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(71) Applicant: NOKIA TECHNOLOGIES OY [FI/FI];

Karakaari 7, 02610 Espoo (FI).

(72) Inventor: HIETALAHTI, Hannu Petri; Uhanperäntie 38,

90810 Kiviniemi (FI).

(74) Agent: BERTHIER, Karine; Alcatel-Lucent International,

Site de Nokia Paris-Saclay, Route de Villejust, 91620

Nozay (FR).

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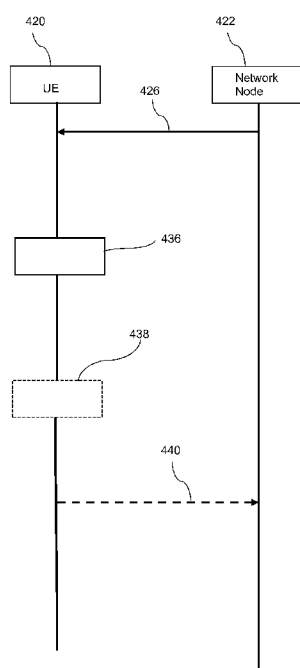


Figure 4

(57) Abstract: An apparatus (420) comprising means for performing: receiving, from a network node (422), information comprising a sequence of registration areas; detecting, at the apparatus (420), a change of registration area that is serving the apparatus (420); and determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

APPARATUS, METHOD AND COMPUTER PROGRAM FOR CHANGING REGISTRATION AREA IN A SEQUENCE OF REGISTRATION AREAS

Field

5 This disclosure relates to a communications network. More particularly, the present disclosure relates to mobility management. More particularly, the present disclosure relates to monitoring registration of a user equipment in a network.

Background

10 A user equipment (UE) in a communications network may be required to register with a network in order for the network to maintain knowledge and/or data indicating if the UE is registered in the network, and if so, where the UE is registered in the network. Information as to where the UE is registered in the network may be in terms of network topology. This knowledge and/or data allows the UE to be paged if downlink data is to be directed towards the UE.

15 If a UE moves from one registration area to another, it may be required to send a registration update to the network.

Statement of invention

20 According to a first aspect there is provided an apparatus comprising means for performing: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

25 According to some examples, each registration area is associated with a satellite, wherein the sequence of registration areas is determined based on a predicted path of each satellite.

According to some examples, when the change is from a registration area in the sequence to a registration area that is next in the sequence, the means are further

configured to perform using the registration area that is next in the sequence without requiring a mobility registration update.

According to some examples, the means are further configured to perform sending a mobility registration update to the network node when the change is from a registration area in the sequence to a registration area that is not next in the sequence.

According to some examples, each registration area comprises at least one tracking area and the information comprises at least one tracking area identity for each tracking area.

According to some examples, the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part of a registration area.

According to some examples, the means are further configured to perform: using the tracking area, the using the tracking area comprising monitoring whether the validity period for the tracking area has expired, wherein the means are further configured to perform stopping using the tracking area when the validity period for the tracking area has expired.

According to some examples, the means are further configured to perform: detecting, during a validity period, whether the respective tracking area for the validity period is available; wherein when the respective tracking area is available during the validity period, using the respective tracking area in the registration area during the validity period without requiring performance of a mobility registration update; and wherein when the respective tracking area is not available during the validity period, sending a mobility registration update to the network node.

According to some examples, the at least one tracking area identity comprises at least one of a cell identifier or a tracking area code.

According to some examples, the apparatus comprises a user equipment.

According to some examples, the network node comprises an access and mobility management function node.

According to some examples, a registration area comprises a list of tracking area identities (TAIs).

According to a second aspect there is provided an apparatus comprising at least one processor; and at least one memory including computer program code; the
5 at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to perform: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and determining
10 whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to some examples, each registration area is associated with a satellite, wherein the sequence of registration areas is determined based on a predicted path of each satellite.

According to some examples, when the change is from a registration area in
15 the sequence to a registration area that is next in the sequence, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform using the registration area that is next in the sequence without requiring a mobility registration update.

According to some examples, the at least one memory and the computer
20 program code are configured to, with the at least one processor, cause the apparatus at least to perform sending a mobility registration update to the network node when the change is from a registration area in the sequence to a registration area that is not next in the sequence.

According to some examples, each registration area comprises at least one
25 tracking area and the information comprises at least one tracking area identity for each tracking area.

According to some examples, the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part
30 of a registration area.

According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform: using the tracking area, the using the tracking area comprising monitoring whether the validity period for the tracking area has expired, wherein the means are further configured to perform stopping using the tracking area when the validity period for the tracking area has expired.

According to some examples, the at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to perform: detecting, during a validity period, whether the respective tracking area for the validity period is available; wherein when the respective tracking area is available during the validity period, using the respective tracking area in the registration area during the validity period without requiring performance of a mobility registration update; and wherein when the respective tracking area is not available during the validity period, sending a mobility registration update to the network node.

According to some examples, the at least one tracking area identity comprises at least one of a cell identifier or a tracking area code.

According to some examples, the apparatus comprises a user equipment.

According to some examples, the network node comprises an access and mobility management function node

According to some examples, a registration area comprises a list of tracking area identities (TAIs).

According to a third aspect there is provided an apparatus comprising: receiving circuitry for receiving, from a network node, information comprising a sequence of registration areas; detecting circuitry for detecting, at the apparatus, a change of registration area that is serving the apparatus; determining circuitry for determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to a fourth aspect there is provided a method comprising: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and

determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to some examples each registration area is associated with a satellite, wherein the sequence of registration areas is determined based on a predicted path of each satellite.

According to some examples, when the change is from a registration area in the sequence to a registration area that is next in the sequence, the method comprises: using the registration area that is next in the sequence without requiring a mobility registration update.

According to some examples, the method comprises: sending a mobility registration update to the network node when the change is from a registration area in the sequence to a registration area that is not next in the sequence.

According to some examples, each registration area comprises at least one tracking area and the information comprises at least one tracking area identity for each tracking area.

According to some examples, the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part of a registration area.

According to some examples, the method comprises: using the tracking area, the using the tracking area comprising monitoring whether the validity period for the tracking area has expired, wherein the means are further configured to perform stopping using the tracking area when the validity period for the tracking area has expired.

According to some examples, the method comprises: detecting, during a validity period, whether the respective tracking area for the validity period is available; wherein when the respective tracking area is available during the validity period, using the respective tracking area in the registration area during the validity period without requiring performance of a mobility registration update; and wherein when the respective tracking area is not available during the validity period, sending a mobility registration update to the network node.

According to some examples, the at least one tracking area identity comprises at least one of a cell identifier or a tracking area code.

According to some examples, the method is performed by a user equipment.

According to some examples, the network node comprises an access and mobility management function node.

According to some examples a registration area comprises a list of tracking area identities.

According to a fifth aspect there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to a sixth aspect there is provided a computer program comprising instructions stored thereon for performing at least the following: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to a seventh aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to an eighth aspect there is provided a non-transitory computer readable medium comprising program instructions stored thereon for performing at least the following: receiving, from a network node, information comprising a sequence of registration areas; detecting, at the apparatus, a change of registration area that is serving the apparatus; and determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

According to a ninth aspect there is provided an apparatus comprising means for performing: sending, to a user equipment, information comprising a sequence of registration areas.

5 According to some examples, each registration area of the sequence is associated with a satellite, wherein the sequence is determined based on a predicted path of each satellite.

According to some examples, the information indicates that when the registration areas available to the user equipment change according to the sequence, the user equipment can use the registration area without performing a mobility
10 registration update.

According to some examples, the information indicates that the user equipment is required to perform sending a mobility registration update to the network node when the registration areas available to the user equipment do not change according to the sequence.

15 According to some examples, each registration area comprises at least one tracking area, and the information comprises at least one tracking area identity for each tracking area.

According to some examples, the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period
20 indicates when the respective tracking area is valid for the apparatus in at least part of a registration area.

According to some examples, the apparatus comprises an access and mobility management function node.

According to some examples, the at least one tracking area identity comprises
25 at least one of a cell identifier or a tracking area code.

According to some examples, a registration area comprises a list of tracking area identities.

According to a tenth aspect there is provided an apparatus comprising at least one processor; and at least one memory including computer program code; the at
30 least one memory and the computer program code configured to, with the at least one

processor, cause the apparatus at least to perform: sending, to a user equipment, information comprising a sequence of registration areas.

According to some examples, each registration area of the sequence is associated with a satellite, wherein the sequence is determined based on a predicted
5 path of each satellite.

According to some examples, the information indicates that when the registration areas available to the user equipment change according to the sequence, the user equipment can use the registration area without performing a mobility registration update.

10 According to some examples, the information indicates that the user equipment is required to perform sending a mobility registration update to the network node when the registration areas available to the user equipment do not change according to the sequence.

According to some examples, each registration area comprises at least one
15 tracking area, and the information comprises at least one tracking area identity for each tracking area.

According to some examples, the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part
20 of a registration area.

According to some examples, the apparatus comprises an access and mobility management function node.

According to some examples, the at least one tracking area identity comprises at least one of a cell identifier or a tracking area code.

25 According to some examples, a registration area comprises a list of tracking area identities.

According to a eleventh aspect there is provided an apparatus comprising: sending circuitry for sending, to a user equipment, information comprising a sequence of registration areas.

According to a twelfth aspect there is provided a method comprising: sending, to a user equipment, information comprising a sequence of registration areas.

According to some examples each registration area of the sequence is associated with a satellite, wherein the sequence is determined based on a predicted
5 path of each satellite.

According to some examples the information indicates that when the registration areas available to the user equipment change according to the sequence, the user equipment can use the registration area without performing a mobility registration update.

10 According to some examples the information indicates that the user equipment is required to perform sending a mobility registration update to the network node when the registration areas available to the user equipment do not change according to the sequence.

According to some examples each registration area comprises at least one
15 tracking area, and the information comprises at least one tracking area identity for each tracking area.

According to some examples the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part
20 of a registration area.

According to some examples the method is performed by an access and mobility management function node.

According to some examples, the at least one tracking area identity comprises at least one of a cell identifier or a tracking area code.

25 According to some examples, a registration area comprises a list of tracking area identities.

According to a thirteenth aspect there is provided a computer program comprising instructions for causing an apparatus to perform at least the following: sending, to a user equipment, information comprising a sequence of registration areas.

According to a fourteenth aspect there is provided a computer program comprising instructions stored thereon for performing at least the following: sending, to a user equipment, information comprising a sequence of registration areas.

5 According to a fifteenth aspect there is provided a non-transitory computer readable medium comprising program instructions for causing an apparatus to perform at least the following: sending, to a user equipment, information comprising a sequence of registration areas.

10 According to a sixteenth aspect there is provided a non-transitory computer readable medium comprising program instructions stored thereon for performing at least the following: sending, to a user equipment, information comprising a sequence of registration areas.

Brief description of Figures

15 The invention will now be described in further detail, by way of example only, with reference to the following examples and accompanying drawings, in which:

Figure 1 shows a schematic example a map and example coverage areas of satellites;

Figure 2 shows a schematic example of predicted paths of a plurality of satellites;

20 Figure 3 shows an example message flow;

Figure 4 shows an example message flow

Figure 5 schematically shows parts of an apparatus, according to an example;

Figure 6 schematically shows parts of a network node, according to an example; and

25 Figure 7 schematically shows a flow chart of a method according to an example.

Detailed description

The present disclosure relates to mobility management in a communication network.

In some situations, communication networks are provided with one or more moving and/or changing coverage areas. This may be due to use of satellites that do not have a Geostationary Orbit (GSO) in the communications network. In other examples, a changing coverage area could be provided due to an industrial application requiring part of a terrestrial access network to be switched on and off at pre-determined intervals.

Satellite-based communication systems can use satellites on various different earth orbits. GSO satellites appear static when observed from a certain point on earth. As long as a UE does not move substantially, mobility updates are not required to be sent to the network when using GSO satellite based communication networks.

Other satellite orbits, such as Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) orbits require a higher satellite velocity than GSO orbits such that a single satellite cannot constantly cover the same part (i.e. the same geographical region) of the earth. A coordinated constellation of multiple satellites can be deployed to maintain coverage over the whole of the earth.

A schematic example of a LEO/MEO satellite and a GEO satellite is shown in Figure 1. A schematic map of the globe is shown at 100. At 102, an example of the geometrical coverage of an LEO satellite is shown. As the LEO satellite completes a LEO, the geometrical coverage area 102 will move across the globe i.e. across map 100.

The geometrical coverage of an LEO satellite is less than that of a GEO satellite. The geometrical coverage of an MEO satellite is also less than that of a GEO satellite. The geometrical coverage of a GEO satellite is shown at 104 by way of example.

A further aspect to consider for satellite based communications is a power supply of the satellite system. Satellite stations orbiting the earth are often powered by solar panels. The capacity of the solar panels determines the maximum power consumption of the satellite-based communication module. Reducing the number of bits communicated to and from the satellite and reducing the number of messages sent to and from the satellite can save power to avoid exceeding the maximum power consumption limit of the satellite.

In 5G networks, an ongoing 5G Non Access Stratum (NAS) procedure for a UE is the registration update. Registration updates can be caused by a UE moving to a new area. This type of update is a Mobility Registration Update. Registration updates

can also be caused by expiry of a network issued periodic registration update timer. This type of update is a Periodic Registration Update.

To avoid sending excessive registration updates to a satellite in a satellite-based communication system, the periodic registration update timer can be extended to a sufficiently long value to minimise the signalling of Periodic Registration Updates. However, in a MEO or LEO satellite based communication system, Mobility Registration Updates signalling UE mobility would be caused by relative motion between the MEO or LEO satellite and the earth-bound UE, when each satellite represents its own Tracking Area. On the other hand, grouping all satellites into a single Tracking Area would lose the mobility management goal of identifying the UE location for paging.

In some examples, the path of a satellite is predicted. The satellite could be, for example, a LEO or MEO satellite.

Further, in some examples, the paths of multiple satellites are predicted. These satellites could be, for example, LEO or MEO satellites.

Figure 2 schematically shows an example of the predicted paths of multiple satellites. The satellites may be LEO or MEO.

At 200 there is provided a schematic map. Map 200 may, for example, be a map of the Earth or a map of a hemisphere of the Earth. Example predicted paths of satellite coverage areas as a satellite moves across map 200 are shown at 210, 212 and 214. It will be appreciated that in some examples, more or fewer satellites may be provided which may also move across map 200.

An example of an area is shown at 216. At a first time, t_1 , area 216 may be the coverage area for the satellite having the satellite path 210. At a second time, t_2 , (which may be different to the first time, or in some cases the same as the first time), area 216 may be the coverage area for the satellite having the satellite path 212. In some examples, the coverage area may be a different size for the two satellites. In some examples, the coverage area may be the same for each of the two satellites. The coverage area may correspond to a Tracking Area (TA) of the satellite. The Tracking Area of a LEO or MEO satellite will move relative to the Earth.

A UE in area 216 therefore may be served by the satellite of path 210 at the first time t_1 and by the satellite of path 212 at the second time t_2 . The UE may therefore be served by these two satellites at different times if the UE remains in the area 216. In some examples, the UE may be served by these two satellites at different

times when the UE is geographically stationary or substantially geographically stationary.

A further example of an area is shown at 218. At a third time, t3, area 218 may be the coverage area for the satellite of path 214. At a fourth time, t4, (which may be different to the third time, or in some cases the same as the third time), area 218 may be the coverage area for the satellite of path 212. In some examples, the coverage area may be a different size for the two satellites. In some examples, the coverage area may be the same for each of the two satellites.

A UE in area 218 therefore may be served by the satellite of path 212 at t3 and by the satellite of path 214 at t4. The UE may therefore be served by these two satellites at different times if the UE remains in the coverage area 218. In some examples, the UE may be served by these two satellites at different times when the UE is geographically stationary or substantially geographically stationary to make the UE mobility insignificant in relation with the satellite constellation.

As the paths of a plurality of satellites can be scheduled and plotted, and as the coverage area of the respective satellites can be predicted, a schedule can be scheduled and/or predicted of when a particular satellite will be able to serve a particular geographic location in a satellite based communications network. This schedule may be predicted and maintained at a network node. If the UE location information is not sufficiently accurate to calculate a pre-timed schedule for all UEs in the satellite coverage area, at least the sequence in which the known satellite orbits sweep (i.e. move) across the coverage area is known. Therefore, if the precise time when the sufficiently stationary UE enters the coverage area of the next satellite is not known with high accuracy, at the next satellite(s) in sequence to pass over the same land area is known such that information comprising a sequence of Registration Areas for the UE can be issued by a network node to the UE. The Registration Area may be considered as the area in which the UE considers itself registered to the serving Public Land Mobile Network (PLMN). In some examples the Registration Area can be expressed in the form of a sequence such as a Tracking Area list. A Tracking Area list may comprise a list of TAIs (Tracking Area Identities) such as Cell IDs or Tracking Area Codes (TACs). A UE can follow the sequence when changing from the present Registration Area to the next Registration Area without having to perform a Registration Update due to mobility.

In some examples, the next available satellite for a stationary, or substantially stationary, UE can be predicted by taking into account the predicted paths of multiple satellites. Furthermore, the coverage area (for example the radius of the coverage area) of a satellite can be taken into account when determining the next available
5 satellite for a stationary (relative to the earth), or substantially stationary, UE.

As long as a UE does not move too much, the prediction of available satellites and the scheduled times at which they can serve a geographic location can be used as the basis for a pre-timed Registration Area. Each satellite can be pre-scheduled for a UE to use when it is due to replace the currently serving satellite. For example,
10 as a currently serving satellite moves towards the horizon from the perspective of the UE a “new” or next satellite may be scheduled to replace this satellite.

Furthermore, a sequence of subsequent Registration Areas can be predicted to replace the current Registration Area. This sequence can be taken in use by the UE on an event-driven basis. This means that two UEs in different locations start to
15 use the next Registration Area list at the time when they see the next satellite emerging above the horizon. The sequence of Registration Areas may be the same, but the UEs in different locations can take the new Registration Area in use at different times, depending on when they can detect the next satellite being available.

In some examples, a network node, such as an Access and Management
20 Function (AMF) node, may store information of which satellites will serve a particular geographic area. In some examples, this geographical area may be considered as a registration area for a certain time period. Each satellite may be identified by TAI such as a Cell ID or a TAC. In some examples, this information may be stored at a UE. A pre-timed schedule, or at least a sequence of Registration Areas and their availability
25 can therefore be predicted. Each Registration area may comprise at least one Tracking Area.

In some examples, the schedule of Registration Areas and their availability may be based on pre-scheduled events other than the predicted paths of satellites. For example, the schedule may be based on predetermined intervals for switching part of
30 a terrestrial access network on and off.

An example message flow diagram is shown at Figure 3. At step 326, UE 320 receives an assignment from network node 322. Network node 322 may be an AMF node. The assignment may be for a registration area, or at least a part of a registration area.

The assignment may also comprise an indication. The indication may identify a Tracking Area for the assigned part of the registration area. In some examples, a part of the registration area may comprise the entire registration area. The Tracking Area may be identified by a TAI such as a Cell ID or TAC. The Tracking Area may be associated with a satellite, or a plurality of satellites. The indication may also comprises information regarding an associated validity period for the identified Tracking Area. The validity period information may indicate the start, end, or start and end of the validity period in the assigned part of the Registration Area for the identified Tracking Area. The validity period information may indicate individually the start or end of the validity period in the assigned part of the Registration Area for an identified tracking area. The validity period information may indicate both the start and end of the validity period in the assigned part of the Registration Area for an identified tracking area.

In some examples, the end of the validity period is not dependent on a Periodic Registration Update cycle.

The indication may identify more than one Tracking Area. Furthermore, the indication may comprise an associated validity period for each identified Tracking Area. In some examples, the indication may comprise a list of TAIs and associated validity periods.

The indication may identify more than one satellite. Furthermore, the indication may comprise an associated validity period for each identified satellite. In some examples, the indication may comprise a list of satellite identifiers and associated validity periods.

The assignment signalled at step 326 may also comprise information indicating that when the identified at least one tracking area is available during the respective at least one validity period, UE 320 can use the assigned part of the registration area during the at least one validity period without performing a mobility registration update.

The assignment signalled at step 326 may also comprise information indicating that the UE 320 is required to send a Mobility Registration Update to network node 322 when the identified at least one tracking area is detected to not be available during the respective at least one validity period or when the UE moves after the current Registration Area to another Registration Area that is not the same as the one that has been indicated by the network to succeed after the current Registration Area. The

network may make this indication by sending information comprising a sequence to the user equipment.

In some examples, the information in the above described indication may be sent to UE 320 in separate messages, and from different network nodes.

5 At step 330, UE 320 detects whether the at least one identified Tracking Area is available. UE 320 may detect whether a tracking area is available during the respective validity period of the tracking area. This may comprise UE 320 using a timer to monitor the validity period. This may further comprise UE 320 checking whether it can use the tracking area identified at step 326 for
10 telecommunications.

If the tracking area is available during the validity period of the tracking area, at step 332, UE 320 will use the assigned part of the Registration Area during the validity period without performing a mobility registration update.

15 If the tracking area is not available during the validity period of the tracking area, at step 334, UE 320 will send a mobility registration update to network node 322. This mobility registration update may indicate to network node 322 that UE 320 has moved out of the assigned part of the Registration Area.

20 In some examples, UE 320 may initially be in an assigned part of the Registration Area. UE 320 may check the time and determine which validity period the current time falls in. UE 320 will then check if the tracking area corresponding to the validity period is available. To perform this check UE 320 may use the information signalled from network node 322 at step 326. When UE 320 determines that a tracking area is not available during its respective validity period, this information can be used to imply that UE 320 has moved out of the assigned part of the Registration Area. In
25 some examples, UE 320 can then perform a Mobility Registration Update to provide location information to the network.

30 When UE 320 determines that a tracking area is available during its respective validity period, this can be used to imply that UE 320 has not moved out of the assigned part of the Registration Area and is not required to perform a Mobility Registration Update.

In further examples, where a plurality of tracking areas and respective validity periods are provided to UE 320 by network node 322, when a first validity period expires a second validity period may begin. When the first validity period ends, UE 320 may stop using the Tracking Area associated with the first validity period. If the

tracking area associated with the second validity period is available when the first validity period ends, UE 320 is not required to provide a Mobility Registration Update.

An example message flow diagram is shown at Figure 4. At step 426, UE 420 receives a sequence of Registration Areas from network node 422. Network node 422 may be an AMF node. Each Registration area in the sequence may comprise at least one TA. A Registration Area in the sequence may comprise a TAI list. Each Tracking Area in the sequence may be identified by a TAI such as a Cell ID or TAC. Each Tracking Area may be associated with a satellite, or a plurality of satellites.

The assignment signalled at step 426 may also comprise information indicating that when it is detected that the availability of a Registration Area to the UE 420 changes, if the availability of the Registration Areas change according to the Registration Area sequence, i.e. the Registration Area that is serving UE 420 changes according to the sequence, UE 420 is not required to send a Mobility Registration Update to the network. However, the information may also indicate that if the availability of the Registration Areas does not change according to the Registration Area sequence, UE 420 is required to send a Mobility Registration Update to the network.

In some examples, the information in the above described assignment, such as the Registration Area sequence, may be sent to UE 320 in separate messages, and from different network nodes.

At step 436, UE 420 detects a change in availability of Registration Area. This may comprise detecting a change in Tracking Area. UE 420 then determines whether the change is from a Registration Area in the sequence to a Registration Area that is next in the sequence.

If the change is from a Registration Area in the sequence to a Registration Area that is next in the sequence, UE 420 continues to use the new Registration Area at step 438 without sending a mobility registration update.

If the change is from a Registration Area in the sequence to a Registration Area that is next in the sequence, UE 420 sends a Mobility Registration Update to Network Node 422 at step 440.

Steps of Figures 3 and 4 may be used in conjunction with one another. For example, step 436 and step 330 may both take place at the same UE.

An example sequence of Registration Areas could be for example, RA1, RA2, RA3, RA4, RA5. In this example sequence, the next Registration Area in the sequence

for RA1 is RA2. The next Registration Area in the sequence for RA2 is RA3. The next Registration Area in the sequence can be considered to be immediately subsequent in the sequence to the current Registration Area.

Some examples may save the power budget of a satellite by reducing the number of Mobility Registration Updates required while providing information as to where the UE is located. This can reduce power required to page a UE for downlink data reception. Some examples avoid excessive mobility management signalling without losing accuracy of UE location. By not losing UE location accuracy, the UE can be more easily paged via a known satellite.

In some examples, the number of overall registration updates is further decreased by setting a long periodic update timer value for Periodic Registration Updates. The timer value may be set as longer than the time taken for the orbit of either of an LEO satellite or a MEO satellite.

In some examples, a paging strategy may be used to further reduce Mobility Registration Updates. More than one satellite can be assigned to a TA. To perform the paging strategy, the network can predict and maintain a schedule of satellites and the locations at which they are able to serve. The schedule may also comprise information of the time periods at which the satellites are able to serve the locations. To page a UE, the network can page the UE via a satellite scheduled to cover the area where the UE was last discovered by the network.

In some examples, the network may assign all satellites of a satellite based communications network to the same TA or list of TAs. The network can then use the above described paging strategy to page the UE.

In some examples, a 5G network may assign an "All PLMN" Registration Area for a UE. This encoding indicates to the UE that it does not need to perform Mobility Registration Updates in the registered PLMN. The network can then use the above described paging strategy to page the UE.

An example of a UE 500 is shown in Figure 5.

The UE 500 may receive signals over an air or radio interface 507 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 5 transceiver apparatus is designated schematically by block 506. The transceiver apparatus 506 may be provided for example by means of a radio part and associated antenna arrangement.

The antenna arrangement may be arranged internally or externally to the wireless device.

A UE is typically provided with at least one data processing entity 501, at least one memory 502 and other possible components 503 for use in software and hardware
5 aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 504. The user may control the operation of the wireless device by means of a suitable user
10 interface such as key pad 505, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 508, a speaker and a microphone can be also provided. Furthermore, a wireless communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto. The
15 communication devices 502, 504, 505 may access the communication system based on various access techniques.

In some examples, the UE 500 can be configured to execute appropriate software code to provide the method of Figures 3 and 4. In some examples the control apparatus can be configured to execute appropriate software code to provide the
20 method steps performed by UE 320 in Figure 3 or by UE 420 in Figure 4.

Figure 6 shows an example of a control apparatus 600 for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station, gNB, a central unit of a cloud architecture or a node of a core network such as an MME or S-GW, a scheduling entity
25 such as a spectrum management entity, or a server or host. Such a control apparatus may host functionality such as that of network node 322 or network node 422. Network node 322 and/or network node 422 may comprise an AMF. The control apparatus may be integrated with or external to a node or module of a core network or RAN. In some embodiments, network nodes comprise a separate control apparatus unit or
30 module. In other embodiments, the control apparatus can be another network element such as a radio network controller or a spectrum controller. In some embodiments, each base station may have such a control apparatus as well as a control apparatus being provided in a radio network controller. The control apparatus 600 can be arranged to provide control on communications in the service area of the system. The

control apparatus 600 comprises at least one memory 601, at least one data processing unit 602, 603 and an input/output interface 604. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The receiver and/or the transmitter may be implemented as a radio front end or a remote radio head. For example the control apparatus 600 can be configured to execute an appropriate software code to provide the control functions.

In some examples, the control apparatus 600 can be configured to execute appropriate software code to provide the method of Figure 3 or 4. In some examples the control apparatus can be configured to execute appropriate software code to provide the method steps performed by network node 322 in Figure 3 or by network node 422 in Figure 4.

Figure 7 is a flow chart of a method according to an example. The flow chart of Figure 7 is viewed from the perspective of an apparatus. For examples the apparatus may be similar to UE 320.

At S1, the method comprises receiving, from a network node, information comprising a sequence of registration areas. The network node may comprise network node 322. The network node may be an AMF node.

At S2, the method comprises detecting, at the apparatus, a change of registration area that is serving the apparatus.

At S3, the method comprises determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence. In some examples, the apparatus may base a decision on whether to send a mobility registration update based on this determination.

It will be understood that the described steps of the method are not necessarily purely sequential, according to some examples. For example, in terms of timings there may be overlap between S1 to S3.

In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described

herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

As used in this application, the term “circuitry” may refer to one or more or all of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) combinations of hardware circuits and software, such as (as applicable): (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation. This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in server, a cellular network device, or other computing or network device.

The embodiments of this invention may be implemented by computer software executable by a data processor of the mobile device, such as in the processor entity, or by hardware, or by a combination of software and hardware. Computer software or program, also called program product, including software routines, applets and/or macros, may be stored in any apparatus-readable data storage medium and they comprise program instructions to perform particular tasks. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to carry out embodiments. The one or more computer-executable components may be at least one software code or portions of it.

Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. The software may be stored on such physical media as memory chips, or memory

blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example DVD and the data variants thereof, CD. The physical media is a non-transitory media.

The memory may be of any type suitable to the local technical environment and
5 may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors may be of any type suitable to the local technical environment, and may comprise one or more of general purpose computers, special purpose computers,
10 microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), FPGA, gate level circuits and processors based on multi core processor architecture, as non-limiting examples.

Embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly
15 automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

The foregoing description has provided by way of non-limiting examples a full and informative description of the exemplary embodiment of this invention. However,
20 various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention as defined in the appended claims. Indeed there is a further embodiment
25 comprising a combination of one or more embodiments with any of the other embodiments previously discussed.

Claims

1. An apparatus comprising means for performing:
 - receiving, from a network node, information comprising a sequence of registration areas;
 - 5 detecting, at the apparatus, a change of registration area that is serving the apparatus; and
 - determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.
- 10 2. An apparatus according to claim 1, wherein each registration area is associated with a satellite, wherein the sequence of registration areas is determined based on a predicted path of each satellite.
- 15 3. An apparatus according to claim 1 or claim 2, wherein when the change is from a registration area in the sequence to a registration area that is next in the sequence, the means are further configured to perform using the registration area that is next in the sequence without requiring a mobility registration update.
- 20 4. An apparatus according to any preceding claim, wherein the means are further configured to perform sending a mobility registration update to the network node when the change is from a registration area in the sequence to a registration area that is not next in the sequence.
- 25 5. An apparatus according to any preceding claim, wherein each registration area comprises at least one tracking area and the information comprises at least one tracking area identity for each tracking area.

6. An apparatus according to claim 5, wherein the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part of a registration area.

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7. An apparatus according to claim 6, wherein the means are further configured to perform:

detecting, during a validity period, whether the respective tracking area for the validity period is available;

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wherein when the respective tracking area is available during the validity period, using the respective tracking area in the registration area during the validity period without requiring performance of a mobility registration update; and

wherein when the respective tracking area is not available during the validity period, sending a mobility registration update to the network node.

15

8. An apparatus according to any preceding claim, wherein the means comprises:

at least one processor; and

at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performances of the apparatus.

20

9. An apparatus comprising means for performing:

sending, to a user equipment, information comprising a sequence of registration areas.

25

10. An apparatus according to claim 9, wherein each registration area of the sequence is associated with a satellite, wherein the sequence is determined based on a predicted path of each satellite.
- 5 11. An apparatus according to any of claims 9 or 10, wherein the information indicates that when the registration areas available to the user equipment change according to the sequence, the user equipment can use the registration area without performing a mobility registration update.
- 10 12. An apparatus according to any of claims 9 to 11, wherein the information indicates that the user equipment is required to perform sending a mobility registration update to the network node when the registration areas available to the user equipment do not change according to the sequence.
- 15 13. An apparatus according to any of claims 9 to 12, wherein each registration area comprises at least one tracking area, and the information comprises at least one tracking area identity for each tracking area.
14. An apparatus according to claim 13, wherein the information further
20 comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part of a registration area.
15. An apparatus according to any of claims 9 to 14, wherein the apparatus
25 comprises an access and mobility management function node.
16. An apparatus according to any of claims 9 to 15, wherein the means comprises:
at least one processor; and

at least one memory including computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the performances of the apparatus.

5 17. A method comprising:

receiving, from a network node, information comprising a sequence of registration areas;

detecting, at the apparatus, a change of registration area that is serving the apparatus; and

10 determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence.

18. A method according to claim 17, wherein each registration area is associated with a satellite, wherein the sequence of registration areas is determined based on a
15 predicted path of each satellite.

19. A method according to claim 17 or claim 18, wherein when the change is from a registration area in the sequence to a registration area that is next in the sequence, the method comprises: using the registration area that is next in the sequence
20 without requiring a mobility registration update.

20. A method according to any of claims 17 to 19, wherein the method comprises: sending a mobility registration update to the network node when the change is from a registration area in the sequence to a registration area that is not next in the
25 sequence.

21. A method according to any of claims 17 to 20, wherein each registration area comprises at least one tracking area and the information comprises at least one tracking area identity for each tracking area.

22. A method according to claim 21, wherein the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus
5 in at least part of a registration area.

23. A method according to claim 22, wherein the method comprises:

detecting, during a validity period, whether the respective tracking area for the validity period is available;

10 wherein when the respective tracking area is available during the validity period, using the respective tracking area in the registration area during the validity period without requiring performance of a mobility registration update; and

wherein when the respective tracking area is not available during the validity period, sending a mobility registration update to the network node.

15

24. A method comprising:

sending, to a user equipment, information comprising a sequence of registration areas.

20 25. A method according to claim 24, wherein each registration area of the sequence is associated with a satellite, wherein the sequence is determined based on a predicted path of each satellite.

26. A method to of claim 24 or 25, wherein the information indicates that when the
25 registration areas available to the user equipment change according to the sequence, the user equipment can use the registration area without performing a mobility registration update.

27. A method according to any of claims 24 to 26, wherein the information indicates that the user equipment is required to perform sending a mobility registration update to the network node when the registration areas available to the user equipment do not change according to the sequence.

5

28. A method according to any of claims 24 to 27, wherein each registration area comprises at least one tracking area, and the information comprises at least one tracking area identity for each tracking area.

10 29. A method according to claim 28, wherein the information further comprises a list of validity periods for each of the tracking areas in the sequence, wherein each validity period indicates when the respective tracking area is valid for the apparatus in at least part of a registration area.

15 30. A method according to any of claims 24 to 29, wherein the method is performed by an access and mobility management function node.

31. A computer program comprising instructions for causing an apparatus to perform at least the following:

20 receiving, from a network node, information comprising a sequence of registration areas;

detecting, at the apparatus, a change of registration area that is serving the apparatus; and

25 determining whether the change is from a registration area in the sequence to a registration area that is next in the sequence

32. A computer program comprising instructions for causing an apparatus to perform at least the following:

sending, to a user equipment, information comprising a sequence of registration areas.

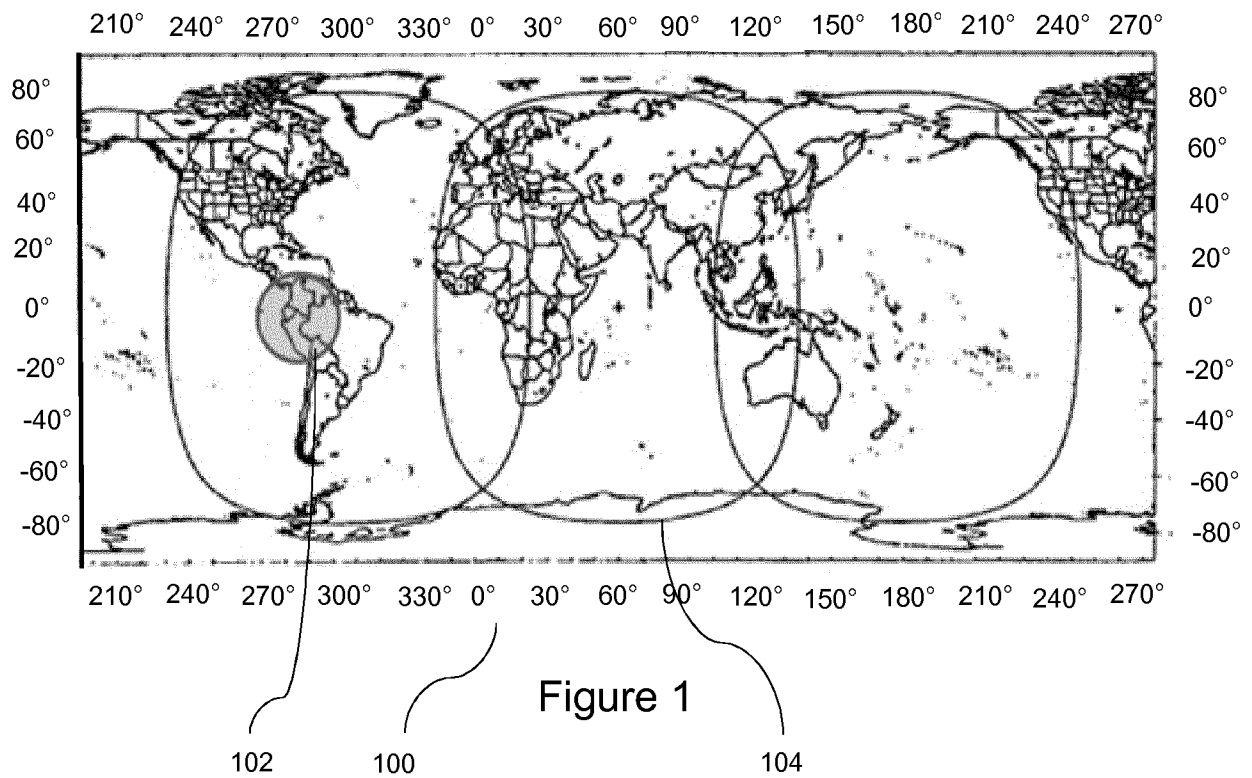
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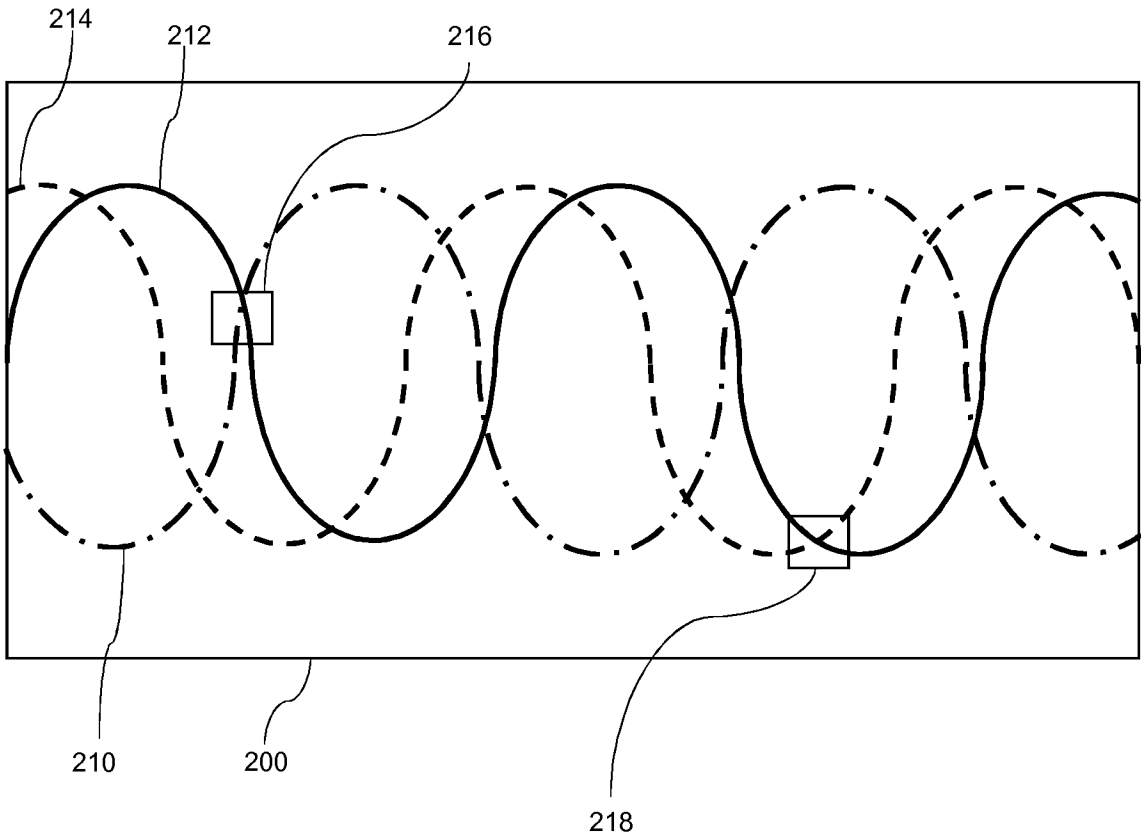


Figure 2

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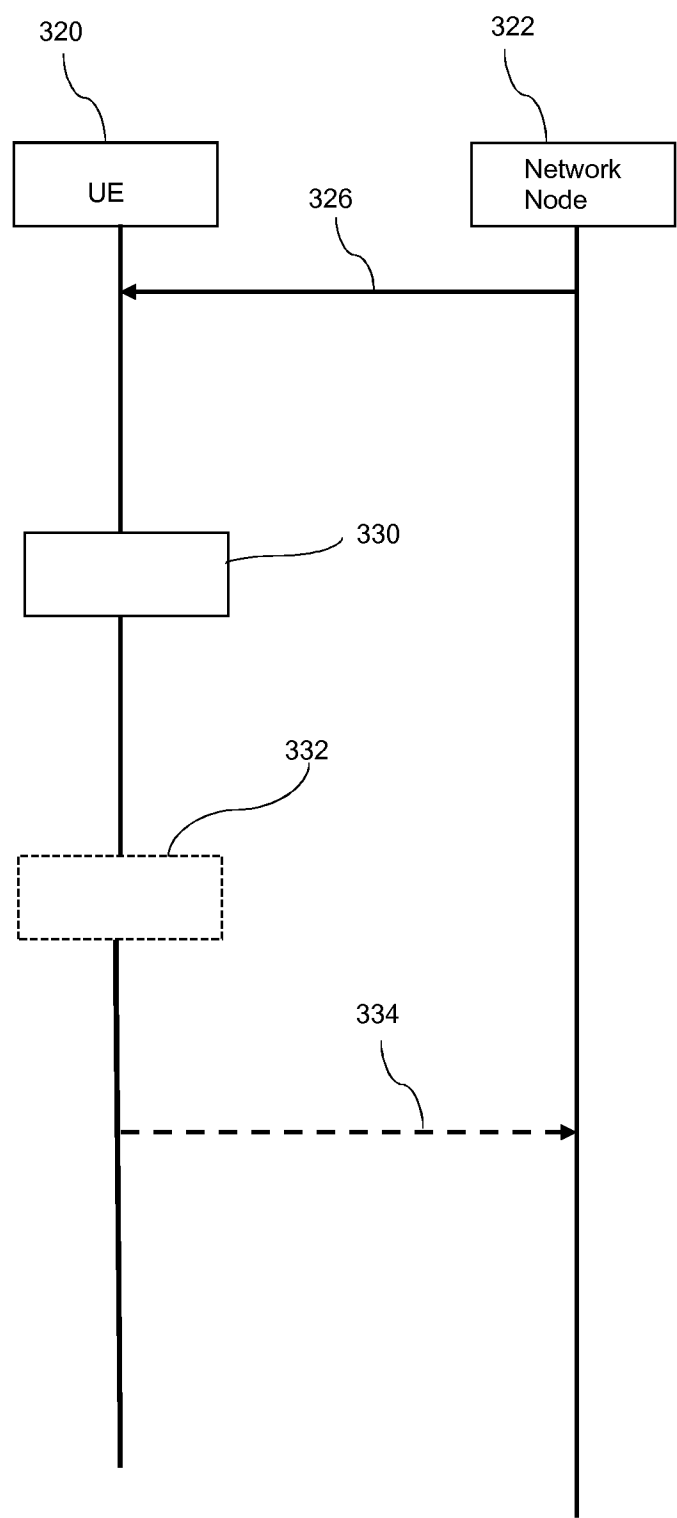


Figure 3

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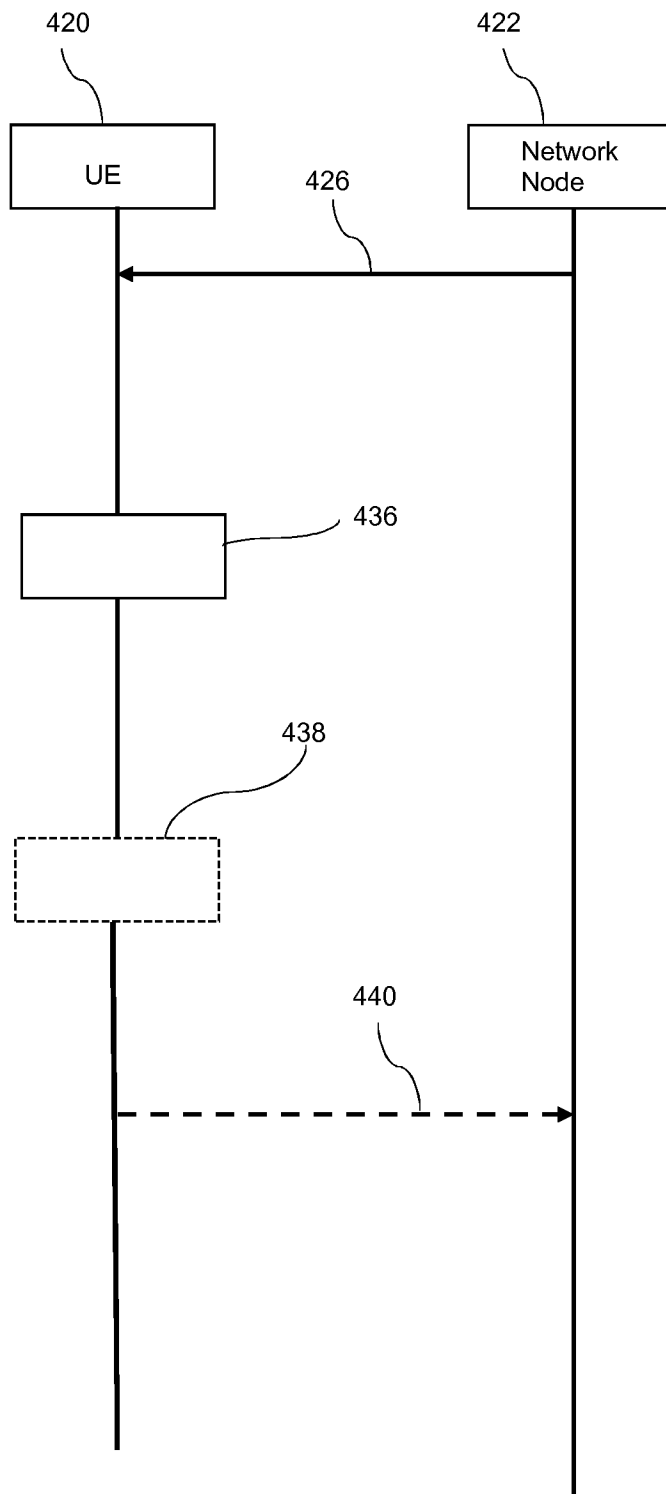


Figure 4

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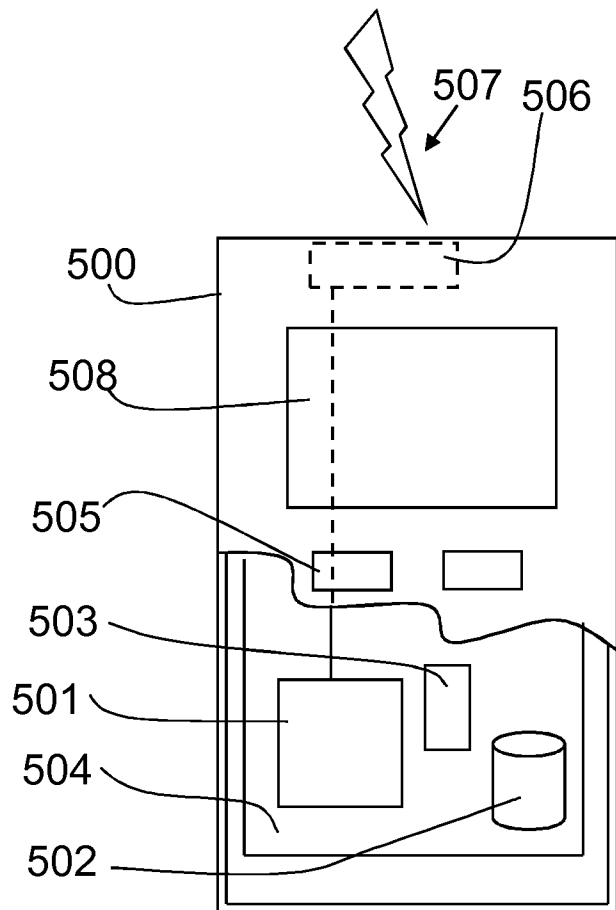


Figure 5

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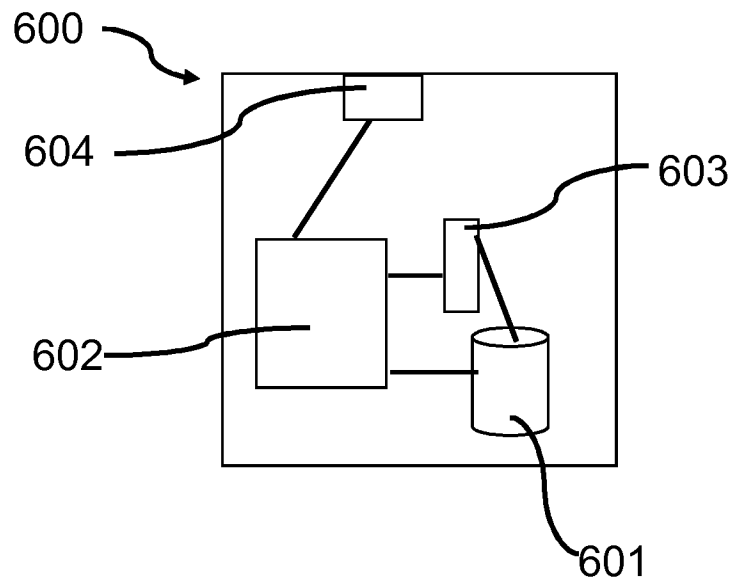


Figure 6

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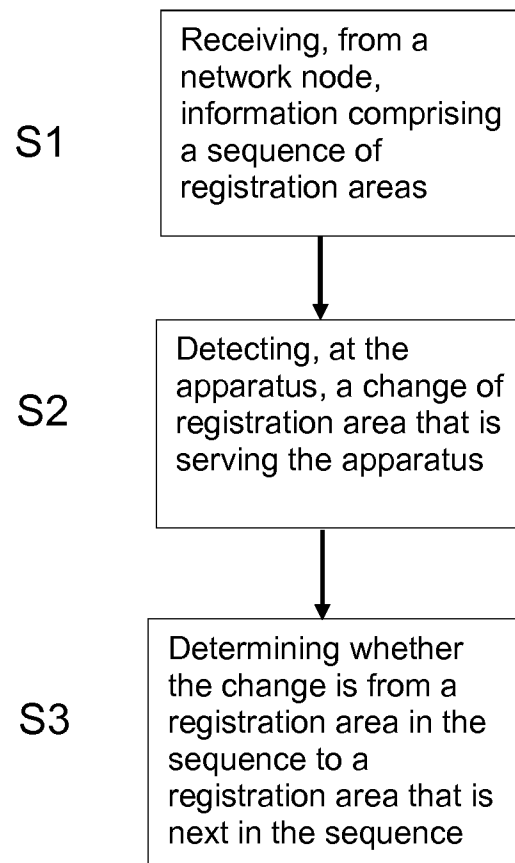


Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/052388

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W60/00

ADD. H04W84/06 H04W84/00 H04B7/185

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

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FRAUNHOFER IIS ET AL: "NR-NTN: Tracking Areas Management", 3GPP DRAFT; R2-1818593 NR-NTN_TRACKING_AREAS_MANAGEMENT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Spokane, USA; 20181112 - 20181116 17 November 2018 (2018-11-17), XP051494903, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg%5Fran/WG2%5FRL2/TSGR2%5F104/Docs/R2%2D1818593%2Ezip [retrieved on 2018-11-17] page 2 point 2.3.1 -/--	1-32



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

4 October 2019

Date of mailing of the international search report

18/10/2019

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Kahl, Marcus

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/052388

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	----- ERICSSON: "Tracking area management and update for NTN", 3GPP DRAFT; R2-1817751 TA FOR NTN, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG2, no. Spokane, US; 20181112 - 20181116 12 November 2018 (2018-11-12), XP051557271, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings%5F3GPP%5FSYNC/RAN2/Docs/R2%2D1817751%2Ezip [retrieved on 2018-11-12] chapter 8.3	1-32
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/052388

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2013/344890 A1 (HAHN GENE BECK [KR] ET AL) 26 December 2013 (2013-12-26) paragraph [0108] -----	4
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Information on patent family members

International application No

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