

(51) International Patent Classification:
H04W 8/08 (2009.01)(21) International Application Number:
PCT/CN2020/140397(22) International Filing Date:
28 December 2020 (28.12.2020)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

(54) Title: COMPUTER-IMPLEMENTED METHOD OF OPERATING MOBILE COMMUNICATION UNIT OF VEHICLE, SYSTEM, AND VEHICLE

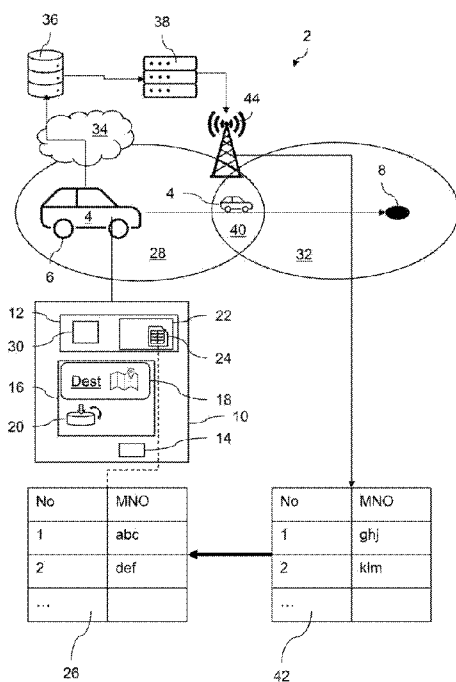


Fig. 1

(57) **Abstract:** Described is a computer-implemented method of operating a mobile communication unit of a vehicle, the mobile communication unit comprising a cellular module and a SIM card, wherein a current RPLMN list is stored on the SIM card, the vehicle further comprising an infotainment head unit and a navigation system, wherein the navigation system and the mobile communication unit are connected to the infotainment head unit, wherein a destination is entered into the navigation system, wherein it is determined whether a current location and the destination of the vehicle are located in different roaming zones, wherein, if the current location and the destination are located in different roaming zones, information related to a required roaming zone change is sent to a backend server via the mobile communication unit, wherein it is checked whether the current RPLMN list stored on the SIM card comprises mobile network operators of the destination roaming zone, wherein, if the current RPLMN list stored on the SIM card does not comprise mobile network operators of the destination roaming zone, an update request is sent to a current mobile network operator to send an updated RPLMN list to the mobile communication unit.

Published:

— *with international search report (Art. 21(3))*

COMPUTER-IMPLEMENTED METHOD OF OPERATING MOBILE COMMUNICATION UNIT OF VEHICLE, SYSTEM, AND VEHICLE

Technical Field

[0001] Described are computer-implemented methods of operating a mobile communication unit of a vehicle, respective systems, and vehicles.

Background Art

[0002] Vehicle telematics services carried over a public land mobile network (PLMN) or other wireless carrier system present certain challenges unique to the mobile vehicle application. For example, some vehicle telematics units (VTU) are designed to permit both voice and data communications over the wireless carrier system using one or more of the various available different transmission technologies, such as 2G CDMA (IS-95), 3G CDMA2000 (IS-2000, 1 XRTT, EVDO), 3G UTMS (W-CDMA, HSPA), 2G/2.5G GSM (GPRS and EDGE). Generally, depending on aspects as the technology used, e.g., GSM versus CDMA, the registration or acquisition process required, the frequent movement of the vehicle into and out of a home PLMN (HPLMN), the availability of one data transmission protocol versus another, and the particular type of call being made to or from the vehicle, the VTU may only have one wireless communication protocol available and suitable for use or may have more than one from which it can select. And while multiple types of wireless transmission may be available at any one time, their associated cost of use can vary making it desirable to judiciously select among them. Similarly, call connection costs associated with data roaming can be significant and it can therefore be desirable to implement connection strategies that minimize roaming and its associated costs.

[0003] This can be especially true for vehicle communication and/or telematics units since, when used, a communication and/or telematics unit may often be moving (with the vehicle) at a speed that exposes it to an ever-changing cellular landscape, which can include rapidly moving between different cellular networks (wireless carrier systems), including into and out of roaming and home cellular networks.

[0004] US 2011/0039559 A1 discloses a system and method for making vehicle originated calls to a telematics service provider or other call center. The method includes identifying a call type associated with a desired wireless communication of speech or data to the call center, and then carrying out one of several different call connection processes depending on the call type. For voice channel cellular connections, an in-band modem cellular connection is preferably established in most instances using a

connection retry strategy that includes primary, secondary, and possibly tertiary connection attempts. Cell selection can be carried out using an acquisition task, background scan and inter-country PLMN reselection process that are used to select among available PLMNs and base stations. The system and method can be carried out in connection with various cellular system technologies but is especially suited for use with GSM systems.

[0005] It is further known that VTUs store registered public land mobile network (RPLMN) lists with available mobile network operators (MNO) on a SIM card. The number of RPLMN entries on a SIM card is, however, limited. In larger territories with many mobile network operator providers, it is oftentimes not possible to store all possible RPLMN entries on the SIM card at the same time, so the territory is usually divided into regions or roaming zones. When a vehicle leaves one roaming zone and enters a new one, which can happen particularly while driving larger distances with the vehicle, an update of the RPLMN list is required. Such update happens over the air (OTA) which is sent to the vehicle's VTU.

[0006] The known method has at least two drawbacks. First, the network selection time after entering a new region is exceedingly high, in particular in moving vehicles. In some instances, it can take up to 200 seconds due to currently available MNOs not being listed in the current RPLMN list stored in the vehicle. This could be dangerous in cases in which an emergency call needs to be performed, for example after an accident. Second, the VTU may not latch to the most preferred carrier in the region which could incur extra costs.

Summary of Invention

Technical Problem

[0007] It is therefore an object of the invention to overcome known obstacles and allow for faster and more efficient transfer between various mobile network operators when leaving a roaming zone and entering a new roaming zone.

Solution to Problem

Technical Solution

[0008] The invention is disclosed in independent claims 1, 9 and 10. Further embodiments are disclosed in the dependent claims.

[0009] Described is a computer-implemented method of operating a mobile communication unit of a vehicle, the mobile communication unit comprising a cellular module and a SIM card, wherein a current RPLMN list is stored on the SIM card, the vehicle further comprising an infotainment head unit and a navigation system, wherein the navigation system and the mobile communication unit are connected to the infotainment head unit, wherein a destination is entered into the navigation system, wherein it is de-

terminated whether a current location and the destination of the vehicle are located in different roaming zones, wherein, if the current location and the destination are located in different roaming zones, information related to a required roaming zone change is sent to a backend server via the mobile communication unit, wherein it is checked whether the current RPLMN list stored on the SIM card comprises mobile network operators of the destination roaming zone, wherein, if the current RPLMN list stored on the SIM card does not comprise mobile network operators of the destination roaming zone, an update request is sent to a current mobile network operator to send an updated RPLMN list to the mobile communication unit.

[0010] The vehicle can be a car, truck, bus, train, or the like.

[0011] The mobile communication unit can be configured to allow for one or more telecommunication standard protocols such as 2G, 3G, LTE, 5G and the like. The cellular module can comprise sender and receiver antennas capable of sending and receiving in the respective frequency bands as required by the standards.

[0012] The SIM card (Subscriber Identification Module) is configured to store an international mobile subscriber identity (IMSI) number and its related key. The SIM card further comprises a storage module for storing certain information such as contacts in an address book. RPLMN lists are also stored on the SIM card. The storage capacity of a SIM card is limited, however, which is why an RPLMN list cannot exceed a certain size and needs to be replaced in a new roaming zone to list the different mobile network operators in the new roaming zone.

[0013] When a destination is entered into the navigation system, which can be done via a human-machine-interface of the infotainment head unit, e.g., a touchscreen, a voice command, a remote device connected to the vehicle, or a control dial knob, it can be determined whether the destination lies in a different roaming zone than the current roaming zone. This determination can be used to anticipate a necessary update of the RPLMN list in the SIM card. Such an update can then be pushed in time from a mobile network operator to the vehicle and stored in the SIM card. The method therefore avoids a temporary loss of service in the new roaming zone and expensive mobile network usage of non-preferred carriers.

[0014] The utilization of the backend server allows for a smaller data repository in the vehicle and less need for updates, which would otherwise have to be pushed to all vehicles implementing the method. Also, the data consumption of the vehicle mobile communication unit is reduced that way.

[0015] According to a first further embodiment, the determination whether the current location and the destination of the vehicle are in the same roaming zone is performed in the vehicle.

[0016] The roaming zones are usually tied to regions or countries and globally determined

for existing mobile communication units, so that a global roaming zone list is quite compact and static. Making the determination at the vehicle reduces mobile data consumption and data traffic and therefore maximizes available bandwidth of the infrastructure. Contacting the backend server only becomes necessary when a roaming zone change is anticipated by the vehicle, in particular by the infotainment head unit of the vehicle.

- [0017] According to another further embodiment, the check whether the current RPLMN list stored on the SIM card comprises mobile network operators of the destination roaming zone is performed on the backend server. Opposite to the roaming zones, the mobile network operator landscape is subject to changes over time and preferred mobile network operators might depend on short-term contracts between a service provider and one or more of the mobile network operators.
- [0018] The backend server can comprise a database of RPLMN lists stored on managed vehicles, which is particularly useful if the vehicle manufacturer or other service providers offer connectivity services to the vehicle users free of charge or at flat rates. The backend server operator can then update the RPLMN lists in case of renegotiations with the mobile network operators.
- [0019] According to a further embodiment, if the current RPLMN list stored on the SIM card does not comprise mobile network operators of the destination roaming zone, the update request is sent from the backend server to a current mobile network operator.
- [0020] The current mobile network operator to which the vehicle is subscribed to can send an updated RPLMN list to the vehicle with no need to reconnect to a different mobile network operator.
- [0021] According to another further embodiment, the sending of the updated RPLMN list is scheduled in accordance with an anticipated change from a current roaming zone to a destination roaming zone.
- [0022] The scheduling can be location based. The mobile network provider can use the switch of the vehicle's connection to a particular or a selection of base stations in an area close to a boarder of a roaming zone as a trigger for sending the updated RPLMN list to the vehicle.
- [0023] According to a further embodiment, it is checked whether a current roaming zone and a destination roaming zone are adjacent to each other, wherein, if the current roaming zone and the destination roaming zone are not adjacent to each other, route information is acquired from the navigation system, wherein at least one intermediate roaming zone adjacent to the current roaming zone is determined, wherein information related to a required roaming zone change is sent to the backend server via the mobile communication unit, wherein it is checked whether the current RPLMN list stored on the SIM card comprises mobile network operators of the intermediate roaming zone,

wherein, if the current RPLMN list stored on the SIM card does not comprise mobile network operators of the intermediate roaming zone, an update request is sent to a current mobile network operator to send an updated RPLMN list to the mobile communication unit.

[0024] With this embodiment, it is possible to use the method in situations where more than one roaming zone change is scheduled to occur according to the route calculated by the navigation system. The method can then be repeated with each set of adjacent roaming zones. If the vehicle is driving in the 2nd roaming zone, for example, a respective update process can be triggered prior to entering the 3rd roaming zone, then for the 3rd and 4th roaming zone and so on.

[0025] According to another further embodiment, the current mobile network operator sends a confirmation about a successful sending of the updated RPLMN list to the backend server.

[0026] This can ensure that the updated RPLMN list is correctly stored on the SIM card.

[0027] According to a further embodiment, the mobile communication unit and/or the navigation system are integrated into the information head unit.

[0028] This allows for a reduction in need for shareable components, for example storage space and processors.

[0029] A first independent aspect relates to a mobile communication system comprising a backend server and at least one vehicle the vehicle comprises a mobile communication unit with a cellular module and a SIM card, wherein a current RPLMN list is stored on the SIM card, the vehicle further comprising an infotainment head unit and a navigation system, wherein the navigation system and the mobile communication unit are connected to the infotainment head unit, wherein navigation system and/or infotainment head unit are configured to determine whether a current location and a destination of the vehicle are located in different roaming zones, wherein the infotainment head unit is configured to send information related to a required roaming zone change to the backend server via the mobile communication unit, wherein backend server or the information head unit are configured to check whether the current RPLMN list stored on the SIM card comprises mobile network operators of the destination roaming zone, wherein, if the current RPLMN list stored on the SIM card does not comprise mobile network operators of the destination roaming zone, the backend server is configured to send an update request to a current mobile network operator to send an updated RPLMN list to the mobile communication unit of the vehicle.

[0030] Another independent aspect relates to vehicle of a mobile communication system as described above.

[0031] Further features, details and properties of the invention are provided in the claims, the drawings, and the following description of embodiments. It is understood that the

features mentioned before and those to be explained below are applicable not only in the combinations stated but also in other combinations or as stand-alone features without leaving the scope of the present invention.

Advantageous Effects of Invention

Advantageous Effects

[0032] Although shown in connection with a car, methods and systems disclosed herein can equally be used with other types of vehicles such as trucks, buses, trains, or the like. The method therefore avoids a temporary loss of service in the new roaming zone and expensive mobile network usage of non-preferred carriers.

Brief Description of Drawings

Description of Drawings

[0033] Below, the invention will be explained in more detail with reference to the accompanying drawings, which also show features essential to the invention, among others, and in which:

[0034] Fig. 1 an environment with a car driving from a current location to a destination;

[0035] Fig. 2 another environment with a car driving from a current location to a destination;

[0036] Fig. 3 a flow chart with a method of updating an RPLMN list according to a roaming zone change.

Best Mode for Carrying out the Invention

Best Mode

[0037] Fig. 1 shows an environment 2 with a car 4 driving from a current location 6 to a destination 8.

[0038] Although shown in connection with a car, methods and systems disclosed herein can equally be used with other types of vehicles such as trucks, buses, trains, or the like.

[0039] The car 4 comprises an infotainment head unit 10 which is depicted separately in Fig. 1. The infotainment head unit 10 comprises a number of components such as a mobile communication unit 12, a navigation system 14, and a human machine interface 16. The human machine interface 16 comprises a display 18 as well as a control dial knob 20. Depending on the concrete embodiment, different ways of entering data into the human machine interface 16 can be used, namely the control dial knob 20, voice recognition, touchscreens, buttons, remote control units and the like.

[0040] The mobile communication unit 12 comprises a SIM card module 22 with a SIM card 24. The SIM card 24 is equipped according to known standards. A current RPLMN list 26 is stored on the SIM card 24. The current RPLMN list 26 comprises several mobile network providers in a current roaming zone 28 the car 4 is located in. The current RPLMN list 26 is used by the mobile communication unit 12 to select a

mobile network operator for data and/or voice transmission.

- [0041] The mobile communication unit 12 also comprises a cellular module 30 which facilitates sending and receiving information using one of the established standards, such as 2G, 3G, LTE, or 5G or the like.
- [0042] With reference to Fig. 1 and Fig. 3, when a destination 8 is entered into the navigation system 14 using the human machine interface 16 of the infotainment head unit 10, the infotainment head unit 10 determines whether the destination 8 is in the same or a different roaming zone. If this is not the case, the method stops.
- [0043] In the situation depicted in Fig. 1, a roaming zone change will occur. The destination 8 is located in a destination roaming zone 32. Under such circumstances, the car 4 sends respective roaming zone change information via a wireless network 34 to a backend server 36. The backend server 36 checks if the RPLMN list currently stored on the SIM card 24 comprises mobile network operators of the destination roaming zone 32. If this is the case, the method ends.
- [0044] If this is not the case, the backend server 36 determines whether at least one destination mobile network operator is stored in the current RPLMN list 24. If this is the case, the method ends.
- [0045] If this is not the case, the backend server 36 sends a request to a mobile network operator 38 to update the RPLMN list of the car 4. The mobile network operator 38 can be the mobile network operator currently used by the car 4, or, if not available in a transition zone 40, a different mobile network operator.
- [0046] In different embodiments the determination of a roaming zone change can occur on the backend server side. In such embodiments, the car will send destination information to the backend server and the backend server will perform the assessment.
- [0047] The mobile network operator 38 then schedules an over the air transmission of an updated RPLMN list 42 which the mobile communication unit 12 will write on the SIM card 24 replacing the current RPLMN list 26.
- [0048] The scheduling is location based. When the car moves into the transition zone 40, and connects to base station 44, the updated RPLMN list 44 is pushed to the car 4.
- [0049] With reference to Fig. 3, after a successful update of the RPLMN list, the mobile communication unit 12 acknowledges the success to the mobile network operator 38 which would otherwise retry the update. The number of retries can be limited.
- [0050] At the end, the mobile communication unit 12 sends a notification to the backend server 36 that the updated RPLMN list is stored on the SIM card 24.
- [0051] In the situation shown in Fig. 2, car 4 crosses multiple roaming zones. Current roaming zone 28 and target roaming zone 32 are not directly adjacent to each other and do not overlap. Instead, an intermediate roaming zone 46 connects current roaming zone 28 on the one side and destination roaming zone 32 on the other side.

- [0052] In this situation, the method is modified such that in a first iteration of the method, an RPLMN update is requested for the intermediate roaming zone 46. The update is pushed to the mobile communication unit 12 of the car 4 via base station 44.
- [0053] In a second iteration of the method, a foreign mobile network operator 48 is requested by the backend server 36 to push an updated RPLMN list valid in the destination roaming zone 32 to the mobile communication unit 12 of the car via a base station 50 which is located near a transition zone 52.
- [0054] The invention is not limited to the embodiments described above but can be modified in various ways.
- [0055] All features and properties disclosed in claims, description, and drawings, including constructive details, spatial orientation, and process steps, can be significant to the invention disclosed herein, either in isolation or in any meaningful combination.
- [0056] Reference Signs List
- [0057] 2:environment; 4:car; 6:current location; 8:destination; 10:infotainment head unit; 12:mobile communication unit; 14:navigation system; 16:human machine interface; 18:display; 20:control dial knob; 22:SIM card module; 24:SIM card; 26:current RPLMN list; 28:current roaming zone; 30:cellular module; 32:destination roaming zone; 34:wireless network; 36:backend server; 38:mobile network operator; 40:transition zone; 42:updated RPLMN list; 44:base station; 46:intermediate roaming zone; 48:foreign mobile network operator; 50:base station; 52:transition zone.

Claims

- [Claim 1] Computer-implemented method of operating a mobile communication unit (12) of a vehicle (4), the mobile communication unit (12) comprising a cellular module (30) and a SIM card (24), wherein a current RPLMN list (26) is stored on the SIM card (24), the vehicle (4) further comprising an infotainment head unit (12) and a navigation system (14), wherein the navigation system (14) and the mobile communication unit (12) are connected to the infotainment head unit (12), wherein a destination (8) is entered into the navigation system (14), wherein it is determined whether a current location (6) and the destination (8) of the vehicle (4) are located in different roaming zones (28, 32, 46), wherein, if the current location (6) and the destination (8) are located in different roaming zones (28, 32, 46), information related to a required roaming zone change is sent to a backend server (36) via the mobile communication unit (12), wherein it is checked whether the current RPLMN list (26) stored on the SIM card (24) comprises mobile network operators (38, 48) of the destination roaming zone (32, 46), wherein, if the current RPLMN list (26) stored on the SIM card (24) does not comprise mobile network operators (38, 48) of the destination roaming zone (32, 46), an update request is sent to a current mobile network operator (38, 48) to send an updated RPLMN list (42) to the mobile communication unit (12).
- [Claim 2] Computer-implemented method according to claim 1, wherein the determination whether the current location (6) and the destination (8) of the vehicle (4) are in the same roaming zone (28, 32, 46) is performed in the vehicle (4).
- [Claim 3] Computer-implemented method according to claim 1 or 2, wherein the check whether the current RPLMN list (26) stored on the SIM card (24) comprises mobile network operators (38, 48) of the destination roaming zone (32, 46) is performed on the backend server (36).
- [Claim 4] Computer-implemented method according to any of the previous claims, wherein, if the current RPLMN list (26) stored on the SIM card (24) does not comprise mobile network operators (38, 48) of the destination roaming zone (32, 46), the update request is sent from the backend server (36) to a current mobile network operator (38, 48).
- [Claim 5] Computer-implemented method according to any of the previous claims, wherein the sending of the updated RPLMN list (42) is

scheduled in accordance with an anticipated change from a current roaming zone (28, 46) to a destination roaming zone (46, 32).

- [Claim 6] Computer-implemented method according to any of the previous claims, wherein it is checked whether a current roaming zone (28) and a destination roaming zone (32) are adjacent to each other, wherein, if the current roaming zone (28, 46) and the destination roaming zone (32, 46) are not adjacent to each other, route information is acquired from the navigation system (14), wherein at least one intermediate roaming zone (46) adjacent to the current roaming zone (28) is determined, wherein information related to a required roaming zone change is sent to the backend server (36) via the mobile communication unit (12), wherein it is checked whether the current RPLMN list (26) stored on the SIM card (24) comprises mobile network operators (38, 48) of the intermediate roaming zone (46), wherein, if the current RPLMN list (26) stored on the SIM card (24) does not comprise mobile network operators (38, 48) of the intermediate roaming zone (46), an update request is sent to a current mobile network operator (38) to send an updated RPLMN list (42) to the mobile communication unit (12).
- [Claim 7] Computer-implemented method according to any of the previous claims, wherein the current mobile network operator (38, 48) sends a confirmation about a successful sending of the updated RPLMN list (42) to the backend server (36).
- [Claim 8] Computer-implemented method according to any of the previous claims, wherein the mobile communication unit (12) and/or the navigation system (14) are integrated into the information head unit (12).
- [Claim 9] Mobile communication system comprising a backend server (36) and at least one vehicle (4) the vehicle (4) comprises a mobile communication unit (12) with a cellular module (30) and a SIM card (24), wherein a current RPLMN list (26) is stored on the SIM card (24), the vehicle (4) further comprising an infotainment head unit (12) and a navigation system (14), wherein the navigation system (14) and the mobile communication unit (12) are connected to the infotainment head unit (12), wherein navigation system (14) and/or infotainment head unit (12) are configured to determine whether a current location (6) and a destination (8) of the vehicle (4) are located in different roaming zones (28, 32, 46), wherein the infotainment head unit (12) is configured to send information related to a required roaming zone change to the backend

server (36) via the mobile communication unit (12), wherein backend server (36) or the information head unit (12) are configured to check whether the current RPLMN list (26) stored on the SIM card (24) comprises mobile network operators (38, 48) of the destination roaming zone (32, 46), wherein, if the current RPLMN list (26) stored on the SIM card (24) does not comprise mobile network operators (38, 48) of the destination roaming zone (32, 46), the backend server (36) is configured to send an update request to a current mobile network operator (38, 48) to send an updated RPLMN list (42) to the mobile communication unit (12) of the vehicle (4).

[Claim 10]

Vehicle of a mobile communication system according to claim 9.

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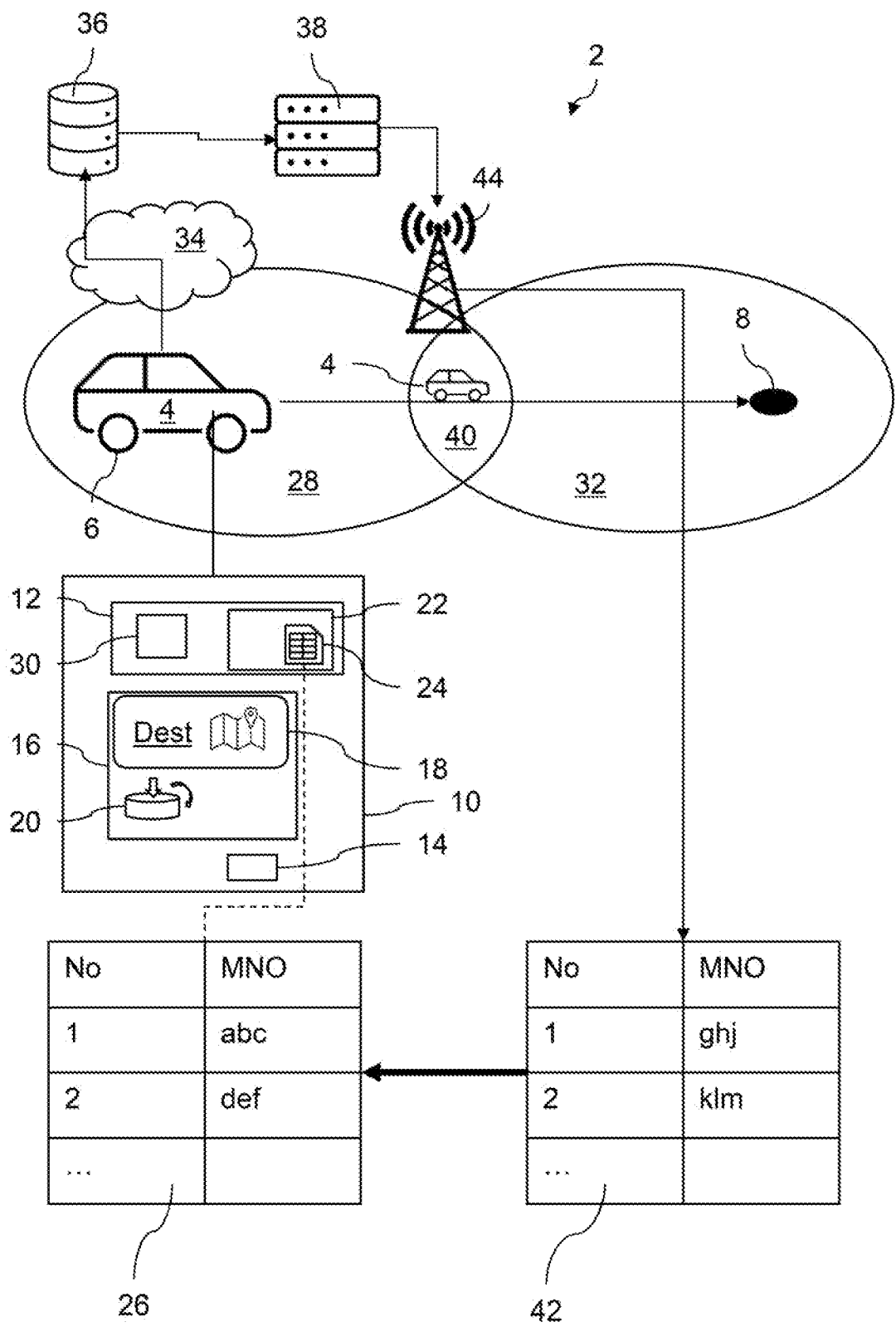


Fig. 1

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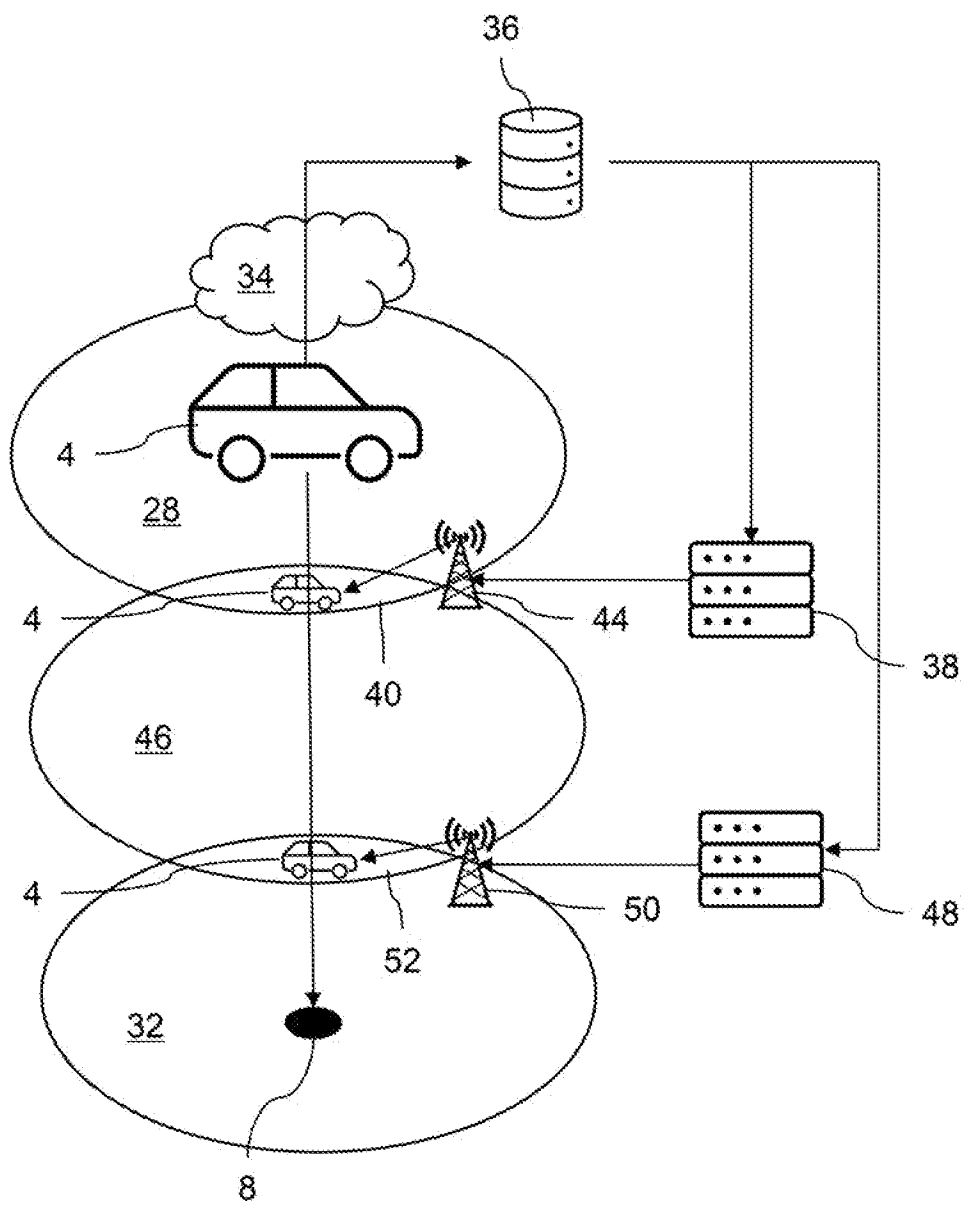


Fig. 2

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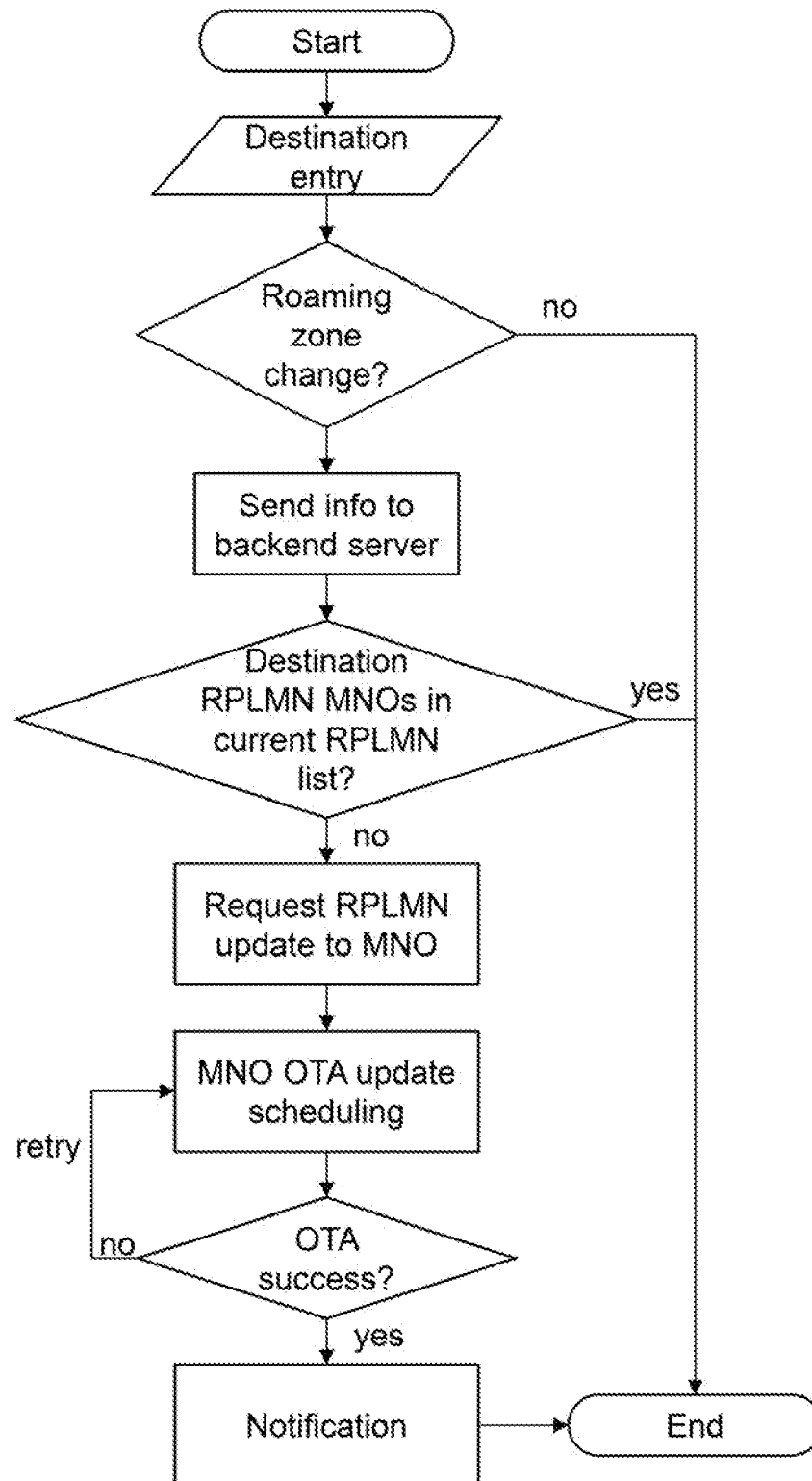


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/140397

A. CLASSIFICATION OF SUBJECT MATTER

H04W 8/08(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W; H04B; H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC, 3GPP: SIM, RPLMN, list, vehicle, infotainment, destination, roam+, updat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2017245135 A1 (SAMSUNG ELECTRONICS CO., LTD.) 24 August 2017 (2017-08-24) description, paragraphs [0033] to [0228] and claims 1-20	1-10
Y	CN 107911812 A (VIVO MOBILE COMMUNICATION CO., LTD.) 13 April 2018 (2018-04-13) description, paragraphs [0027] to [0135] and claims 1-14	1-10
A	US 2011039559 A1 (GENERAL MOTORS COMPANY) 17 February 2011 (2011-02-17) the whole document	1-10
A	3GPP. "3rd Generation Partnership Project; Technical Specification Group <TSG name>; Overview of 3GPP Release 7; Summary of all Release 7 Features(Release 7)" 3GPP TR 08.007 V0.9.1, 31 July 2008 (2008-07-31), section 17.6	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

25 August 2021

Date of mailing of the international search report

09 October 2021

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/140397

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