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(71) Applicant: **Kapsch TrafficCom AB**
551 10 Jönköping (SE)

(72) Inventor: **Rogö, Johan**
566 35 Habo (SE)

(74) Representative: **Zacco Sweden AB**
P.O. Box 5581
114 85 Stockholm (SE)

(54) **Lean map matching OBU with an adaptive digital map**

(57) The object of the present invention is to provide a method for calculating a road charge for a vehicle, whereby said vehicle is provided with an OBU, wherein the OBU is provided with a GNSS receiver. The OBU is adapted to communicate with a central system and to receive position-information from the GNSS receiver. The OBU is provided with road charge object data regarding primary road charge objects and the central system is provided with road charge object data regarding at least secondary road charge objects. The OBU can detect passages of primary road charge objects and when the vehicle is travelling outside of the primary road charge object zone the OBU transmits information regarding the position of the vehicle to the central system such that the central system can detect passages of secondary road charge objects. The inventive method also comprises detection of appropriate updates of the road charge object data and methods for updating the road charge object data. The invention also relates to a system running such method.

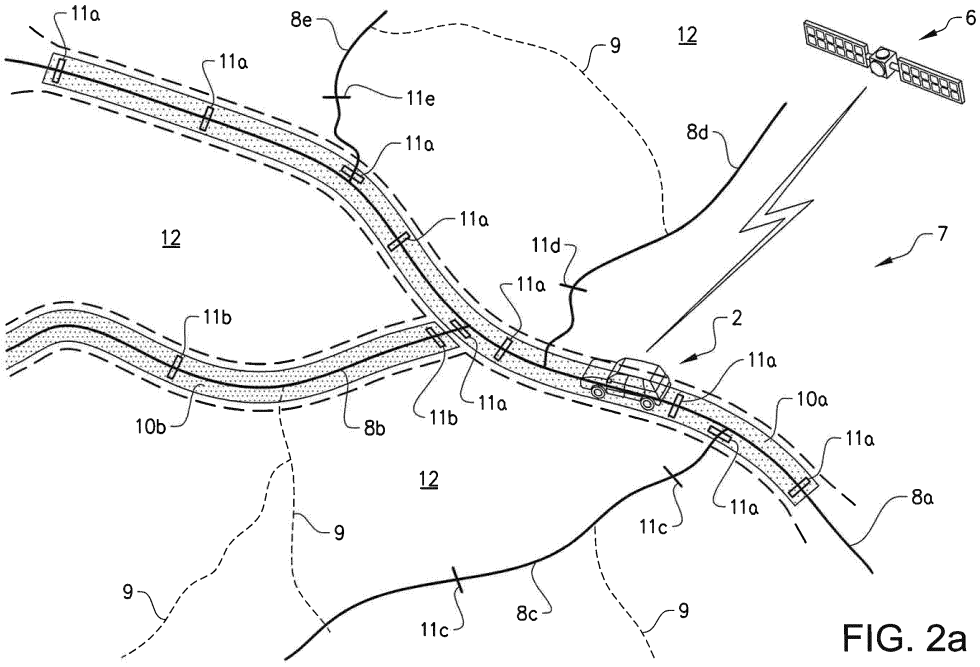

FIG. 2a

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of electronic road charge systems, and particularly to a method for calculating a road charge for a vehicle provided with an on board unit (OBU), wherein the OBU is provided with a GNSS receiver and adapted to communicate with a central system. According to the inventive method the road charge object detection responsibility is divided between the OBU and the central system. By applying the inventive method it is possible to optimize the OBU from a complexity and cost perspective, and to optimize the amount of transmitted data between the OBU and the central system.

BACKGROUND ART

[0002] Over the past years, it has become more and more common to impose busy roads, bridges, city limits etc. with road charge. The primary object can either be to obtain an economic contribution to construction and maintenance of the infrastructure or to in some way restrict or control the traffic. Road charge may e.g. be used as an instrument to redirect traffic from busy areas or roads, to distribute the traffic flow over a longer period of time or to create an incentive for higher usage of public transportation.

[0003] For the first implemented road charge systems, which mainly concerned freeways, the fee collection was often handled manually at certain check points, which was both costly and time consuming. Today, camera based road charge collecting systems or systems using some kind of transponder and gantries are most common. The camera based systems are dependent on that the number plate of the vehicle is clearly visible. Conventional road charge collecting systems using transponders and gantries generally comprise an OBU, arranged in a vehicle, which is connecting to a second unit such as e. g. a road side unit (RSU), which in turn is connected to a central system. These systems are neither dependent on visual detection nor of the need of manual work to perform the road charge transaction. GNSS systems, such as e.g. GPS, can also be used in order for road charge collecting systems to keep track of a vehicle, and based on the driven path of the vehicle establish a road charge. Such systems need to be provided with information regarding the position of the vehicle, and also with a digital map regarding what roads, areas and like that are subjected to road charge. In this context, a digital map do not necessarily need to be a regular map but may be a database comprising a set of geographical objects, positions, road sections, areas or like.

[0004] Matching the positions of the vehicle to the digital map, and performing related road charge calculations, can either be performed in the OBU or in the central system. If the map matching is performed in the OBU, it is required that the OBU comprises a digital map with information regarding charge tariffs for roads, areas or like for all roads or areas where the vehicle might be travelling. This requires continuous updating of the digital map and requires advanced OBUs with large memory capacity. This makes such OBUs complex and expensive. If the map matching and road charge calculation is performed in the central system, it is required that the central system continuously is provided with the position of the vehicle. This means that a large amount of data needs to be transmitted from the OBU to the central system.

[0005] Thus, there is a need for further improvements.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is to provide a method for calculating road charge for vehicles which requires less advanced on board units (OBUs) in regard of complexity and memory capacity, as well as minimizing the quantity of data that has to be transmitted between the OBU and the central system. This enables that smaller and less costly OBUs can be used.

[0007] It has been concluded that the vast majority of the travelled mileage, in particular for commercial vehicles, is conducted on a few percent of the roads of the entire road network. By utilizing the fact that the majority of travelled mileage is conducted on a few percentage of the roads, it is possible to divide the road network such that one group of roads may represent the majority of all travelled mileage although only comprising a minority of available roads. This can be used in order to improve how the road network is divided in regard of road charge. According to the inventive method roads of a road network that are provided with road charge are divided by establishing certain road charge objects. A road charge object is a predefined geographical object representing a passage on a road section that when it is crossed will trigger that an event is detected. There are various ways in which such road section can be defined, all of which are considered to be within the scope of the invention. Such event may be that a road charge will be charged the vehicle travelling said road section according to a predetermined tariff. The road charge objects are divided into primary and secondary road charge objects, wherein the most frequently used roads are roads provided with the primary road charge objects and the not as frequently used roads are roads provided with the secondary road charge objects.

[0008] According to a preferred aspect of the inventive method a vehicle is provided with an OBU, wherein the OBU is adapted to receive position-information from any type of position determination system, preferably by using a receiver. These position determination systems are commonly referred to as GNSS systems and will be described together with the concept of position-information in more detail later. The OBU is provided with road charge object data regarding a predefined number of primary

road charge objects and is adapted to communicate with a central system. The central system is provided with road charge object data regarding at least a predefined number of secondary road charge objects. The road charge object data comprises a continuously updated digital map of respective road charge objects, such that if the position of the vehicle is known it is possible to determine when the vehicle has passed respective road charge object. According to a preferred aspect of the inventive method the road charge object data of respective road charge object comprises a defined geographical area surrounding respective road charge object. This is referred to as the geo-zone of that road charge object.

[0009] Additionally, the central system is adapted to process vehicle passages of road charge objects for calculation of a road charge. According to the inventive method the OBU continuously is receiving position-information, and based on the position-information the OBU detects passages of a primary road charge objects. The OBU subsequently transmits such passages of primary road charge objects to the central system. The transmission can be performed instantly or at discrete times. Such discrete times may be when predefined conditions are fulfilled such as that at least at predetermined time interval has passed. After receiving the passages of the primary road charge objects the central system processes the passages of the primary road charge objects.

[0010] By utilizing the fact that the majority of travelled mileage is conducted on a few percentages of the roads it is possible to provide the OBU with road charge data for the majority of the travelled mileage without requiring advanced OBUs with large memory capacity. This has the advantage that the OBU does not need to transmit the position of the vehicle to the central system continuously which means the less information needs to be transmitted. What need to be transmitted as long as the vehicle travels on roads provided with primary road charge objects are just the passages of primary road charge objects, which as stated preferably can be done at discrete times.

[0011] According to one aspect of the inventive method the OBU preferably also comprises detection means, storing means and communication means, whereas the central system preferably comprises detection means, calculation means, storing means and communication means.

[0012] According to another aspect of the inventive method detection of such an event referred to above may also trigger that a recording of relevant information such as e.g. recently travelled route and/or engine parameters is created. What information that is recorded is dependent on respective embodiment of the inventive method and different variations are considered to be within the scope of this invention. This is referred to as charge object recording and will be disclosed more in detail later throughout the description.

[0013] As previously stated, the OBU is provided with a GNSS receiver, meaning that the OBU either comprises a GNSS receiver or is arranged in connection to a GNSS receiver, such that the GNSS receiver can provide the OBU with information. The information the GNSS receiver provides to the OBU comprises information regarding the position of the vehicle in which the OBU and the GNSS receiver is provided or information enabling the OBU to determine the position of the vehicle. This is referred to as position-information. The position of the vehicle may be determined by using any suitable Global Navigation Satellite Systems (GNSS) systems such as e.g. GPS, Galileo or GLONASS, but can also be determined by using other available means such as WiFi, or the cellular network. All these embodiments are considered to be comprised in the term referred to as GNSS system, and with the term GNSS receiver a receiver configured to receive information of such system is referred to. The determination of the position of the vehicle, either in the OBU or at the central system, by using a GNSS receiver or like is not part of the invention per se and is considered to be known to a person skilled in the art.

[0014] According to yet another aspect of the inventive method a group of road charge objects constitute a road charge object zone. The road charge objects can thereby be divided into primary and secondary road charge objects zones comprising the geo-zone of respective road charge object. The geo-zones of respective road charge object can preferably be used at the creation of road charge object recordings.

[0015] As previously stated, the OBU is provided with charge object data for the primary road charge objects, and such charge object data comprises a number of positions before and after respective primary road charge object. The primary road charge objects, and preferably a number of positions before and after respective primary road charge object, defines respective primary road charge object zone. The road charge object data of the primary road charge objects of a primary road charge object zone the OBU is provided with is adapted such that the as long as the vehicle is travelling within said primary road charge object zone the position of the vehicle can be determined by the OBU.

[0016] According to one aspect of the inventive method the OBU can detect that the vehicle is present within a secondary road charge object zone by that it is predefined that the vehicle is present in a secondary road charge object zone if the vehicle is outside the primary road charge object zone. Thus, according to one aspect of the inventive method when the OBU detects that the vehicle enters or is present within a secondary road charge object zone the OBU continuously transmits the position of the vehicle to the central system. As will be disclosed in detail later, the positions may be transmitted instantly or at discrete times, wherein if the positions are transmitted at discrete times the positions need to be stored in the OBU before being transmitted.

[0017] Thus, the OBU is provided with charge object data for primary road charge objects such that the OBU can determine, when being provided with position-infor-

mation from the GNSS receiver or like, if the vehicle in which the OBU is provided is travelling within or is entering a primary road charge object zone. According to one aspect of the inventive method, if the OBU cannot determine that the vehicle is travelling within the primary road charge object zone, which is the geographical area for which the OBU is provided with charge object data for, the vehicle provided with the OBU is travelling within a secondary road charge object zone.

[0018] By only transmitting the position of the vehicle from the OBU to the central system when the vehicle is present within a secondary road charge object zone the amount of transmitted information can be reduced considerably.

[0019] According to one other aspect of the inventive method the OBU may be provided with information for detecting when the vehicle is present within a specific secondary road charge object zone. If the OBU is provided with data for detecting when the vehicle is present within a specific secondary road charge object zone the secondary road charge objects zones preferably are reasonably simple geographical or geometrical objects which require insignificant memory capacity of the OBU.

[0020] According to one aspect of the inventive method roads without road charge objects are not subjected for road charge. Such roads are referred to as roads provided with no road charge objects.

[0021] Roads provided with no road charge objects can be dealt with according to two different approaches.

[0022] According to one aspect of the inventive method information necessary to identify when the vehicle is travelling on roads provided with no road charge object is preferably provided to the OBU such that the OBU can determine that neither information regarding such roads needs to be stored in the OBU nor transmitted to the central system.

[0023] According to another preferred aspect of the inventive method information necessary to identify when the vehicle is travelling on roads provided with no road charge objects may be provided in the central system. Thus, the central system will be able to detect when the vehicle is travelling on such roads when being provided with position-information from the OBU.

[0024] According to yet one aspect of the inventive method the central system is receiving the transmitted position of the vehicle when the vehicle is present within a secondary road charge object zone. The central system is provided with road charge object data for at least the secondary road charge objects and can use the continuously received position of the vehicle to detect a passage of a secondary road charge object. The central system can also be provided with road charge object data for the primary road charge objects.

[0025] Since the roads provided with primary road charge objects represent the most frequently travelled roads, and these are the roads that the OBU is provided with road charge object data for, and the central system is provided with road charge object data for the secondary road charge objects, which represents the not so frequently travelled roads, the map matching responsibility can be divided between the OBU and the central system. By dividing the road charge object detection responsibility between the OBU and the central system it is possible to minimize the amount of information that needs to be transmitted between the OBU and the central system. The central system may store the detected passage of a secondary road charge object for later processing.

[0026] According to one aspect of the inventive method the OBU transmits the passage of the primary road charge objects from the OBU to the central system at the time of the passage.

[0027] Transmitting the passage of a primary road charge object at the time of the passage has the advantage that the central system will be provided with the information regarding the passage of a primary road charge object instantly.

[0028] According to another aspect of the inventive method the method comprises that the OBU stores passages of the primary road charge objects in the OBU as they are detected, wherein a number of passages forms a package of detected road charge object passages. These stored passages are subsequently transmitted from the OBU to the central system when any of a number of predefined conditions is fulfilled.

[0029] The OBU may e.g. store passages of the primary road charge objects and transmit the package of passages at predefined times. The passages of primary road charge objects stored in the OBU can also be transmitted from the OBU to the central system when a memory capacity of the OBU reaches a predefined threshold value such as predefined memory capacity utilization levels

[0030] These aspects of the method have the advantage that stored passages of primary road charge objects needs to be transmitted less often. How often the stored passages are sent from the OBU to the central system may e.g. be dependent on the memory capacity of the OBU. Consequently the memory capacity of the OBU can be optimized according to how often it is desired that passages of primary road charge objects are transmitted. Also, this aspect of the method has the advantage that the OBU is not dependent on continuous connection to the central system as long as the vehicle is present within a primary road charge object zone.

[0031] According to another aspect of the method the OBU transmits stored passages of primary road charge objects from the OBU to the central system according to predefined time intervals.

[0032] This aspect of the method has the advantage that the information regarding passages of primary road charge objects can be transmitted on a timely basis, such as e.g. hourly, daily, weekly for timely reoccurring calculation of road charge.

[0033] The aspect of the method where the transmitting of passages of primary road charge objects are performed on timely basis is preferably combined with the

aspect of the method where passages of primary road charge objects are transmitted when the memory capacity of the OBU reaches the predefined threshold value for redundancy.

[0034] In a preferred aspect of the inventive method the memory of the OBU is formatted, or the stored passages of primary road charge objects are set to be overwritten, once the information regarding stored passages of primary road charge objects are transmitted to the central system.

[0035] The central system may store the detected passages of a secondary road charge objects and the received passages of primary road charge objects for later processing or process them for road charge calculation when the passage is detected or received respectively.

[0036] According to a preferred aspect of the inventive method a number of the most recent previous positions of the vehicle are continuously stored in the memory of the OBU in order to be able to follow the movements of the vehicle. Additionally, according to the inventive method, the method comprises creating of a road charge object recording when passing a primary or secondary road charge object. The road charge object recording preferably comprises a first number of the most recent previous positions of the vehicle, preceding the passage of the road charge object with respective time stamp. The time stamp may comprise information regarding e.g. date and time for the passage. Additionally, the road charge object recording may comprise the ID of the road charge object and a message authentication code. The message authentication code can be an automatically generated code or like which can be used in order to verify that the recording is authentic. Finally, the road charge object recording may comprise a second number of vehicle positions, subsequent to the passage of the road charge object, with respective time stamp. The recording of subsequent vehicle positions is terminated after the second number of vehicle positions has been recorded. Also the second numbers of vehicle positions are stored with respective time stamp.

[0037] In a preferred embodiment of the inventive method the charge object recording comprises all of the above stated recordable information.

[0038] According to yet another aspect of the inventive method all road charge objects are provided with a road charge object ID. The road charge object ID is preferably provided in the road charge object data of the road charge objects. Also the primary and secondary road charge object zones can be provided with individual road charge object IDs.

[0039] The method also comprises creating of a road charge object recording at a passage of a secondary road charge object. The road charge object recording created at the passage of a secondary road charge object preferably comprises the same information as a charge object recording created at the passage of a primary road charge object.

[0040] By analyzing the road charge object recordings it is possible to identify and map up the movements of a specific vehicle, and the charge object recording may e. g. be used during disputes and litigations regarding road charge.

[0041] The creation of the road charge object recording can be performed either by the OBU or by the central system. According to one aspect of the inventive method the creation of the road charge object recording is performed in the OBU when the OBU detects that the vehicle is passing a primary road charge object and in the central system when the central system detects that the vehicle is passing a secondary road charge object. The road charge object recording created in the OBU is preferably transmitted from the OBU to the central system together with the passage of the primary road charge object. Transmitting road charge object recordings created in the OBU at the passage of respective primary road charge object together with the passage of the primary road charge object, wherein said passage can be transmitted at the time of the passage, when the memory capacity of the OBU reaches a predefined threshold value at predetermined time intervals or when other conditions are fulfilled, has the advantage that no additional transmissions is required due to the creation of the road charge object recording.

[0042] It is also an object of the present invention to provide a system comprising an OBU, wherein the OBU is provided with position receiving means such as a GNSS receiver, and a central system, wherein said system is characterized in that it is running the inventive method.

[0043] According to the inventive system the OBU provided with position receiving means such as a GNSS receiver is provided in the vehicle. The OBU is configured to communicate with the central system and to be provided with position-information from the GNSS receiver. The OBU is provided with processing means adapted to detect passages and with road charge object data regarding primary road charge objects, such that the OBU can detect when the vehicle in which the OBU is provided is passing a primary road charge object. The processing means are also adapted to transmit a detected passage of a primary road charge object to the central system.

[0044] The OBU is further adapted to detect when the OBU enters a secondary road charge object zone and continuously store and transmit the position of the OBU to the central system as long as the OBU, and thus the vehicle in which the OBU is provided, is present within a secondary road charge object zone. The OBU can e.g. transmit the stored positions continuously, at predefined times or at predefined memory capacity utilization levels.

[0045] The central system is configured to communicate with the OBU to continuously receive information regarding the position of the vehicle when transmitted from the OBU. The central system is provided with road charge object data regarding at least secondary road charge objects and means adapted to detect a passage of a secondary road charge object such that the central

system can detect a passage of a secondary road charge object based on information transmitted from the OBU. The central system is additionally configured to receive passages of primary road charge objects, detected by the OBU, and subsequently transmitted from the OBU to the central system. Further, the central system is provided with means for storing passages of primary and secondary road charge objects and means for processing passages of primary and secondary road charge objects for calculation of a road charge.

[0046] Thus, by utilizing the fact that the majority of travelled mileage is conducted on a few percentage of the roads, the road charge objects of the road network can be divided in primary road charge objects and secondary road charge objects, wherein the primary road charge objects represents the majority of all travelled mileage although only comprising a minority of available road charge objects. By dividing the road charge object detection responsibility between the OBU and the central system, and by providing the OBU with road charge object data regarding the primary road charge objects and the central system with road charge object data regarding secondary road charge objects, it is possible to significantly reduce the amount of data that needs to be transmitted between the OBU and the central system. It is also possible to optimize the OBU since less advanced OBUs is required with less memory capacity, thus less expensive OBUs can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047]

Fig. 1 shows a schematic drawing of a vehicle provided with an OBU and a GNSS receiver,

Fig. 2a-c schematically shows a road network,

Fig. 3 shows a flowchart over the inventive method,

Fig. 4 shows a flowchart over the creation of a road charge object recording, and

Fig. 5 shows a flowchart over one example of how an OBU can be updated.

DETAILED DESCRIPTION

[0048] Fig. 1 shows a system 1 for calculating a road charge for a vehicle 2. The system comprises an on board unit (OBU) 3, a central system 4 and a GNSS receiver 5, wherein the OBU 3 and the GNSS receiver 5 is provided in the vehicle 2. The GNSS receiver 5 is configured to receive signals from satellites 6, such that the GNSS receiver can determine the position of the vehicle 2. The GNSS receiver 5 is provided in connection to the OBU 3, such that the GNSS receiver can provide the OBU 3 with information enabling the OBU to determine the position of the vehicle 2. Further, the OBU 3 is provided to transmit the position of the vehicle 2 to the central system 4 when that is required.

[0049] According to the inventive method the OBU 3 is provided with a digital map covering the most frequently used roads while the central system 4 is provided with a digital map covering all roads or just roads outside of the most frequently used roads. By providing the OBU 3 with a digital map covering the most frequently used roads, the OBU 3 is only required to transmit information regarding the position of the vehicle 2 to the central system 4 when the vehicle 2 is travelling on roads subjected to road charge but still outside of the most frequently used roads.

[0050] Fig. 2a, 2b and 2c shows schematic drawings of an example of a road network 7, and how said road network 7 is divided in roads provided with primary road charge objects, roads provided with secondary road charge objects and road charge object zones according to an embodiment of the inventive method. Fig. 2a, 2b and 2c are solely for clarification purposes of the embodiment and should not be interpreted to be limiting for the invention. Fig. 2a, 2b and 2c are not shown to scale.

[0051] According to the embodiment shown in fig. 2a the road network 7, comprises roads 8a;8b;8c;8d;8e subjected to road charge and roads not subjected to road charge 9. The roads not subjected to road charge 9 are roads provided with no road charge objects. According to the embodiment shown in fig. 2a the roads 8a;8b represent the most frequently used roads and the roads 8c;8d;8e represent not so frequently used roads. The most frequently used roads 8a;8b are examples of roads provided with primary road charge objects whereas the not so frequently used roads 8c;8d;8e are examples of roads provided with secondary road charge objects. The roads provided with primary road charge objects 8a;8b are encapsulated by a dotted area respectively, wherein said dotted areas represent primary road charge object zones 10a;10b. Outside of the primary road charge object zones 10a;10b are dashed lines indicating the borders of secondary road charge object zones 12. The primary road charge object zones 10a;10b comprise the roads provided with primary road charge objects 8a;8b whereas the secondary road charge object zones 12 comprise the roads provided with secondary road charge objects 8c;8d;8e. Further, as can be seen from the embodiment shown in fig. 2a, a vehicle 2 is travelling on the road provided with primary road charge objects 8a, wherein the vehicle 2 is receiving signals from a satellite 6. The satellite 6 represents one of many satellites in a system of satellites from which the vehicle 2 is receiving signals in order to be able to establish the position of the vehicle 2.

[0052] Within the primary road charge object zones 10a;10b are primary road charge objects 11a;11b located. As is schematically shown in fig. 2a the primary road charge objects 11a;11b are preferably arranged at road exits and on longer road sections, which can be suitable passages to provide with a road charge. In the embodi-

ment shown in fig. 2a all roads or areas outside the primary road charge object zones 10a;10b are part of the secondary road charge object zones 12. In the secondary road charge object zones 12 secondary road charge objects 11c;11d;11e are located. Additionally, roads 9 provided with no road charge objects are shown.

[0053] According to the inventive method for calculating road charge, and by referring to the embodiment shown in fig. 2a: A vehicle 2, travelling on the road provided with primary road charge objects 8a, is provided with an OBU and a GNSS receiver. The GNSS receiver is connected to the OBU and is receiving signals from satellites 6 in order to be able to determine the current position of the vehicle 2. The OBU is additionally provided with road charge object data for the primary road charge objects 11a;11b. A central system is also part of the system running the method for calculation of road charge. The central system is at least provided with road charge object data regarding the secondary road charge objects 11c;11d;11e. As long as the vehicle 2, provided with the OBU, is travelling on the most frequently used roads 8a;8b the OBU is provided with road charge object data for detecting when the vehicle passes a primary road charge object 11a;11b. When the vehicle 2 passes a primary road charge object 11a;11b the passage is detected by the OBU, and is subsequently transmitted to the central system. The transmission can be performed instantly or the detected passage may be stored in the OBU and subsequently transmitted when predefined conditions are fulfilled. If the vehicle 2 leaves the most frequently used roads 8a;8b the OBU detects that the vehicle is present within a secondary road charge object zone 12 by detecting that no road charge object data for the road the vehicle 2 currently is travelling on is available in the OBU, thus the vehicle 2 is travelling within a secondary road charge object zone 12.

[0054] This initiates that the OBU starts to transmit information regarding the position of the vehicle 2 to the central system. As long as the vehicle 2 is present within the secondary road charge object zone 12 the OBU continuously transmits information regarding the position of the vehicle 2 to the central system. The central system receives the information transmitted from the OBU, and since the central system is provided with road charge object data for at least the secondary road charge objects 11c;11d;11e, the central system can detect passages of secondary road charge objects 11c;11d:11e.

[0055] By dividing the map matching responsibility between the OBU and the central system less complex OBUs can be used and less information needs to be transmitted between the OBU and the central system.

[0056] Referring now to fig. 2b, showing a close up of segments of the most frequently used roads provided with primary road charge objects 8a;8b, and primary road charge object zones 10a;10b comprising primary road charge objects 11a;11b.

[0057] In the embodiment shown can be seen that a not shown vehicle travelling on the road 8d pass a primary road charge object 11a when entering into the primary road charge object zone 10a. Also when exiting the primary road charge object zone 10a the vehicle passes a primary road charge object 11a. Correspondingly, when entering the road provided with primary road charge objects 8b the vehicle will pass a primary road charge object 11b. Fig. 2b shows examples of how the road charge objects 11a;11b can be provided.

[0058] Fig. 2c shows an embodiment where a further close up of a road 8a and a road charge object 11a is shown. As has been stated before, a vehicle using the inventive method is provided with an OBU and a GNSS receiver, wherein the GNSS receiver is connected to the OBU. The GNSS receiver is continuously receiving signals from satellites and is continuously determining the position of the vehicle in which the GNSS receiver is provided. In fig. 2c can be seen that along a route of a vehicle travelling on the road 8a provided with primary road charge objects a number of vehicle positions 13 are indicated. According to the embodiment shown in fig. 2c the vehicle positions 13 are indicating positions of the vehicle where the GNSS receiver of said vehicle has determined the position of the vehicle. A number of the most recent previous vehicle positions 13 are continuously, temporarily stored in the memory of the OBU. This enables that it is possible to track the movements of a vehicle before passing a road charge object 11a. By storing a number of vehicle positions 13 before and after passing a road charge object 11a, the passage of the road charge object 11a can be stored together with a recording of the movement of the vehicle before and after said passage in a road charge object recording.

[0059] Tracking the movements and continuously storing a number of the latest vehicle positions of the vehicle can be useful e.g. for mapping driving behavior, in order to facilitate backtracking of the movements of the vehicle or in order to facilitate law enforcement.

[0060] Fig. 3 shows a flowchart over one embodiment of the inventive method. The system using the method comprises an OBU, a GNSS receiver and a central system. The OBU is provided with road charge object data for primary road charge objects and the central system is provided with road charge object data for at least secondary road charge objects. The method is initiated by that a GNSS receiver, which is receiving signals from satellites, determines the position of the vehicle and communicates the position-information to the OBU, 300. Based on the position-information the OBU can detect if the vehicle is present within a primary or secondary road charge object zone, and can detect passages of primary road charge objects 310.

[0061] If a passage of a primary road charge object is detected 310, according to the embodiment of the inventive method shown in fig. 3 a road charge object recording is created 320. The creation of the road charge object recording 320 is further described in connection with the embodiment shown in fig. 4.

[0062] If the OBU detects that the vehicle is present

within a secondary road charge object zone the OBU starts to transmit the information regarding the position of the vehicle to the central system 330. The detected positions may either be transmitted instantly or may be stored in the OBU in position packages which subsequently are sent when at least one predetermined condition is fulfilled. Such predefined condition may be that a number of positions are stored, that the memory capacity of the OBU has reached a predefined utilization level or that a predefined time interval has passed. The central system receives the information regarding the position of the vehicle, and can based on that information detect if the vehicle passes a secondary road charge object 340. The secondary road charge object zones can comprise both road sections provided with secondary road charge objects and roads provided with no road charge objects. According to the embodiment shown in fig. 3, when the central system detects a passage of a secondary road charge object 340 a road charge object recording is created 350, as is further described in connection with the embodiment shown in fig. 4. The road charge object recording is thereafter stored in the central system 370.

[0063] If the road charge object recording is created in the OBU, the road charge object recording is transmitted to the central system 360 where the road charge object recording is stored 370. The stored road charge object recordings are thereafter processed for calculation of road charge 380.

[0064] Additionally, the OBU can be updated 390 according to an updating method such as the one described in connection to the embodiment of the shown in fig. 5.

[0065] As previously disclosed, fig. 4 shows an example of how a road charge object recording can be created at the passage of a primary or secondary road charge object. The creation of the road charge object recording is initiated by that a passage of a primary or secondary road charge object is detected 400. Passages of primary road charge objects are detected by the OBU and passages of secondary road charge objects are detected by the central system. At the detection of a passage of a road charge object the creation of a road charge object recording is initiated 410. According to a preferred aspect of the inventive method a number of the most recent previous positions of the vehicle is continuously and temporarily stored in a memory of the OBU or of the central system, depending on if the vehicle is present within a primary or secondary road charge object zone, in order to be able to continuously follow the movements of the vehicle.

[0066] According to another preferred aspect of the inventive method, as stated every road charge object is provided with a respective geographical zone surrounding respective road charge object, referred to as geo-zone. When a charge object recording is created preferably a number of vehicle positions within such zone are stored.

[0067] At the creation of the road charge object recording 410 a first number of previous vehicle positions, preferably from within the geo-zone of respective road charge object, is stored with respective time stamp, wherein the time stamp may comprise information regarding e.g. date and time of the passage, together with the road charge object ID of concerned road charge object 420. Also, at the creation of a road charge object recording 410 a second recording of a second number of vehicle positions, also preferably from within the geo-zone of respective road charge object, subsequent to the passage of the road charge object, with respective time stamp, is initiated 430. The second recording is terminated after the second number of vehicle positions has been recorded 440, and the recorded vehicle positions are stored. Additionally, according to the example of the embodiment of the inventive method shown in fig. 4 a message authentication code is added to the road charge object recording 450. The message authentication code can be an automatically generated code or like which can be used in order to verify that the recording is authentic. Finally, the complete road charge object recording, comprising the road charge object ID, the first number of vehicle positions previous to the passage of the road charge object, the second number of vehicle positions subsequent to the passage of the road charge object and the message authentication code, is stored for later processing 460. If the road charge object recording is created in the OBU the road charge object recording is transmitted to the central system, preferably according to any of the disclosed methods for transmitting passages of primary road charge objects from the OBU to the central system, and is subsequently stored in the central system.

[0068] The different method steps for creating a road charge object recording can be used irrespectively of each other, and alternative methods for creating a road charge object recording may only comprise some of the above stated method steps. Also other additional features or method steps such as e.g. recording of current engine parameters at a detected passage can be added to the method for creating road charge object recordings.

[0069] The road charge object recordings can serve as a post-process confirmation of that the detection of a road charge object is correct, or as proof in disputes or objections regarding road charge.

[0070] Referring now to the embodiment shown in fig. 5, showing a flowchart over one possible example of the inventive method regarding to how the OBU can be updated with new primary road charge objects.

[0071] As stated, the OBU is by default provided with road charge object data regarding the primary road charge objects. The by default provided road charge object data is preferably selected to give best possible road coverage for concerned vehicle or group of vehicles. The selection of by default provided road charge data can e. g. be dependent on expected driving behavior of concerned vehicle or be a standard selection. It is preferred that this road charge object data can be updated if the road network is expanded, if new road charge objects

are added or removed or if anything affecting the road network or the road charge objects is changed. Thus, it is desirable that the road charge object data provided in the OBU can be updated remotely, both due to changes of the road network and according to the actual driving behavior.

[0072] What primary road charge objects, and for how many primary road charge objects the OBU is provided with road charge object data for by default, can e.g. be dependent on what type of OBU that is used, the memory capacity of the OBU, the manufacturer of the OBU or in what region the vehicle provided with the OBU is intended to operate.

[0073] Upgrading of the by default provided road charge object data can be performed in many different ways, such as by that upgrade packages are sent from the central system to the OBU when appropriate or that the OBU is connected to a database at regular service visits at a workshop.

[0074] An embodiment of the inventive method for updating the OBU is shown in fig. 5. The method is initiated by that a passage of a secondary road charge object is detected by the central system 500. The detection of the passage of the secondary road charge object 500 is enabled by that the central system is provided with road charge object data for the secondary road charge object and that the central system is provided with information regarding the position of the vehicle transmitted by the OBU to the central system, according to possible alternatives previously described. At the detection of the passage of the secondary road charge object the passage is stored in the central system with respective road charge object ID 510. Thereafter an evaluation is performed 520, evaluating whether any road charge object ID has been stored a number of times exceeding a threshold value during a predefined time period. The threshold value is preferably pre-set and can be dependent on various parameters such as memory capacity of present OBU, intended use for the vehicle or the expected driving behavior of the vehicle. The predefined time period can be fix, such as a quarter, a month, a week or like, or sliding in time, such as the last 30 days, the last 24 hours or like. The predefined time period can e.g. be dependent on expected driving behavior and/or intended use of concerned vehicle.

[0075] If a secondary road charge object ID has been stored a number of times exceeding the threshold value during the predefined time period an evaluation whether it is possible to upload additional road charge object data is performed 530. If it is possible to upload additional road charge object data without affecting the road charge object data already provided in the OBU uploading of new road charge object data is initiated 540.

[0076] According to one aspect of the method one possible approach for uploading new road charge object data is that road charge object data for a number of secondary road charge objects is wirelessly uploaded from the central system to the OBU when appropriate, such as at predefined time intervals. In order to get better control of the active set of road charge object data it is preferred that the uploaded road charge object data is activated at a predetermined activation date. The OBU can also be updated by being connected to a database at reoccurring visits at workshops or like.

[0077] The road charge object data provided to the OBU by default can, depending on the configuration of the OBU, either be permanent or be able to overwrite. Also, depending on the memory capacity of the OBU, different amounts of additional road charge object data can be added to the road charge object data provided to the OBU by default. If it is not possible to upload additional road charge object data 540 without affecting the road charge object data already provided in the OBU an evaluation whether the existing road charge object data provided in the OBU can be and should be replaced is performed 550. If the existing road charge object data provided in the OBU can be and should be replaced may e. g. be dependent on if the by default provided road charge object data is protected or can be overwritten. It is also possible that additional evaluation criteria such as e.g. evaluation of which of the new road charge object data and the existing road charge object data provided in the OBU that is most useful, if existing road charge object data are part of a corporate specific basic supply, that some road charge object data are mandatory according to regulation or standardization etc. are applied.

[0078] If additional road charge object data of secondary road charge object is uploaded to the OBU 540 these previously secondary road charge objects will become primary road charge objects 560.

[0079] In order to be able to manage all road charge object data for all secondary road charge objects the secondary road charge objects and accompanying road charge object data is preferably divided in secondary road charge object data packages, wherein the division in secondary road charge object zones can be one possible means for grouping the secondary road charge objects. The secondary road charge objects can also be divided in packages comprising more than one secondary road charge object zone or in packages comprising secondary road charge objects along a certain route or important road section. The road charge object data is preferably uploaded to the OBU according to these secondary road charge object data packages.

[0080] As previously stated, the road charge object data provided in the OBU can also be updated due to changes of the road network. The infrastructure is changing continuously and new, bigger and better roads are built while old roads are demolished or no longer attractive to use. New legislation can also affect where and how road charge is applied. Consequently, it is important that the road charge object data provided in the OBU can be updated also due to this aspect. Updates according to changes of the road network are preferably provided to the OBU by the same methods as described above, e.g. by wireless uploading or by connecting the OBU to a

database at reoccurring visits at workshops.

[0081] This is but one example of a method for updating of the OBU, but the updating operation can be performed in many different ways, all without departing from the scope of the invention. This single example is not intended to limit the scope of protection.

Claims

1. A method for calculating a road charge for a vehicle (2), whereby said vehicle is provided with an on board unit (OBU) (3), wherein the OBU (3) is adapted to communicate with a central system (4) and to receive position-information and wherein the central system (4) is provided with road charge object data regarding a predefined number of road charge objects, wherein
   road charge objects are predefined objects provided with road charge and the road charge objects are divided into primary and secondary road charge objects (11a;11b;11c;11d;11e), and
   the central system (4) is adapted for processing vehicle passages of road charge objects (11a;11b;11c;11d;11e) and the OBU (3) is provided with road charge object data regarding the primary road charge objects (11a;11b) and wherein the OBU (3) is;

   - continuously receiving information enabling determination of the position of the vehicle (2),
   - detecting a passage of a primary road charge object (11a;11b),
   - transmitting the passage of the primary road charge object (11a;11b) to the central system (4) at least at predetermined intervals.

2. The method according to any of the preceding claims, wherein a group of road charge objects (11a;11b;11c;11d;11e) constitutes a road charge object zone (10a;10b;12), which thereby are divided into primary (10a;10b) and secondary (12) road charge objects zones comprising primary (11a;11b) and secondary (11c;11d;11e) road charge objects correspondently, and
   wherein the OBU (3) is:

   - detecting when the vehicle enters a secondary road charge object zone (12), and
   - transmitting the position of the vehicle (2) to the central system (4) when the vehicle (2) is present within a secondary road charge object zone (12).

3. The method according to claim 2, wherein the method additionally comprises following operations executed by the central system (4):

   - receiving the transmitted position of the vehicle (2) when the vehicle (2) is present within a secondary road charge object zone (12), and
   - detecting a passage of a secondary road charge object (11c;11d;11e).

4. The method according to any of the preceding claims, wherein
   the OBU is:

   - transmitting the passage of the primary road charge object (11a;11b) from the OBU (3) to the central system (4) at the time of the passage.

5. The method according to any of the preceding claims, wherein the OBU is;

   - storing the passage of the primary road charge object (11a;11b) in the OBU (3),
   - transmitting stored passages of primary road charge objects (11a;11b) from the OBU (3) to the central system (4) when predefined conditions are fulfilled.

6. The method according to any of the preceding claims, wherein the OBU is;

   - storing the passage of the primary road charge object (11a;11b) in the OBU (3),
   - transmitting stored passages of primary road charge objects (11a;11b) from the OBU (3) to the central system (4) when a memory capacity of the OBU (3) reaches a predefined threshold value.

7. The method according to any of the preceding claims, wherein the OBU (3) is:

   - storing the passage of the primary road charge object (11a;11b) in the OBU (3),
   - transmitting stored passages of primary road charge objects (11a;11b) from the OBU (3) to the central system (4) at predefined time intervals.

8. The method according to any of the preceding claims, wherein all road charge objects (11a;11b;11c;11d;11e) are provided with a road charge object ID, wherein the road charge object ID is provided in the road charge object data, and wherein the method additionally comprises at least one of:

   - creating of a road charge object recording at a passage of a road charge object (11a;11b;11c;11d;11e), and wherein the road charge object recording comprises:

- a first number of the most recent previous positions of the vehicle (2), preceding the passage of the road charge object (11a;11b;11c;11d;11e), with respective time stamp,
- the ID of a road charge object (11a;11b;11c;11d;11e),
- a second number of positions of the vehicle, subsequent to the passage of the road charge object (11a;11b;11c;11d;11e), with respective time stamp, and
- a message authentication code.

9. The method according to claim 8, wherein the creation of the road charge object recording is performed in the OBU (3) when the OBU (3) detects that the vehicle (2) is passing a primary road charge object (11a;11b).

10. The method according to claim 9, wherein the road charge object recording is transmitted from the OBU (3) to the central system (4) together with the passage of the primary road charge object (11a;11b).

11. The method according to any of claim 8 to 10, wherein the creation of the road charge object recording is performed in the central system (4) when the central system (4) detects that the vehicle is passing a secondary road charge object (11c;11d;11e).

12. The method according to any of the preceding claims, wherein at a detection of a passage of a specific secondary road charge object (11c; 11d, 11e), the passage is stored in the central system (CS), whereby when a predefined number of passages of said specific secondary road charge objects (11c; 11d, 11e) has been stored during a predefined time period said specific secondary road charge object (11c; 11d; 11e) is uploaded to the OBU (3) as a primary road charge object (11a; 11b)

13. A system (1) comprising an OBU (3) and a central system (4), wherein
the OBU (3) is adapted to communicate with the central system (4) and to receive position-information, and wherein
the OBU (3) and the central system (4) are configured for running the inventive method according to any of claim 1-12.

14. A program comprising program code means for performing the steps of any of claims 1-12 when said program is applied in an OBU (3) and a central system (4).

15. A computer readable medium carrying a program comprising program code means for performing the steps of any of claims 1-12 when said program product is applied in an OBU (3) and a central system (4).

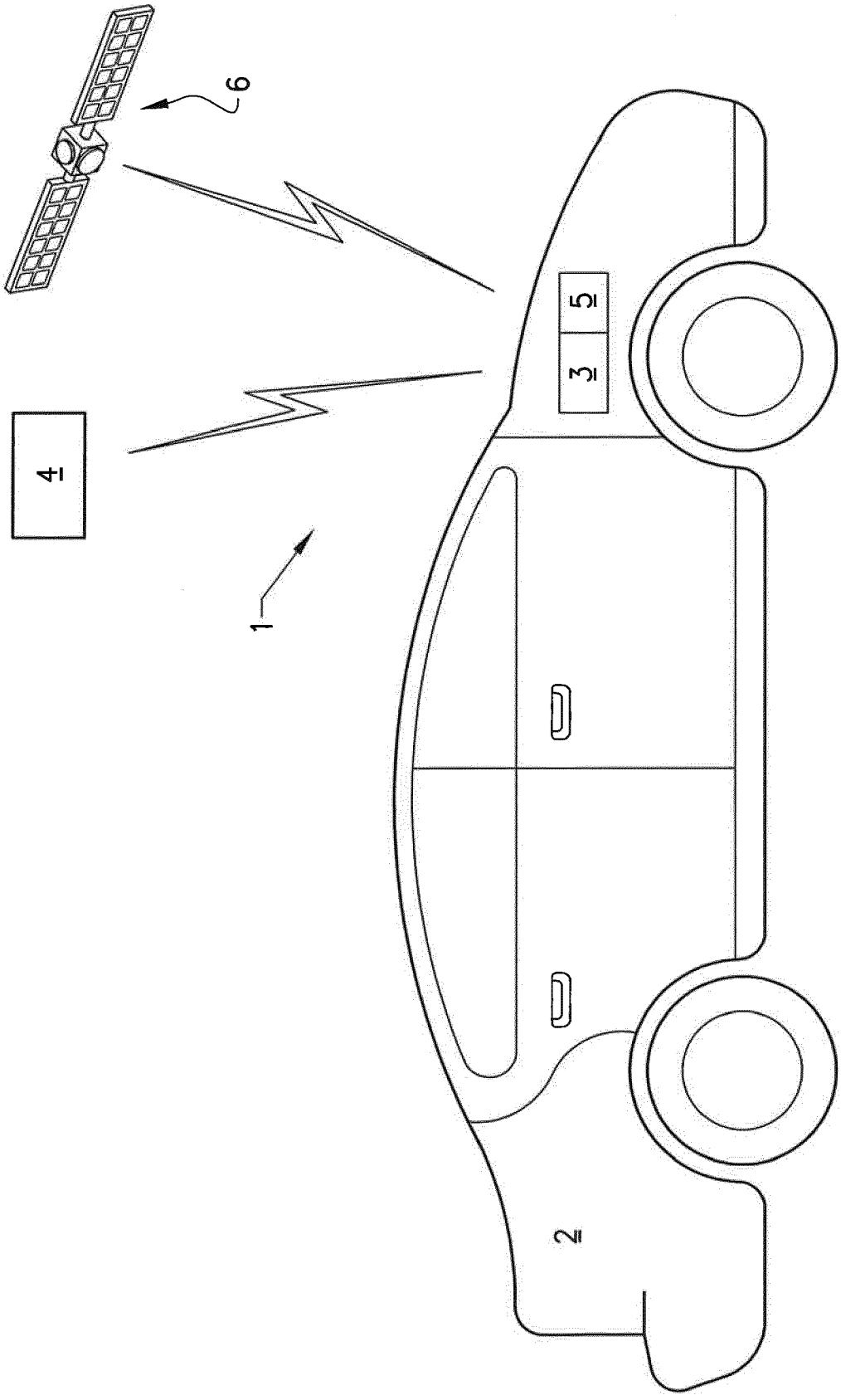


FIG. 1

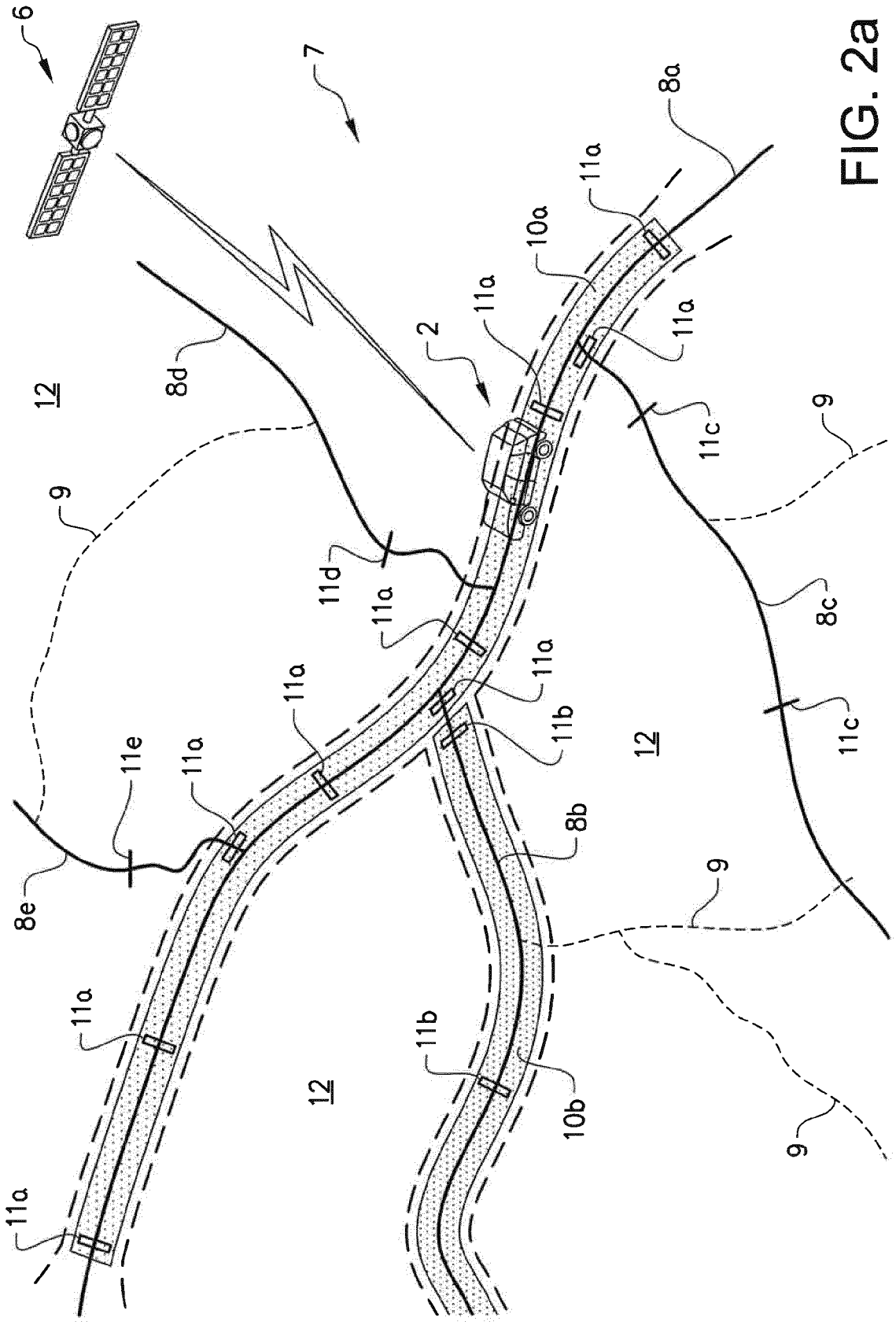

6
7
8a
11a
10a
11a
11a
2
8d
12
11c
9
9
11d
11a
8c
11a
11a
11b
11e
11a
12
11c
8b
8e
9
11a
11b
12
10b
9
11a

FIG. 2a

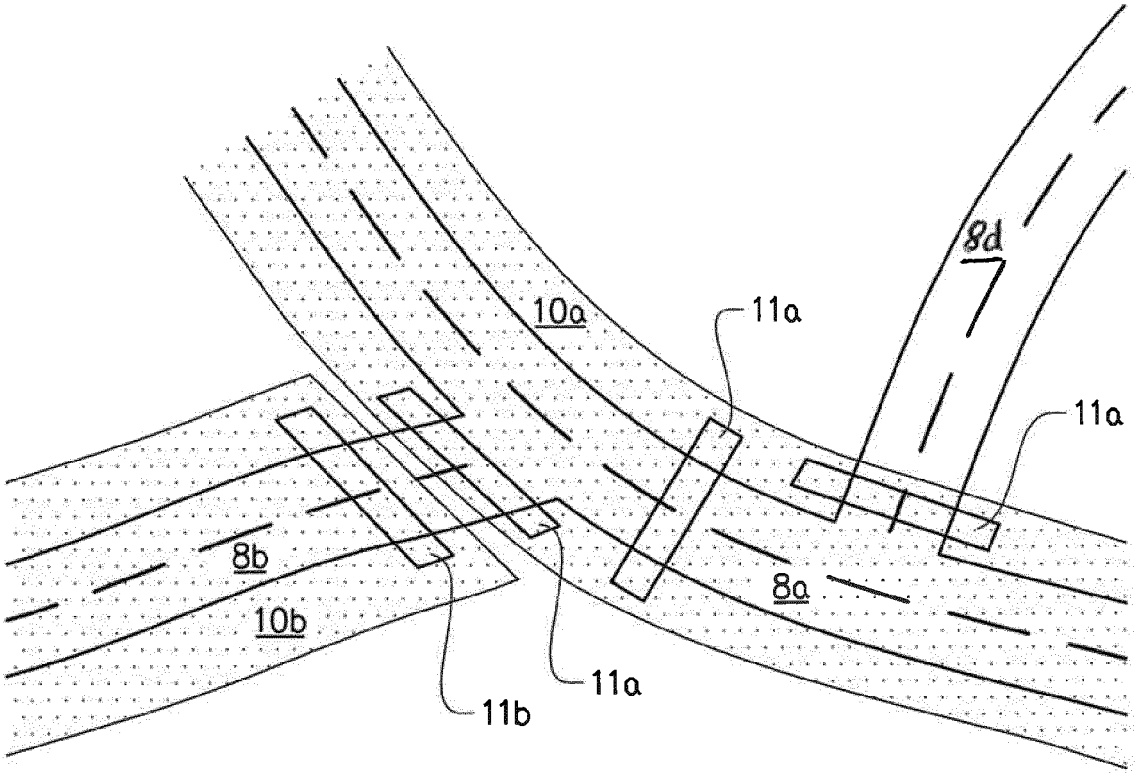


FIG. 2b

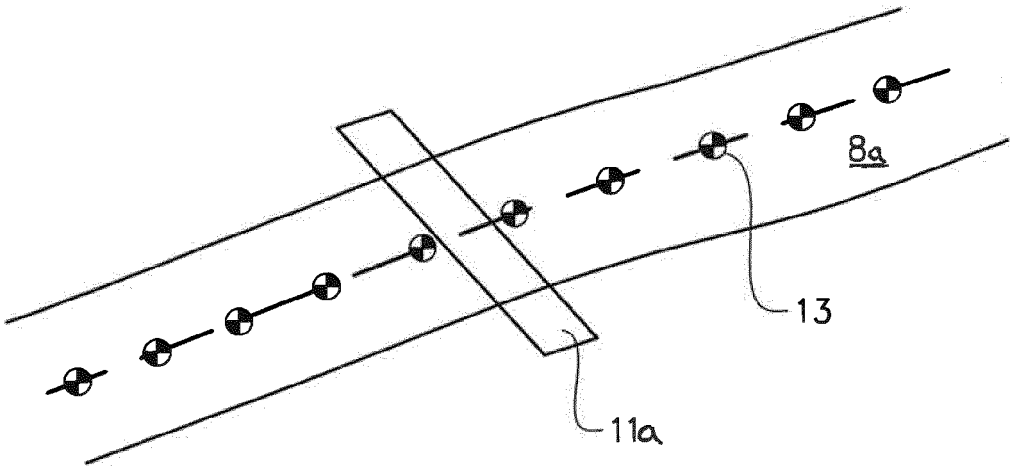


FIG. 2c

Fig. 3

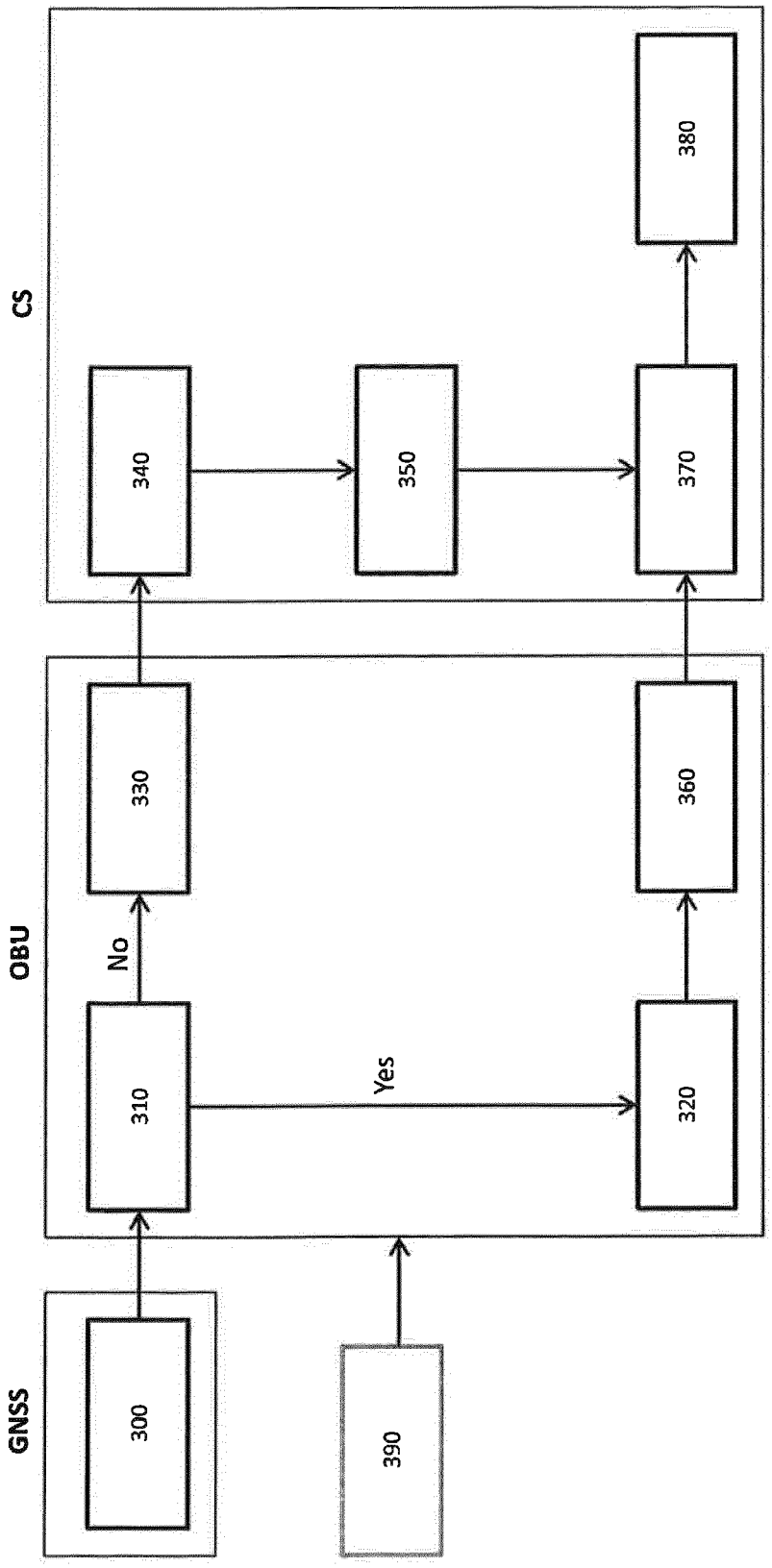


Fig. 4

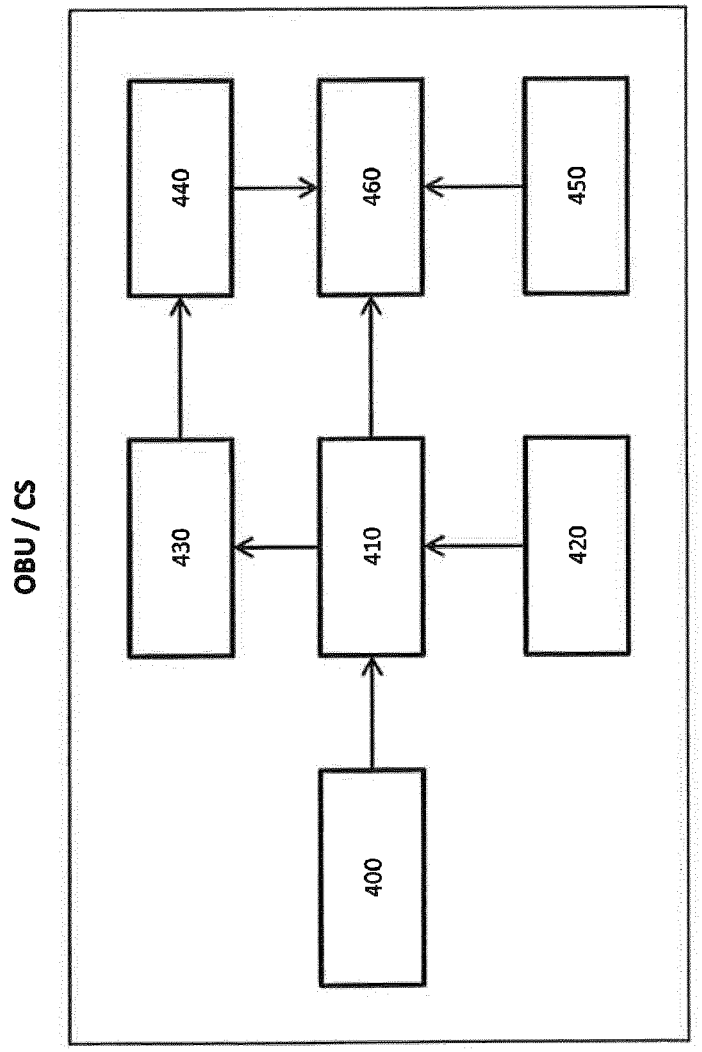
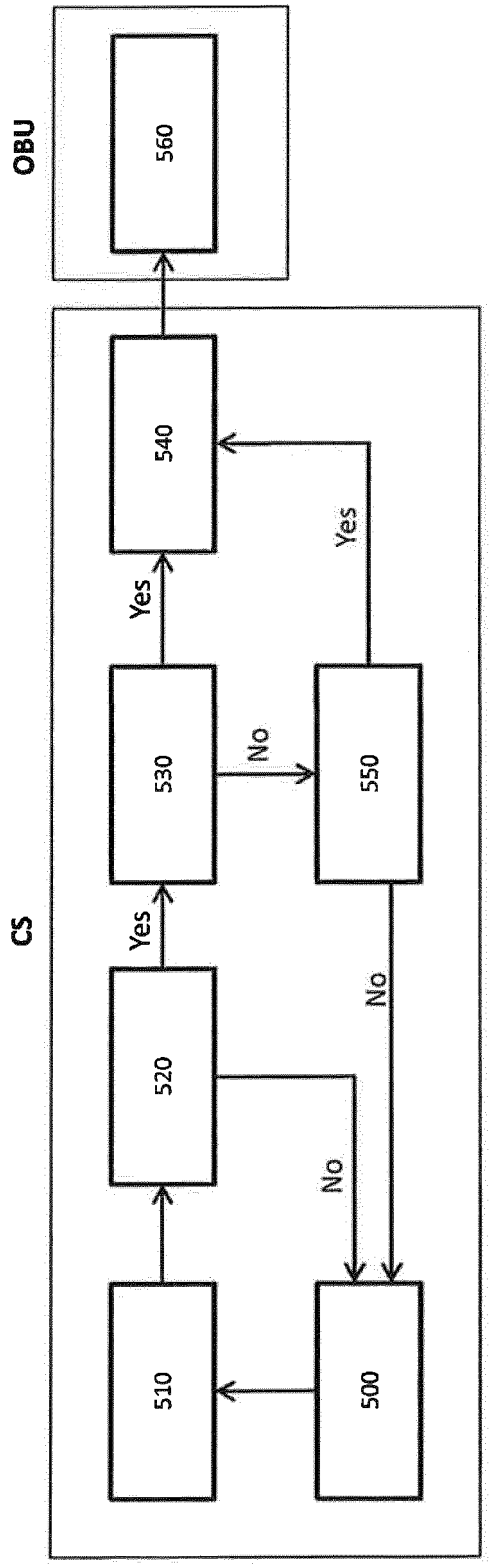


Fig. 5



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Application Number
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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	27 May 2014	Ngandu, William

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EUROPEAN SEARCH REPORT

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