. Additionally it supports time-of-day restrictions to capture any required time-based behavioural changes. As a result the operational behaviour can be controlled in much finer detail than in existing systems, resulting in a more optimal use of scarce communications, data storage, and computing resources, and therefore it can reduce both equipment in the mobile and back office systems and operational costs.

[0015] In order that the invention may be better understood, a preferred embodiment will now be described, by way of example only, with reference to the accompanying schematic drawings, in which:

Fig. 1 shows an example of geographical zones on a map in accordance with a preferred embodiment of the invention;

Fig. 2 is a data flow diagram of the preferred embodiment of the invention; and

Fig. 3 is a block diagram of the embodiment of Figs. 1 and 2.

[0016] The telemetry apparatus consists of the following major subsystems: a mobile telemetry device fitted to the vehicle and comprising of a position determination unit (e.g. GNSS receiver), a processing unit, a communications unit for reporting (e.g. GPRS modem), a data storage unit, and a power supply; and a central processing facility (or "back office") which can communicate with the telemetry device via a communications network or by manual exchange of data storage media. Additional supporting systems may include positioning infrastructure, roadside equipment, and the communications network itself.

[0017] When the device is in operation the current position and velocity is periodically calculated by the position determination unit and sent to the processing unit. The processing unit is responsible for sub-sampling the position data, packaging and compressing the data for transmission or storage, and forwarding it to the back office via the communications network. The telemetry device may also receive commands and configuration data from the back office for remote device management.

[0018] The configuration parameters that control the sub-sampling process effectively determine the reporting behaviour of the device. In a typical implementation these parameters may include the maximum distance travelled or time elapsed between position reports, and/or the maximum change in heading or speed between position reports. Additional parameters may include the authentication keys required for communicating with the roadside equipment or the communications network.

[0019] The telemetry device supports the management of multiple groups of configuration parameters, with each group associated with at least one geographical region or zone. Through this association the behaviour of the device can be made to change according to its current location provided the device can identify the correct zone amongst several possibly overlapping alternatives.

[0020] One example, shown in Figure 1, is a collection of overlapping geographical zones A,B,C, although not all the zones need overlap. Each of these zones is given a priority $p>0$ such that a zone with a higher priority takes precedence over lower priority zones. It is also useful to define a default zone (not shown) with $p=0$ (the lowest priority) that encompasses all possible positions. For simplicity the zones are shown as ellipses, however in practice polygons are typically used with the edges corresponding to geographical features such as a road or legislative boundary.

[0021] The vehicle can enter a new zone by moving inside a zone with a higher priority than the current zone, or by moving outside the current zone into a zone of lower priority. Entry into a zone is detected by comparing the current position of the vehicle against a list containing the definitions of each zone using any appropriate "point-in-polygon" algorithm.

[0022] Note that "entry" into a zone is synonymous with "leaving" a different zone. A change in the current zone causes the system to generate a "zone event" signifying the change. This zone event can be used either within the telemetry device or in external supporting systems to trigger changes in behaviour or mode of operation.

[0023] The priority level, and a map database defining the zones, is stored in the data storage unit.

[0024] There could optionally be more than one set of zones, each set having a different set of priority levels, for respective reporting parameters.

[0025] For Figure 1, the sequence of generated events numbered 1 to 5 occurs as the vehicle crosses over the zone boundaries. Initially the vehicle moves from the default zone (priority 0, defined as everywhere other than the defined zones) into the first defined zone causing event 1. The sequence of generated zone events is:

Zone event	From Zone	To Zone
1	Default	A

(continued)

Zone event	From Zone	To Zone
2	A	B
3	B	A
4	A	C
5	C	Default

[0026] Each zone is associated with a data reporting parameter set that can cause a change in the behaviour of the telemetry device when that zone is entered. Such a parameter set may uniquely represent a particular set of operational requirements (e.g. a particular road user charging scheme), or may satisfy multiple sets of requirements through appropriate aggregation of requirements.

[0027] The parameter set associated with the current zone (i.e. the last zone to generate a zone event) stays in effect until it is superseded by a subsequent zone event. If no parameter set is associated with a zone then the current parameter set remains in effect, possibly indefinitely.

[0028] Because the change between parameter sets occurs on the transition into a new zone and not on inclusion inside a zone it is possible to dynamically change both the zone and parameter set definitions in real-time, for example over a communications link, without affecting the current behaviour. Such behaviour is desirable for avoiding disruption in the generated sub-sampled data stream as the vehicle crosses the zone.

[0029] For example consider the zones A, B, and C in Figure 1, each encompassing a different road user charging scheme, labelled Suburban Scheme, Urban Scheme, and Motorway Scheme respectively. If vehicles in the Urban Scheme also had to satisfy the operational requirements of the Suburban Scheme, then the parameter set for zone B would be constructed by merging the requirements from both schemes.

[0030] The exact algorithm for combining parameters depends on the nature of the parameter, but in this example the simple approach of choosing the value which results in the highest reporting rate is used. For example the 100 m and 1 km requirements for reporting by distance interval in the Urban Scheme and Suburban Scheme are combined to give a composite value of 100 m, thereby satisfying the requirements of both schemes.

Parameter	Set for Zone A	Set for Zone B	Set for Zone C
Applicable Schemes	Suburban Scheme	Urban Scheme Suburban Scheme	Motorway Scheme
Report by distance interval	100 m	100 m	10 km
Report by time interval	60 s	60 s	1 hour
Report by heading change	180°	45°	180°
Report by speed change	50 km/hour	50 km/hour	75 km/hour
Authentication key	EB5A	89FD	A78E
Network name	d78@local.network	d78@local.network	m12er@national.network

[0031] Given a new parameter set on entry into a zone, the processing unit can re-configure the communication devices as required, and re-initialise the sub-sampling algorithm to begin generating a data stream compliant with the operational requirements of the new zone.

[0032] If the reporting parameters are specified as deltas from the previously reported event (e.g. time since last reported event) then the sub-sampling algorithm can be efficiently implemented as a logical-OR operation. In the example the parameter set for Zone B results in the simple sub-sampling algorithm "if (vehicle has travelled more than 100 m since last reported event) or (more than 60 s has elapsed since the last reported event) or (the vehicle heading has changed by more than 45° since the last reported event) or (the vehicle speed has changed by more than 50 km/hour since the last reported event) then (generate a new reported event)". This approach is readily extendible to additional sub-sampling parameters. In a typical implementation the zone event generated on entry into a new zone forms the first reported event in the new sub-sampled sequence.

[0033] The sub-sampled events are then collated and compression to ensure efficient storage or transmission, and the resulting packaged events or either stored in the device data store or transmitted to the back office system for further

analysis and report generation.

[0034] The invention can be implemented as a combination of hardware and software suitable for installation in a vehicle.

[0035] A preferred implementation, as shown in Figure 3, uses a GNSS receiver as the position determination unit, a central processing unit (CPU) as the processing unit, non-volatile flash memory for storage of the software, zone definitions, parameter sets, and buffering of sub-sampled event data, and a GPRS or WiFi communications interface. The CPU executes customised software which includes the algorithms described above for detection of zone entry and sub-sampling of event data.

[0036] The implementation follows the description above and is shown in Figure 2. For every position event provided by the GNSS receiver the CPU first checks if the vehicle has entered a new zone by comparing the current position against the zone definitions held in flash memory. If a new zone has been entered and has a parameter set attached then the new parameter set takes effect in the CPU thus changing the device behaviour. In addition an event is added to the event buffer contained in the flash memory identifying where and when the new parameter set came into effect. The CPU continues to process positions from the GNSS receiver, applying the sub-sampling algorithm described above. The resulting sub-sampled events are also stored in the event buffer. When sufficient events have been buffered in the flash memory the CPU compresses the buffer and packages it for transmission to the back office via the communications interface and associated network. Alternatively the packaged event data may be stored permanently in the flash memory for later manual retrieval.

[0037] If the implementation includes facilities for communicating with road-side equipment (e.g. a DSRC modem) then the process of communicating with the road-side equipment can also be used to trigger entry into a defined zone. One particular use of this capability is to use the road-side equipment to place the mobile telemetry device in a high-reporting rate diagnostics mode, for example to obtain detailed event data from a suspicious or possibly faulty device.

[0038] The zone definitions are typically generated in the back office system using appropriate GIS tools, and similarly the associated parameter sets may be either manually or automatically generated using appropriate support tools in the back office system. If required the zone definitions and associated parameter sets can be sent to the telemetry device using the communications network thus facilitating remote maintenance of the device without removing it from the vehicle.

Claims

1. Mobile telemetry apparatus for use in a vehicle, comprising a processor and a data storage unit containing a map database, the apparatus configured to store in a long term storage unit or to transmit to an external back-office system output data representative of the position or speed or the vehicle, the processor being programmed to respond to measured parameters indicative of vehicle motion and to access the map database representative of possible vehicle positions, to generate the output data; wherein the map database comprises a plurality of zones and a set of data reporting parameters associated with each zone, and the processor is programmed to determine in which zone the vehicle is positioned and to transmit the output data in accordance with the reporting parameters associated with that zone.

2. Apparatus according to claim 1, comprising a transceiver configured for data communication with road-side apparatus.

3. Apparatus according to claim 2, in which the processor is configured to determine that the vehicle has moved to a new zone based on the data received from the road-side apparatus.

4. Apparatus according to any preceding claim, comprising a Global Navigation Satellite System, GNSS, receiver configured to provide, as the measured parameters, data indicative of vehicle position.

5. Apparatus according to any preceding claim, in which the map database comprises data indicative of a priority level for each zone, some at least of the zones partially overlapping each other, and the processor is programmed to determine that the appropriate set of data reporting parameters is that set associated with the zone with the higher or the highest priority level in the event that it determines the vehicle position to be in plural zones.

6. Apparatus according to any preceding claim, in which the data reporting parameters comprise: the frequency of data reporting events, or the number of data reporting events for a given distance travelled, or the triggering of a data reporting event by a vehicle heading change of at least a predetermined angle or by a speed change of at least a predetermined speed difference, or an authentication key for the transmission, or more than one of the aforesaid parameters.

7. Apparatus according to any preceding claim, in which the back-office system is arranged for road-user charging.

8. A method of mobile vehicle telemetry comprising transmitting to an external back-office system or storing in a long term storage unit output data representative of the position or speed of the vehicle, responding to measured parameters indicative of vehicle motion and accessing a map database representative of possible vehicle positions, to generate the output data; wherein the map database comprises a plurality of zones and a set of data reporting parameters associated with each zone; the method comprising determining in which zone the vehicle is positioned and transmitting the output data in accordance with the reporting parameters associated with that zone.

9. A method according to claim 8, comprising communicating with road-side apparatus.

10. A method according to claim 9, comprising determining that the vehicle has moved to a new zone based on data received from the road-side apparatus.

11. A method according to any of claims 8 to 10, comprising receiving GNSS transmissions to provide, as the measured parameters, data indicative of vehicle position.

12. A method according to any of claims 8 to 11, in which the map database comprises data indicative of a priority level for each zone, some at least of the zones partially overlapping, and the method comprises determining that the appropriate set of data reporting parameters is that set associated with the zone with the higher or the highest priority level in the event that the vehicle position is determined to be in plural zones.

13. A method according to any of claims 8 to 12, in which the data reporting parameters comprise: the frequency of data reporting events, or the number of data reporting events for a given distance travelled, or the triggering of a data reporting event by a vehicle heading change of at least a predetermined angle or by a speed change of at least a predetermined speed difference, or an authentication key for the transmission, or more than one of the aforesaid parameters.

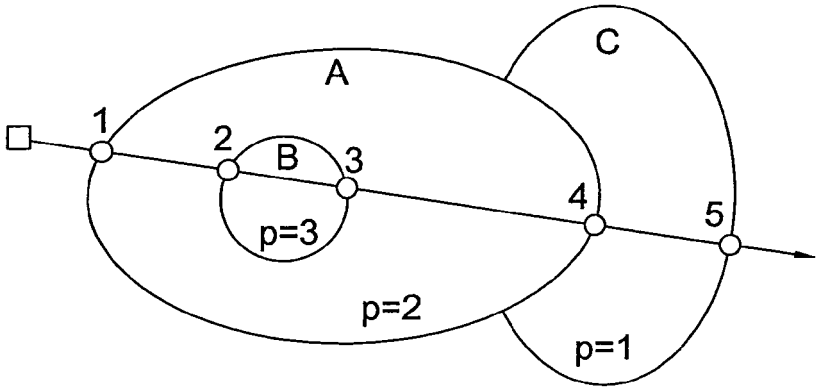
A
B
C
1
2
3
4
5
p=3
p=2
p=1

Fig. 1

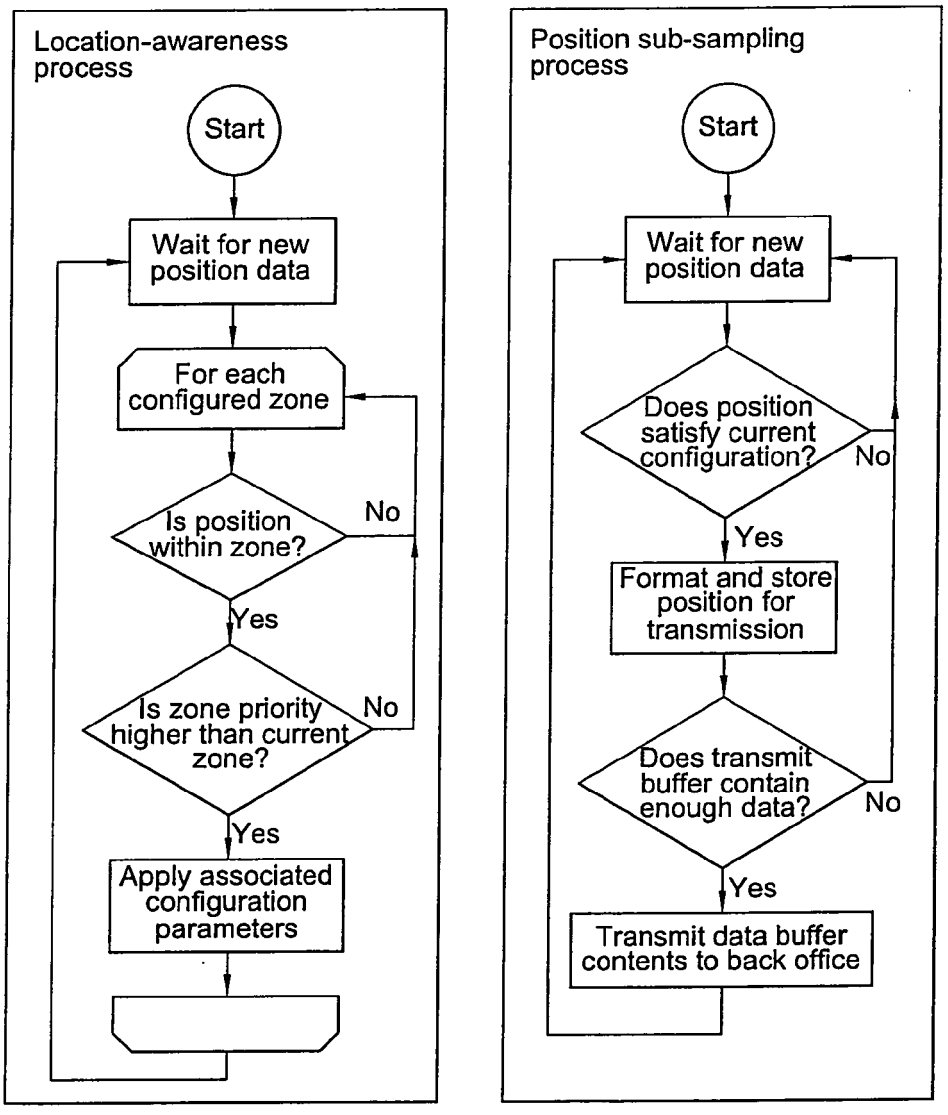
Location-awareness process
Start
Wait for new position data
For each configured zone
Is position within zone?
No
Yes
Is zone priority higher than current zone?
No
Yes
Apply associated configuration parameters
Position sub-sampling process
Start
Wait for new position data
Does position satisfy current configuration?
No
Yes
Format and store position for transmission
Does transmit buffer contain enough data?
No
Yes
Transmit data buffer contents to back office

Fig. 2

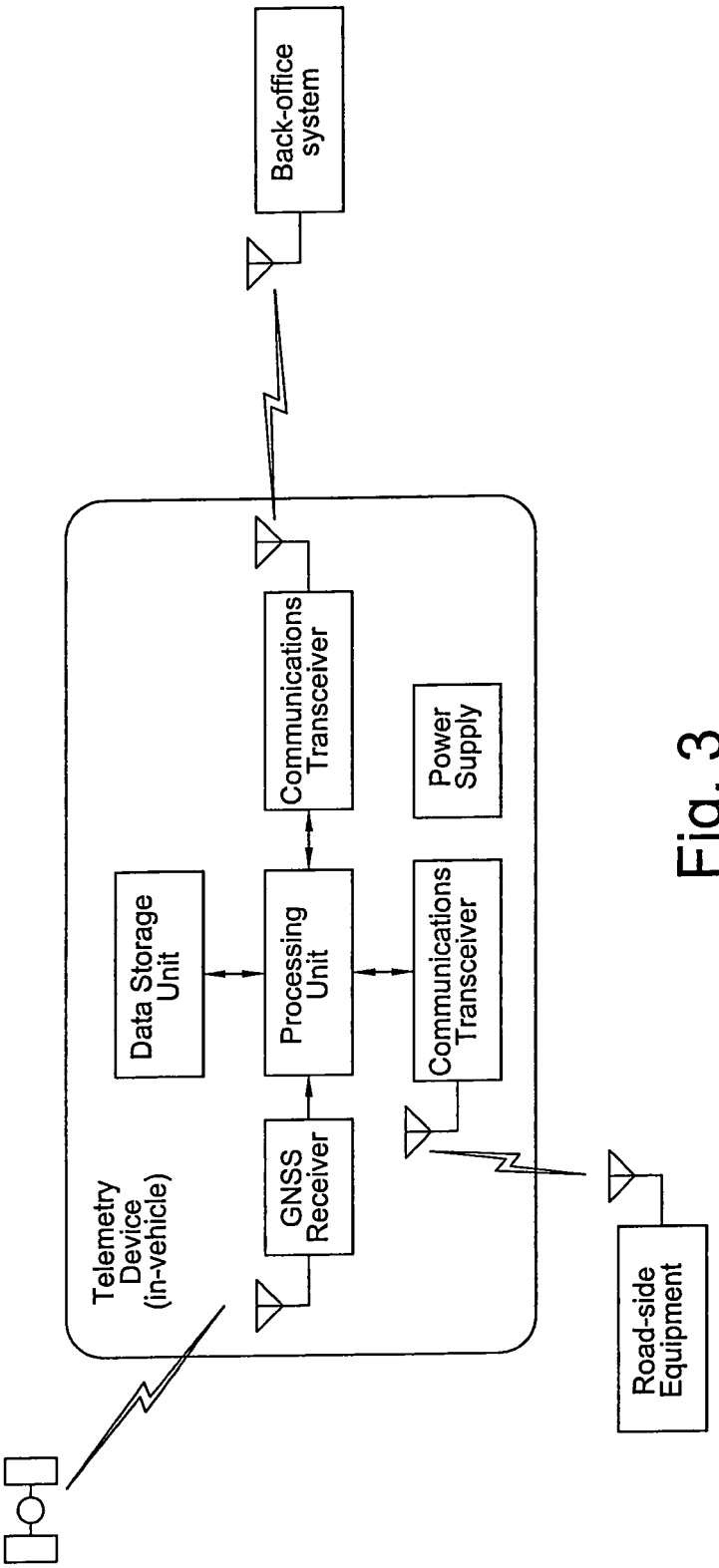
Back-office system
Telemetry Device (in-vehicle)
Communications Transceiver
Power Supply
Data Storage Unit
Processing Unit
Communications Transceiver
GNSS Receiver
Road-side Equipment

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 10 25 2110

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	9 May 2011	Quartier, Frank

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

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