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(54) **Title:** INITIATION OF TRANSFER OF USER EQUIPMENT TO BASE STATION ACCORDING TO VISUAL DATA

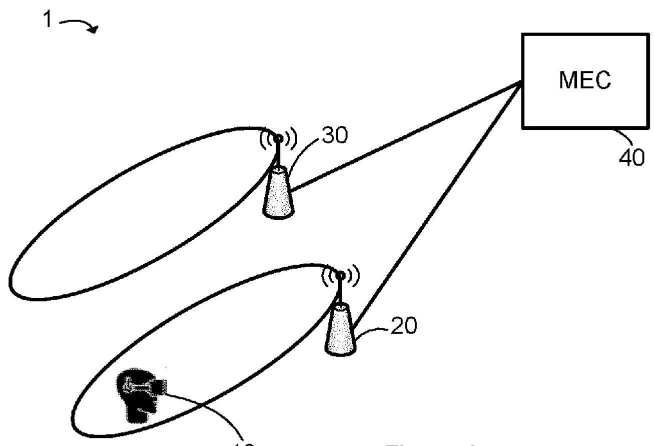

Figure 1

(57) **Abstract:** This invention provides a method, and a network node for implementing the method, of initiating a transfer in a cellular telecommunications network, wherein the cellular telecommunications network comprises a User Equipment, UE, and a base station, wherein the UE includes a camera, the method comprising: storing visual data including a visual representation of at least a part of the base station; receiving visual data captured by the camera of the UE; performing a computer vision operation, trained on the stored visual data, on the captured visual data to determine that the visual representation of the base station or part thereof is present in the captured visual data; and, initiating a transfer of the UE to the base station.

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INITIATION OF TRANSFER OF USER EQUIPMENT TO BASE STATION ACCORDING TO VISUAL DATA

Field of the Invention

The present invention relates to a method in a cellular telecommunications network.

Background

Cellular telecommunications networks include a plurality of base stations, each having a coverage area within which the base station provides voice and data services to a plurality of User Equipments (UEs). UEs are often mobile and therefore can move from the coverage area of a current (“serving”) base station to the coverage area of another base station. When this occurs, the UE must be transferred to the other base station (in which the other base station is known as the “target” of that transfer) so that the target base station thereafter provides voice and data services to the UE.

Base stations of conventional cellular telecommunications networks operated with transmission powers and frequency bands that permitted coverage areas of several square kilometres. However, base stations of modern cellular telecommunications networks can also utilise frequency bands with relatively high frequencies that correspond to relatively small coverage areas. This includes, for example, millimetre wave (mmWave) frequency bands of 30-300GHz. Furthermore, such high frequencies have relatively high attenuation through building materials, so that outdoor base stations of modern cellular telecommunications networks provide relatively poor indoor service. To ensure a good quality connection with a base station operating in these frequency bands, a UE should have Line of Sight (LoS) with the base station. Furthermore, to maintain connectivity in these modern networks where UEs require LoS to the base station, the UE must be transferred between base stations (or between distinct beams of a single base station) more frequently. This results in a corresponding increase in control signalling for the UE to perform radio measurement reporting.

Summary of the Invention

According to a first aspect of the invention, there is provided a method of initiating a transfer in a cellular telecommunications network, wherein the cellular telecommunications network comprises a User Equipment, UE, and a base station, wherein the UE includes a camera, the method comprising: storing visual data including a visual representation of at least a part of the base station; receiving visual data captured by the camera of the UE; performing a computer vision operation, trained on the stored visual data, on the captured visual data to determine that the visual representation of the base station or part thereof is present in the captured visual data; and, initiating a transfer of the UE to the base station.

The base station may have a first and second mode and may use more energy when operating in the first mode than the second mode, wherein the base station is initially in the second mode, and the step of initiating the transfer of the UE may include initiating a switch in the base station from the second mode to the first mode.

The base station may be a target base station and the UE may be served, prior to the transfer, by a serving base station having the first and second mode, and the method may further comprise the step of initiating a switch in the serving base station from the first mode to the second mode.

The stored visual data may include a first visual representation of at least a part of a serving base station and a second visual representation of at least a part of a target base station, and the method may further comprise the steps of: processing a sequence of visual data captured by the camera of the UE to: determine that the second visual representation of the target base station or part thereof is present in the captured visual data, and determine that relative motion between an obstacle, the UE and the serving base station is such that there is a probability above a threshold that the object will block a line of sight between the UE and the serving base station; and, in response, the step of transferring the UE is to transfer the UE from the serving base station to the target base station.

The method may be implemented in one or more of a group comprising: the UE, the base station, and a network node.

The visual representation of at least part of the base station may further include one or more features in the base station’s surroundings.

According to a second aspect of the invention, there is provided a computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method of the first aspect of the invention. The computer program may be stored on a computer-readable data carrier.

According to a third aspect of the invention, there is provided a network node in a cellular telecommunications network, the network node having a transceiver, a processor and a memory configured to cooperate to carry out the method of the first aspect of the invention. The network node may be a UE or a base station.

Brief Description of the Figures

In order that the present invention may be better understood, embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of an embodiment of a cellular telecommunications network of the present invention;
Figure 2 is a schematic diagram of a first base station of the network of Figure 1;
Figure 3 is a schematic diagram of a UE of the network of Figure 1;
Figure 4 is a schematic diagram of an edge computing node of the network of Figure 1;
Figure 5 is a schematic diagram of a cellular telecommunications network implementing a first embodiment of a method of the present invention, in a first state;
Figure 6 is a schematic diagram of the cellular telecommunications network implementing the first embodiment of a method of the present invention, in a second state;
Figure 7 is a flow diagram illustrating the first embodiment of the method of the present invention;
Figure 8 is a schematic diagram of a cellular telecommunications network implementing a second embodiment of a method of the present invention, in a first state;
Figure 9 is a schematic diagram of the cellular telecommunications network implementing the second embodiment of a method of the present invention, in a second state;
Figure 10 is a flow diagram illustrating the second embodiment of the method of the present invention;
Figure 11 is a schematic diagram of a cellular telecommunications network implementing a third embodiment of a method of the present invention, in a first state;

Figure 12 is a schematic diagram of the cellular telecommunications network implementing the third embodiment of a method of the present invention, in a second state; and

Figure 13 is a flow diagram illustrating the third embodiment of the method of the present invention.

Detailed Description of Embodiments

A first embodiment of a cellular telecommunications network 1 will now be described with reference to Figures 1 to 4. The cellular telecommunications network 1 includes a User Equipment (UE) 10, a first base station 20, a second base station 30 and a Mobile Edge Computing (MEC) server 40. Figure 1 illustrates a first beam of the first base station 20 being transmitted about a coverage area. Although the first base station 20 is likely to transmit a plurality of beams, only this first beam is shown for simplicity. The UE 10 is shown as being positioned within the first beam of the first base station 20. Figure 1 also illustrates a first beam of the second base station being transmitted about a coverage area. Again, the second base station 30 is likely to transmit a plurality of beams, but only this first beam is shown for simplicity.

The first base station 20 is shown in more detail in Figure 2. The first base station 20 includes a first communications interface 21, a processor 23, memory 25 and a second interface 27, all connected via bus 29. In this embodiment, the first communications interface 21 is an antenna configured for wireless communications using signals having frequencies ranging from 30GHz to 300GHz (such signals are known as millimetre waves, mmWave), and the second communications interface 27 is a wired connection (e.g. optical fibre) to one or more cellular core networking nodes (including the MEC 40). The processor 23 and memory 25 are configured for facilitating these communications, such as by processing and storing data packets sent/received via the first and second communications interfaces.

In this embodiment, the second base station 30 is substantially the same as the first base station 20.

The UE 10 is shown in more detail in Figure 3. In this embodiment, the UE 10 is a virtual reality headset configured for cellular telecommunications. Accordingly, the UE 10 includes a communications interface 11, a processor 12, memory 13, an optical camera

14, and a display 15, all connected via bus 16. In this embodiment, the communications interface 11 is an antenna configured for wireless communications using signals having frequencies ranging from 30GHz to 300GHz. The optical camera 14 is configured for capturing images or video (i.e. a sequence of images) in the visible spectrum (that is, of electromagnetic radiation having wavelengths in the range of around 400 to 700 nanometres).

The MEC 40 is shown in more detail in Figure 4. In this embodiment, the MEC 40 includes a communications interface 41, a processor 43, and memory 45, all connected via bus 47. Memory 45 includes a database of visual training data for a computer vision learning agent. In this embodiment, memory 45 includes a database having a first database table including:

1. a base station identifier uniquely identifying the base station from any other base station in the network (e.g. an enhanced Cell Global Identifier, eCGI, for the base station),
2. location data for the base station (e.g. the base station’s Global Navigation Satellite System, GNSS, coordinates), and
3. a base station image identifier (uniquely identifying images of that base station *in situ*) used to look up corresponding images of that base station in a second database table.

The second database table therefore includes the base station image identifier and one or more images of that base station in its real-world position (e.g. at a variety of angles). This data is used to train a computer vision process implemented by processor 43.

Memory 45 is updated with new information for each base station, and information on each new base station in the cellular telecommunications network. For example, memory 45 may be updated with new images of the first and second base stations in their real-world positions on a periodic basis, and updated with information on a new base station being added to the network and one or more images of that base station in its real-world position.

The processor 43 of MEC 40 implements a computer vision process by a learning agent 43a and an inference agent 43b. The learning agent 43a is configured to train a machine learning algorithm, in this case a classification model, based on the visual training data in the database. The classification model maps between each input image from the second database table and the corresponding base station identifier. The trained classification model may then be used by the inference agent 43b.

The learning agent 43a performs periodic learning operations to update the classification algorithm, thus adapting to any new images of existing base stations or of images of new base stations.

The inference agent 43b uses the trained classification model in order to map between an input image (e.g. an image captured by the optical camera 14 of the UE 10) and a base station identifier. This will be explained in more detail, below.

A first embodiment of a method of the present invention will now be described with reference to Figures 5 to 7. In this first embodiment, as shown in Figure 5, the UE 10 is being served by the first base station 20 and is positioned within the coverage area of the first base station's first beam. In step S1, the UE 10 captures an image via its optical camera 14. In this example, the captured image includes the second base station 30. The image is transmitted to the MEC 40, via the first base station 20.

In step S3, the inference agent 43b takes the captured image as its input and, using its trained classification model, outputs a base station identifier. In this example, the inference agent 43b uses its trained classification model to output a base station image identifier (based on a mapping between the captured image and one or more images of the second base station 30 stored in the second database table). The processor 43 then uses the stored mapping (from the first database table) to map between the base station image identifier and the base station identifier (e.g. eCGI) for the second base station 30.

In step S5, the MEC 40 sends a message to the first base station 20 including 1) the base station identifier (e.g. eCGI) of the second base station 30, and 2) an indicator that the UE 10 has LoS to the second base station 30.

In step S6, the first base station 20 consults its Neighbour Relations Table (NRT) to determine whether or not the second base station 30 is a known neighbour. If not, then the first base station 20 establishes an X2 connection (that is, an inter-base station connection) with the second base station 30 and records information for the second base station 30 in its NRT.

In step S7, the first base station 20 sends an X2 message to the second base station 30 identifying the UE 10 and the UE's GNSS coordinates. In step S9, the second base station 30 reacts to this message by reconfiguring its first beam so that its coverage area covers the UE 10. That is, the second base station 30 may calculate a distance and an orientation angle to the UE 10 based on its own GNSS coordinates and the UE's GNSS coordinates. The second base station 30 may then reconfigure its first beam to transmit at the calculated orientation angle and over the calculated distance. In step S11, the first base station 20 receives confirmation that the UE 10 is now within the coverage area of the first beam of the second base station 30. In this embodiment, this confirmation is via a confirmation message from the second base station 30. In step S13, the first base station 20 initiates a transfer of the UE 10 to the second base station 30 so that the UE 10 is thereafter served by the second base station 30. Following this reconfiguration, the cellular telecommunications network 1 is as shown in Figure 6.

In cellular telecommunications networks utilising relatively high frequency bands (such as the mmWave frequency band used in this embodiment), UEs have a better quality connection when the UE and serving base station have LoS. Accordingly, this embodiment utilises the optical camera of the UE 10 and a computer vision process to determine that the UE 10 has LoS with the base station and, in response, initiates a transfer of the UE to that base station. This embodiment therefore omits the typical UE measurement reporting parts of a traditional handover. Such steps are unnecessary following this positive determination that the UE 10 has LoS with the second base station 30. Furthermore, this embodiment supports a transfer of the UE 10 to another base station when such a transfer would not be possible with a traditional handover. That is, the second base station's first beam does not initially cover the UE 10 (as shown in Figure 5), so the UE's measurement reports would not identify the second base station 30 (such that the first base station's NRT would not identify the second base station 30) and the transfer would not be possible. However, as illustrated above, by identifying that the UE 10 has LoS with the second base station 30 from the captured image, the second base station 30 may reconfigure in order to provide service in a coverage area that covers the UE 10 so that a transfer to the second base station 30 becomes possible.

In the above embodiment, the first base station 20 reacts to the message from the MEC server 40 by performing several steps resulting in a transfer of the UE 10 to the second base station 30. This may be due to, for example, the connection between the UE and first base station degrading (e.g. if measurement reports or the visual data indicate that the distance between the UE and first base station are increasing). However, the skilled person will understand that this reaction may also be used to balance network load.

A second embodiment of a method of the present invention will now be described with reference to Figures 8 to 10. This second embodiment utilises the same cellular telecommunications network of the first embodiment and therefore the same reference numerals will be used. Furthermore, steps S1 to S6 are also performed in this second embodiment, so that the MEC 40 sends a message to the first base station 20 including 1) the base station identifier (e.g. eCGI) of the second base station 30, and 2) and indicator that the UE 10 has LoS to the second base station 30, and, in response, the first base station 20 confirms/establishes an X2 connection with the second base station 30.

The first and second base stations 20, 30 may operate in either a first (active) state or a second (energy saving) state. The first and second base stations 20, 30 use more energy when in the active state than when in the energy saving state. Following step S6, the first and second base stations 20, 30 communicate over their X2 connection to update their respective NRTs with information on the neighbouring base station. This information includes the operating state of the base station. In this second embodiment, as shown in Figure 8, the second base station 30 is initially in an energy saving state. In step S8, the first base station 20 sends an activation signal (over the X2 connection) to the second base station 30. This activation signal causes the second base station 30 to switch from the energy saving state to the active (i.e. non-energy saving state) mode of operation. In this second embodiment, the activation signal further includes an identifier for the UE 10 and the UE’s GNSS coordinates. Similar to the first embodiment, the second base station 30 responds to this information by reconfiguring its first beam so that its coverage area covers the UE 10. Following this reconfiguration, the second base station 30 sends a message to the first base station 20 confirming that the UE 10 is now within the coverage area of the first beam of the second base station 30, and, in response, the first base station 20 initiates a transfer of the UE 10 to the second base station 30 (that is, implementing steps S9, S11 and S13 of the first embodiment).

Following these steps, the cellular telecommunications network is in the configuration shown in Figure 9.

This second embodiment therefore provides a further benefit in detecting LoS between a UE and a base station based on an image captured from the UE's optical camera in that, in response, the base station may be switched from an energy saving mode of operation to a normal (active) mode of operation. The base station may then be used as a handover target. This is also possible when the second base station 30 is not already known to the first base station 20 (that is, the second base station 30 is not a member of the first base station's NRT), as the identification of the second base station 30 from the image captured by the UE 10 allows the first base station 20 to identify the second base station 30 as a neighbour even though the UE is not present in the second base station's first beam.

In an enhancement to this second embodiment, the MEC server 40 continues to process visual data received from the UE 10 and determines that the UE 10 subsequently loses LoS with the first base station 20. Following this determination, the MEC 40 sends an instruction message to the first base station 20 to switch from its normal (active) mode of operation to an energy saving mode of operation. This second embodiment therefore uses LoS information to switch base stations into and out of energy saving mode.

A third embodiment of a method of the present invention will now be described with reference to Figures 11 to 13. This third embodiment also utilises the same cellular telecommunications network of the first embodiment and therefore the same reference numerals will be used. In a first step of this embodiment (step S17) the UE 10 captures a sequence of images using its optical camera. This sequence of images is sent to the MEC server 40 via the first base station 20.

In step S19, the MEC server 40 processes the sequence of images and determines that both the first and second base station 20, 30 are present (using the inference agent 43b and the trained classification model, as discussed in the first embodiment above).

In step S21, the MEC server 40 is also able to identify a moving object in the sequence of images. This is achieved by background subtraction to determine that the object has a different position in different images of the sequence of images. In this example, the

MEC server 40 implements the background subtraction method detailed in "ViBe: A Universal Background Subtraction Algorithm for Video Sequences," O. Barnich and M. Van Droogenbroeck, IEEE Transactions on Image Processing, vol. 20, no. 6, pp. 1709-1724, June 2011.

In step S23, the MEC server 40 determines whether the moving object is on a path such that it will block LoS between the UE 10 and first base station 20. This is based on both an object tracking function (such as “Deep Learning for Moving Object Detection and Tracking from a Single Camera in Unmanned Aerial Vehicles (UAVs)”, Dong Hye Ye et al., IS&T International Symposium on Electronic Imaging 2018) and a relative depth determination function (such as “Single-Image Depth Perception in the Wild”, Chen et al., 30th Conference on Neural Information Processing Systems). In this example, the result of this determination is that the moving object will block LoS between the UE 10 and first base station 20. In response to this positive determination, the MEC server 40 sends a message to the first base station 20 to trigger a transfer of the UE 10 to the second base station 30 (step 25). The network is then in the configuration shown in Figure 12.

The third embodiment therefore provides the advantage that a future blockage between the UE and serving base station may be predicted and, in response, a pre-emptive transfer of the UE to another base station with which it has LoS may be initiated. The UE therefore continues to receive service from a base station with which it has LoS, thus ensuring continuity of Quality of Service (QoS). The skilled person will understand that it is non-essential for the blockage to be caused by a moving object. That is, the blockage may be predicted based on any form of relative movement between the UE, object and base station. For example, the object may be stationary, but the motion of the base station and/or UE may result in a loss of LoS between the UE and base station, which may be predicted from the sequence of images and, in response, a pre-emptive transfer may be initiated. Furthermore, the skilled person will understand that the third embodiment may be implemented by the MEC server 40 determining the probability that the relative motion between the UE, base station and object is such that the object will block LoS between the UE and base station, and comparing this probability to a threshold.

In the above embodiments, the MEC server 40 included memory 45 having a first database table storing a base station identifier for each base station and base station image identifier(s) for one or more images of that base station (the images being stored in a second database table). The images were of that exact base station as installed in the real-world. Furthermore, there may be a plurality of images of that exact base station, in which each image is from a different image capture position. By using this data to train the classification model, the MEC server 40 can then use the trained classification model to uniquely identify the base station that is within the captured visual data from the UE 10. The skilled person will understand that it is beneficial to use an image (or images) of the base station including one or more distinctive features in the base station's surroundings. These distinctive features (and their spatial relationship to the base station) may improve the accuracy of the classification model.

The skilled person will also understand that, in some scenarios, only a part of the base station may be visible (e.g. the antenna) with the remainder of the base station being located inside a housing and invisible from the point of view of many UEs. For example, some modern base stations are located inside lampposts, with the antenna extending from the top of the lamppost and the remainder of the base station being located inside the lamppost housing. Of course, the image(s) used to train the classification model would then include only the visible part of the base station (the antenna) and the other parts of the image (such as the lamppost) form part of the distinctive features in its surroundings that are used to train the classification model to recognise that base station.

It is also non-essential that the images of the base station are of that exact base station as installed in the real-world. In an alternative arrangement, memory 45 includes a third database table having a base station model identifier identifying a model of base station (of which there may be several base stations in the network of this particular model) and one or more images of this model of base station. The first database table may also further identify the model of base station for each base station in the network. The MEC server's learning agent 43a is then configured to train a further machine learning algorithm, again a classification model, based on the images of the third database table. This second classification model maps between each image from the third database table and the corresponding base station model identifier. The inference agent 43b may then use this second classification model (e.g. in the event the classification model of the first embodiment above does not successfully identify an exact base station) to identify the model of base station within the captured image from the UE 10. The inference agent 43b has not yet uniquely identified the second base station 30 at this stage, as several base stations may be based on that model. Accordingly, the inference agent 43b uses location data for the UE 10 to determine that the UE 10 is within a threshold distance of the second base station 30. The inference agent 43b may combine this data (that the UE 10 is within the threshold distance of the second base station 30 and that the captured image from the UE 10 includes the model of base station associated with the second base station 30) to determine that it is the second base station 30 in the captured image. The inference agent 43b then outputs the base station identifier (e.g. the enhanced Cell Global Identifier).

In the above embodiments, the computer vision operation is performed in the MEC server 40. However, this is non-essential and the method could be performed in any single node or distributed across several nodes in the network. For example, each base station in the network may store the same data that is stored in memory 45 of the MEC server 40, but limited only to nearby base stations (e.g. only those base stations identified in its Neighbour Relations Table, NRT). In this scenario, when a UE connects to the base station, the base station may forward the data to the UE so that the computer vision operations may be performed locally in the UE. Following a positive identification of another base station within an image captured by the UE, the UE may send a message to the base station indicating that it has LoS with the other base station. Following a transfer to the other base station, the UE may then receive new data from the other base station for its computer vision operations.

Furthermore, in the above embodiments, the UE 10 and first and second base stations 20, 30 are configured for mmWave communications. The benefits are particularly relevant for such communications due to the requirement for LoS (or near LoS) between the UE and base station. However, the skilled person will understand that this is non-essential. That is, the UE 10 and first and second base stations 20, 30 may communicate using any frequency band and cellular telecommunications protocol and realise these benefits, as confirming LoS will nonetheless indicate that the UE and base station will have a good quality connection and would furthermore allow the handover process to skip the measurement reporting step, thus saving network resources (including e.g. bandwidth, power and memory) which would have been used on the measurement reporting.

The MEC server includes memory for storing data on the base stations in the network. This may be of a subset of base stations in the network (such as those in the geographical region of the MEC server) to reduce storage requirements. In this scenario, the database may be updated with any moving base station that moves into or out of the geographical region.

In the above embodiments, the UE 10 is a virtual reality headset. However, this is also non-essential, and the UE may be any form of user equipment that includes a camera for capturing visual data in the visible light spectrum and a communications interface for communicating via a cellular telecommunications protocol. The skilled person will also understand that the present invention is not limited to the use of visible spectrum (although that may be preferable due to the availability of optical cameras on UEs). That is, the computer vision processes outlined above may operate in other parts of the electromagnetic spectrum, such as infrared, and thus the methods of the present invention may be implemented based on visual data captured by cameras operating outside the visible spectrum.

In a further enhancement to the above embodiments, a successful transfer of the UE to the target base station may be reported back to the MEC server. This success may be based on both the UE connecting to the target base station and also the UE receiving connection characteristics (e.g. Signal to Noise Ratio, SNR, or throughput) which is indicative of LoS. This data may be used to add the image captured by the UE to the second database table, which improves the body of training data for the learning agent, and also acts as a form of supervised learning to indicate that the previous classification model was accurate.

The skilled person will understand that any combination of features is possible within the scope of the invention, as claimed.

CLAIMS

1. A method of initiating a transfer in a cellular telecommunications network, wherein the cellular telecommunications network comprises a User Equipment, UE, and a base station, wherein the UE includes a camera, the method comprising:
storing visual data including a visual representation of at least a part of the base station;
receiving visual data captured by the camera of the UE;
performing a computer vision operation, trained on the stored visual data, on the captured visual data to determine that the visual representation of the base station or part thereof is present in the captured visual data; and,
initiating a transfer of the UE to the base station.

2. A method as claimed in Claim 1, in which the base station has a first and second mode and uses more energy when operating in the first mode than the second mode, wherein the base station is initially in the second mode, and the step of initiating the transfer of the UE includes initiating a switch in the base station from the second mode to the first mode.

3. A method as claimed in Claim 2, wherein the base station is a target base station and the UE is served, prior to the transfer, by a serving base station having the first and second mode, and the method further comprises the step of initiating a switch in the serving base station from the first mode to the second mode.

4. A method as claimed in any one of the preceding claims, wherein the stored visual data includes a first visual representation of at least a part of a serving base station and a second visual representation of at least a part of a target base station, and the method further comprises the steps of:
processing a sequence of visual data captured by the camera of the UE to:
determine that the second visual representation of the target base station or part thereof is present in the captured visual data, and
determine that relative motion between an obstacle, the UE and the serving base station is such that there is a probability above a threshold that the object will block a line of sight between the UE and the serving base station; and, in response,

the step of transferring the UE is to transfer the UE from the serving base station to the target base station.

5. A method as claimed in any one of the preceding claims, implemented in one or more of a group comprising: the UE, the base station, and a network node.

6. A method as claimed in any one of the preceding claims, wherein the visual representation of at least part of the base station further includes one or more features in the base station’s surroundings.

7. A computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method of any one of the preceding claims.

8. A computer-readable data carrier having stored thereon the computer program of Claim 7.

9. A network node in a cellular telecommunications network, the network node having a transceiver, a processor and a memory configured to cooperate to carry out the method of any one of the preceding claims.

10. A network node as claimed in Claim 9, being either the UE or the base station.

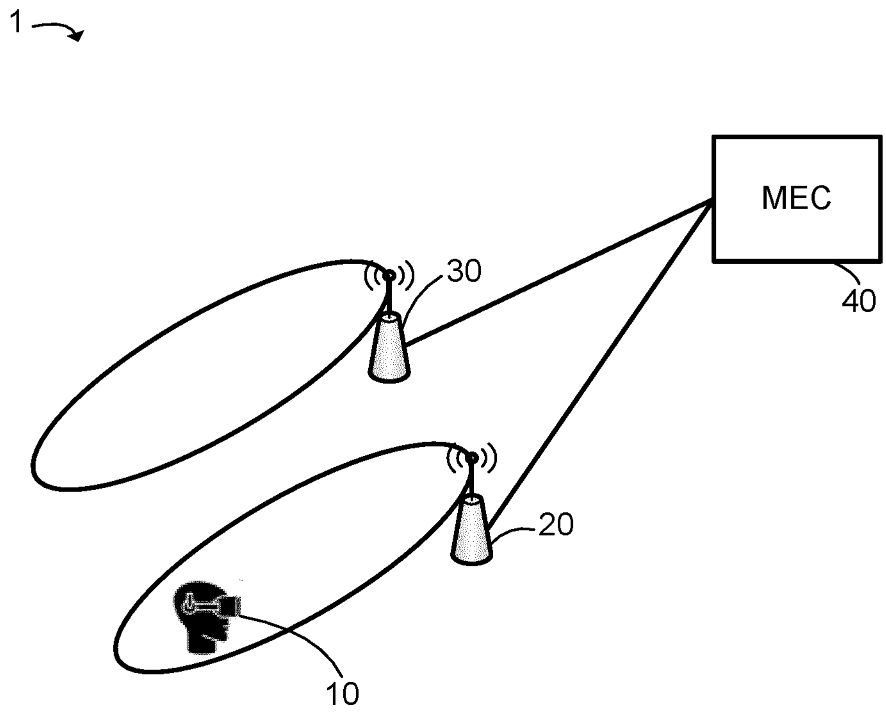

Figure 1

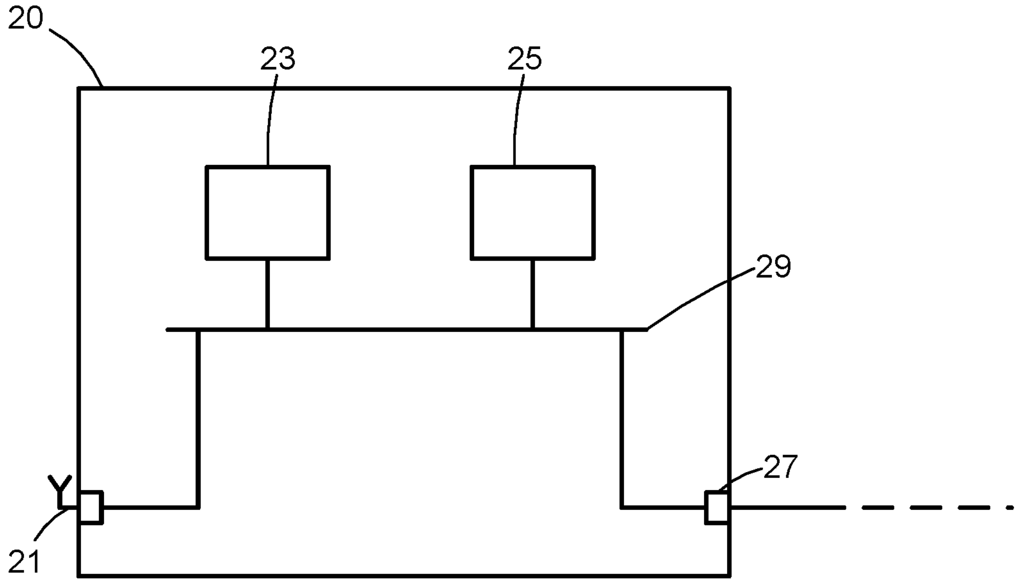

Figure 2

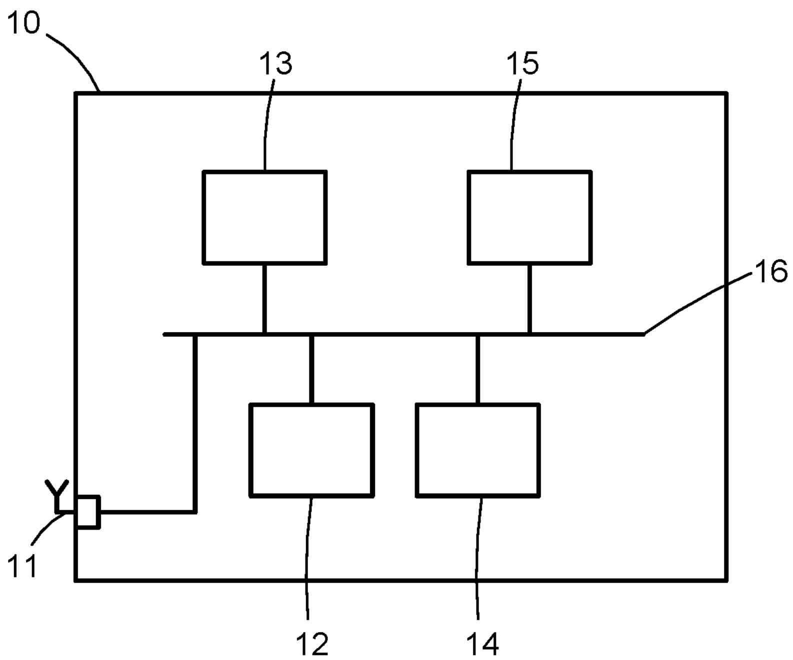

Figure 3

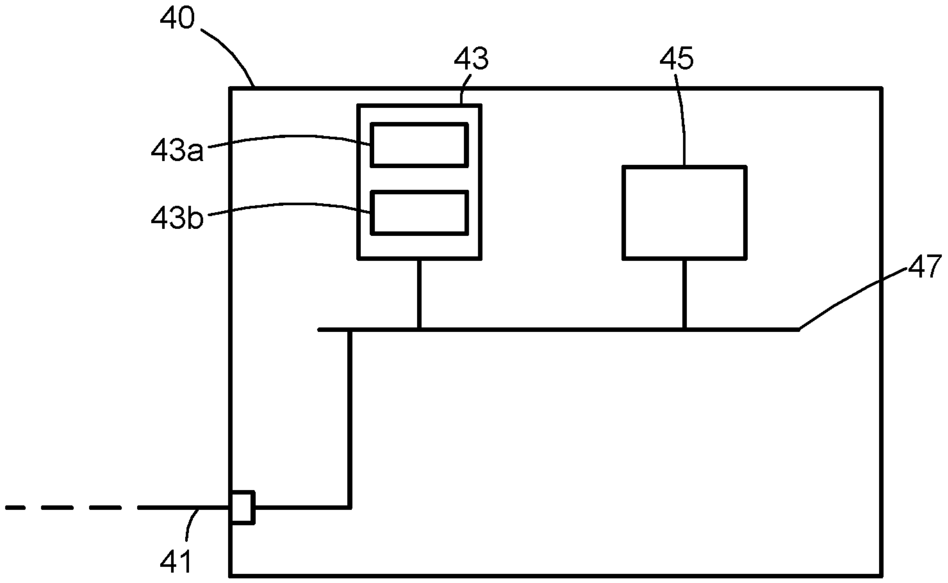

Figure 4

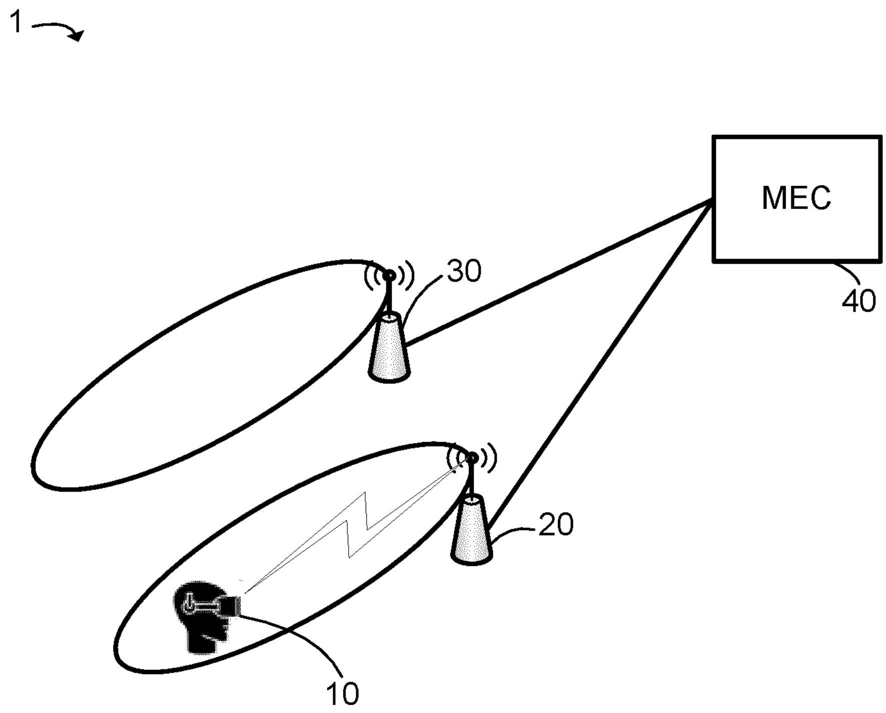

Figure 5

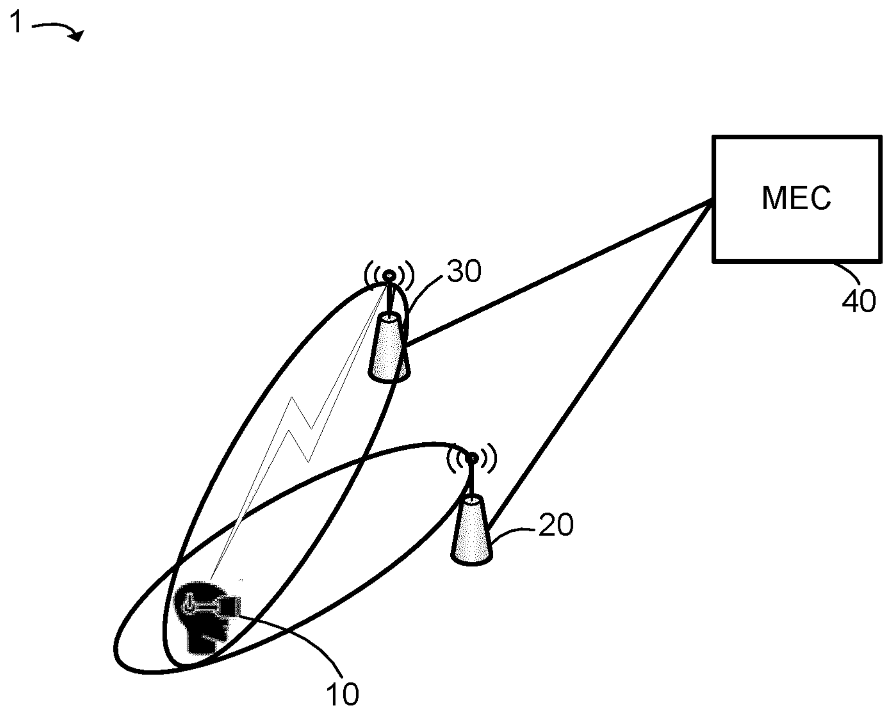

Figure 6

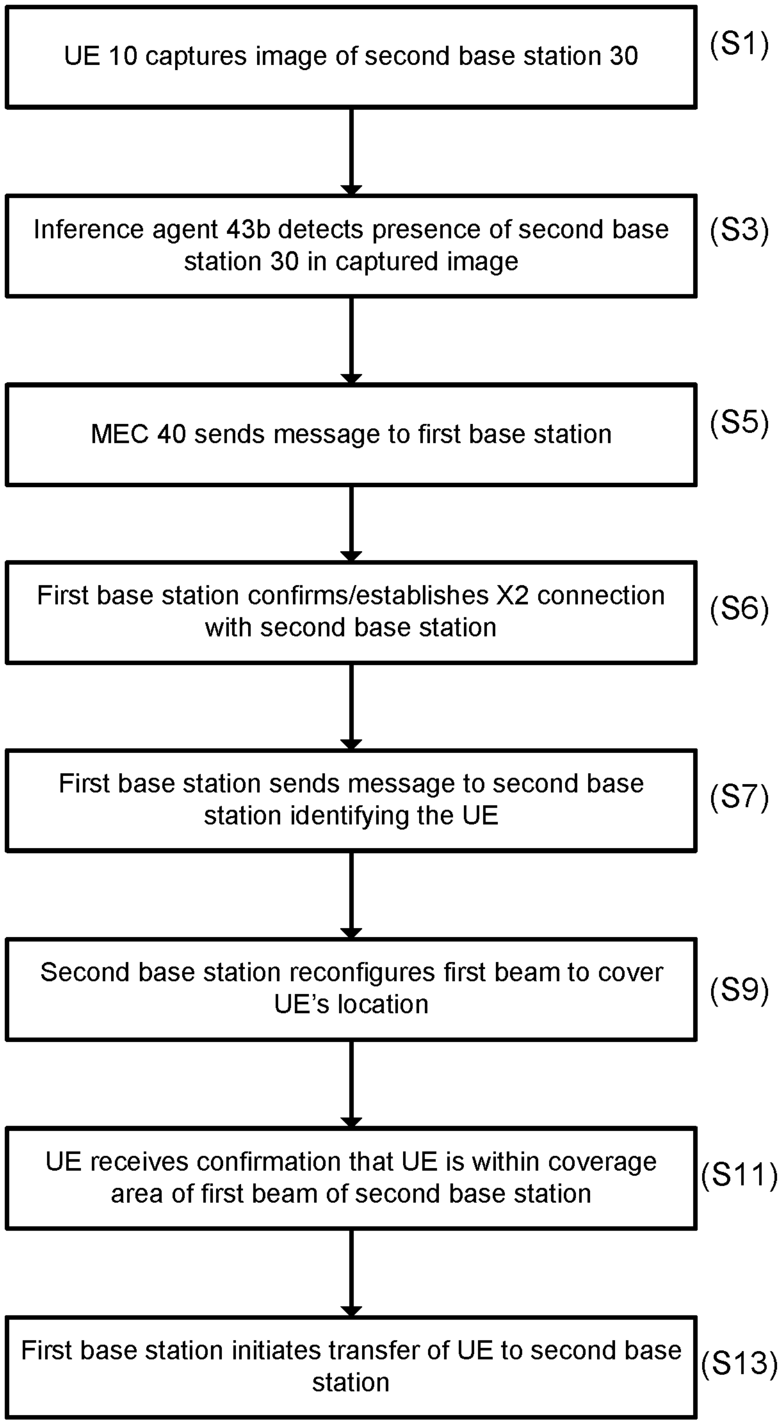
UE 10 captures image of second base station 30
(S1)
Inference agent 43b detects presence of second base station 30 in captured image
(S3)
MEC 40 sends message to first base station
(S5)
First base station confirms/establishes X2 connection with second base station
(S6)
First base station sends message to second base station identifying the UE
(S7)
Second base station reconfigures first beam to cover UE's location
(S9)
UE receives confirmation that UE is within coverage area of first beam of second base station
(S11)
First base station initiates transfer of UE to second base station
(S13)

Figure 7

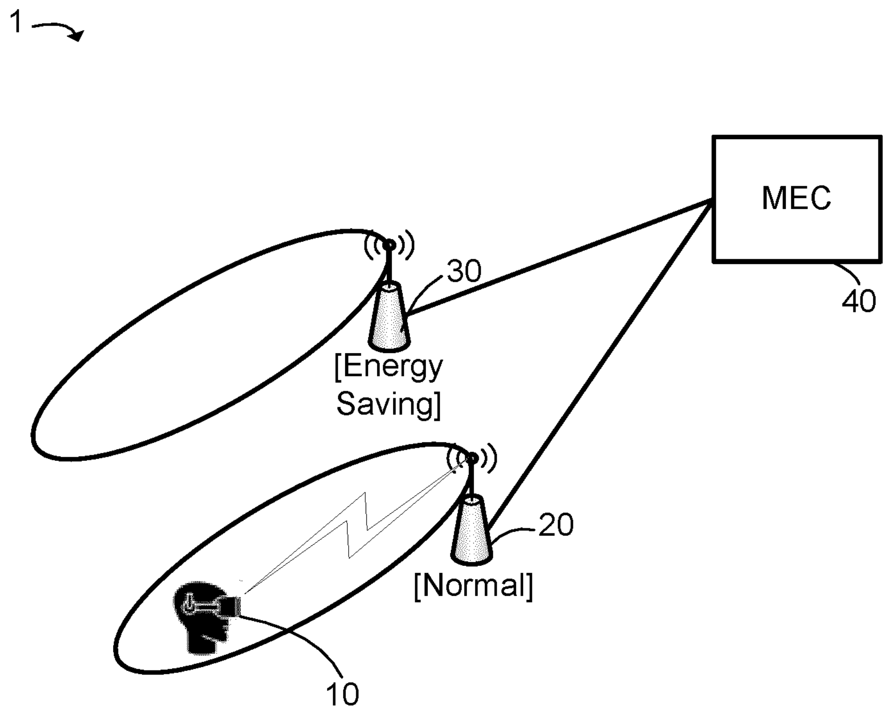

Figure 8

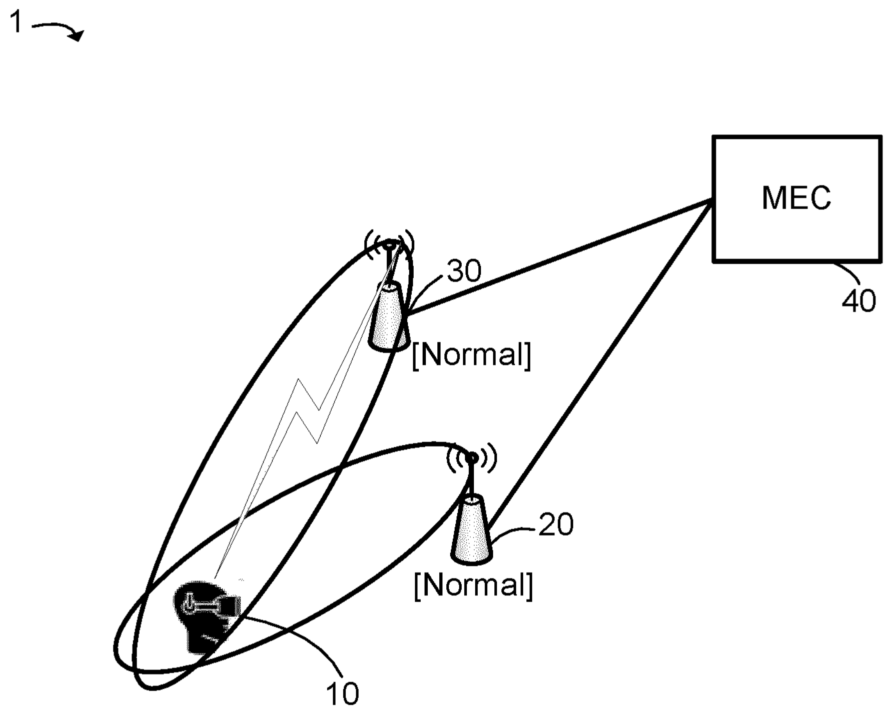

Figure 9

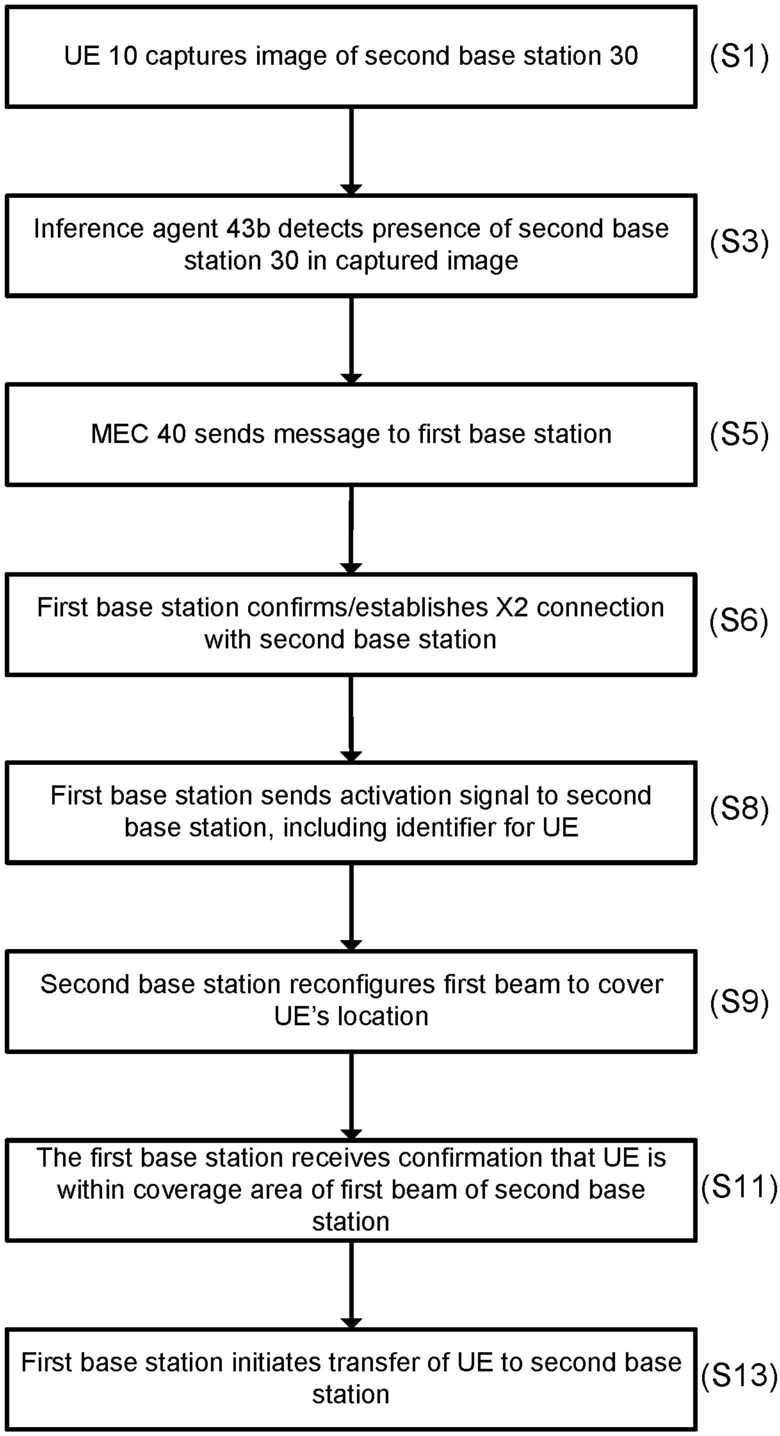
UE 10 captures image of second base station 30
(S1)
Inference agent 43b detects presence of second base station 30 in captured image
(S3)
MEC 40 sends message to first base station
(S5)
First base station confirms/establishes X2 connection with second base station
(S6)
First base station sends activation signal to second base station, including identifier for UE
(S8)
Second base station reconfigures first beam to cover UE's location
(S9)
The first base station receives confirmation that UE is within coverage area of first beam of second base station
(S11)
First base station initiates transfer of UE to second base station
(S13)

Figure 10

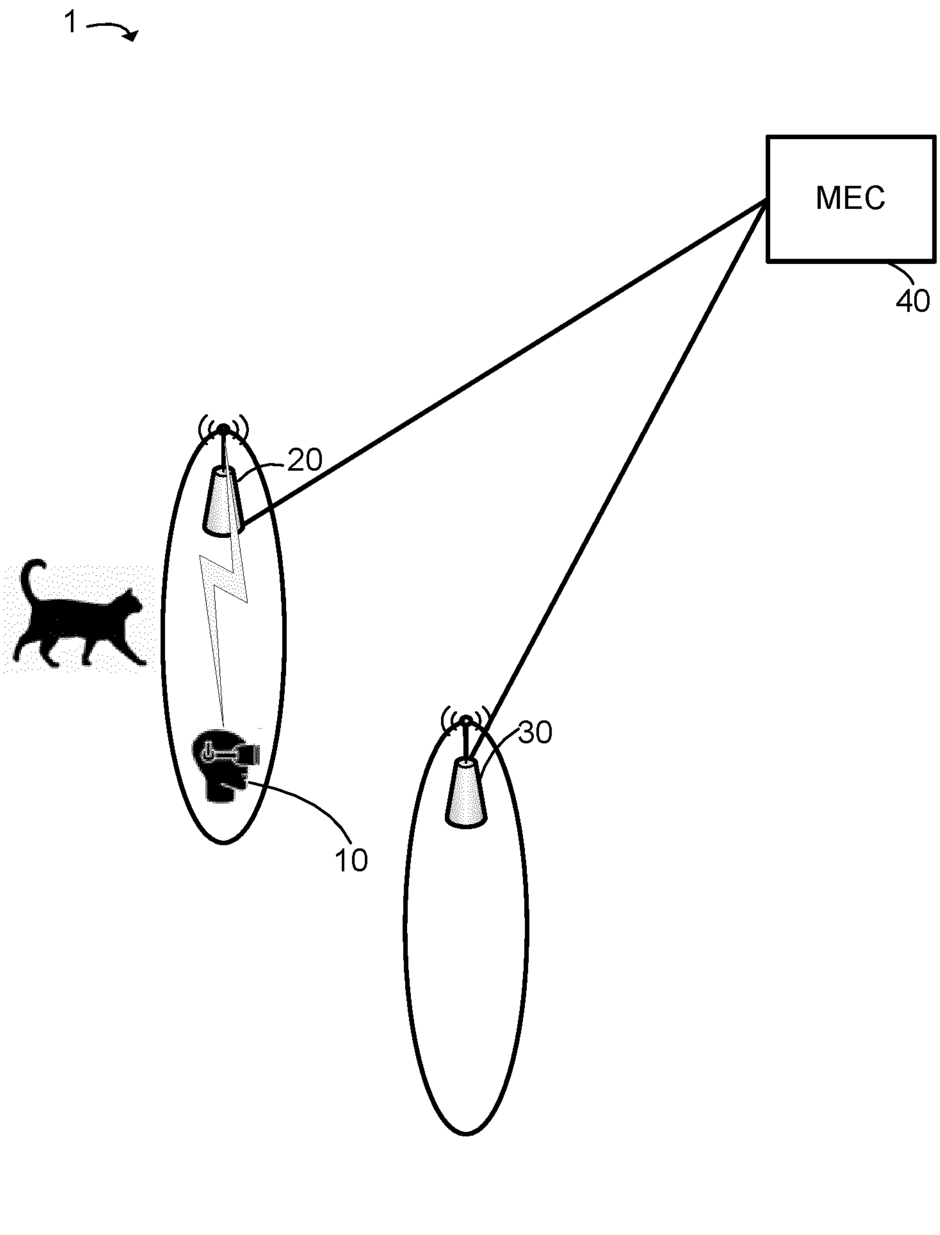

Figure 11

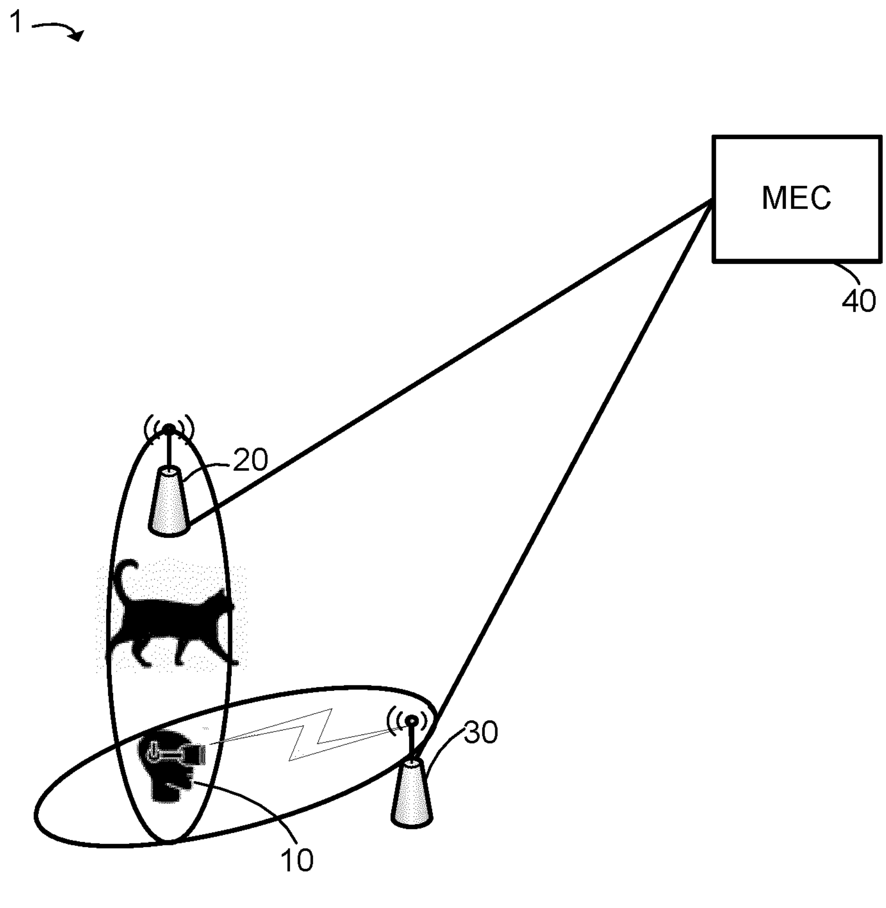

Figure 12

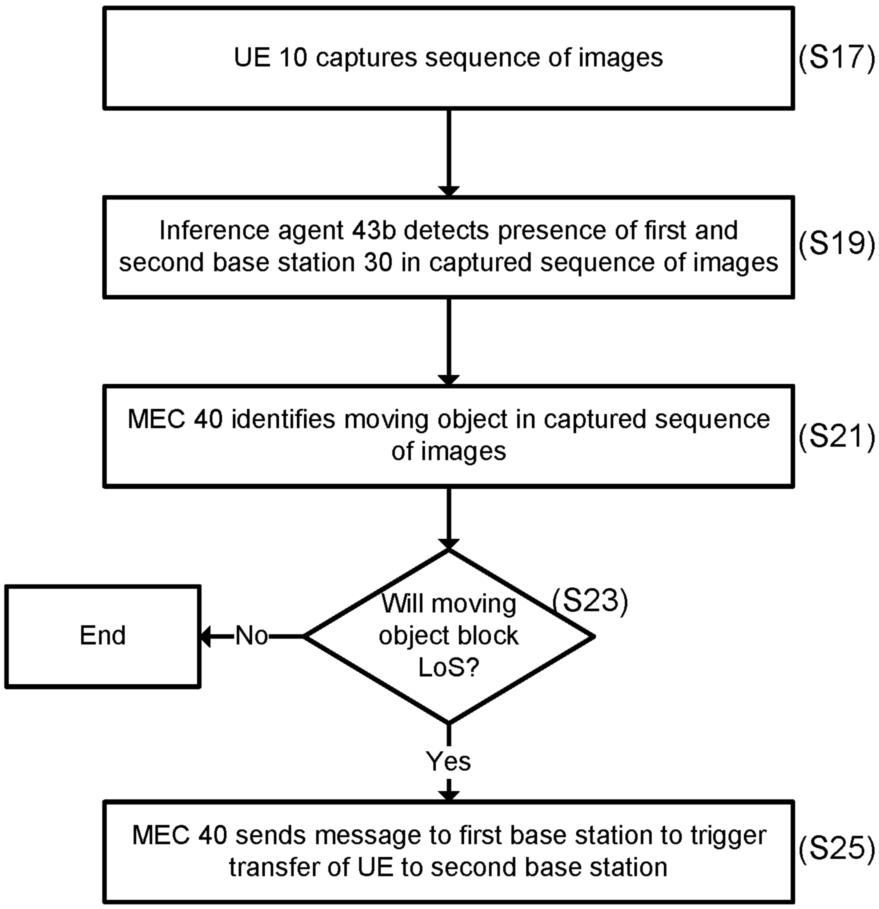
UE 10 captures sequence of images
(S17)
Inference agent 43b detects presence of first and second base station 30 in captured sequence of images
(S19)
MEC 40 identifies moving object in captured sequence of images
(S21)
Will moving object block LoS?
(S23)
No
End
Yes
MEC 40 sends message to first base station to trigger transfer of UE to second base station
(S25)

Figure 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/065932

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/24
ADD. H04W36/00

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

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	WO 2014/014776 A1 (QUALCOMM INC [US]) 23 January 2014 (2014-01-23) abstract paragraph [0088] - paragraph [0093] -----	1-10
A	US 2018/270783 A1 (VENKATRAMAN SAI PRADEEP [US] ET AL) 20 September 2018 (2018-09-20) paragraph [0031] paragraph [0043] - paragraph [0050] paragraph [0087] - paragraph [0092] -----	1-10
A	KR 2016 0012952 A (KOREA ELECTRONICS TELECOMM [KR]) 3 February 2016 (2016-02-03) paragraph [0006] - paragraph [0009] paragraphs [0024], [0053] -----	1-10
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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	Date of mailing of the international search report
6 July 2020	14/07/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Aulló Navarro, A

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NOKIA ET AL: "Implications of High Frequency Bands on Mobility", 3GPP DRAFT; R2-1700060 IMPLICATIONS OF HIGH FREQUENCY BANDS ON MOBILITY, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX , vol. RAN WG2, no. Spokane, USA; 20170117 - 20170119 17 January 2017 (2017-01-17), XP051210647, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN2/Docs/ [retrieved on 2017-01-17] the whole document -----	1-10
A	GB 2 554 544 A (BRITISH TELECOMM [GB]) 4 April 2018 (2018-04-04) page 7, line 32 - page 10, line 20 -----	1-10

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/065932

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		GB 2554544 A	04-04-2018