[0289] At block 2710, a base station may transmit SI via a second signal in accordance with the indication, the second signal being transmitted via a broadcast or broad-beam operation. The SI may be transmitted as a fixed periodic broadcast or broad-beam transmission. The operations at block 2710 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 20, or 21, or the SI transmit module 1445 described with reference to FIGs. 14 or 15.

[0290] Thus, the method 2700 may provide for wireless communication, and in particular, for SI transmission. It should be noted that the method 2700 is just one implementation and that the operations of the method 2700 may be rearranged or otherwise modified such that other implementations are possible.

[0291] **FIG. 28** is a flow chart illustrating an example of a method 2800 for wireless communication at a base station, in accordance with various aspects of the present disclosure. For clarity, the method 2800 is described below with reference to aspects of one or more of the base stations 105 described with reference to FIGs. 14, 15, 16, 20, or 21. In some examples a base station may execute one or more sets of codes to control the functional elements of the base station to perform the functions described below. In some examples, the method 2800 may be performed by a base station during an initial access procedure of a UE.

[0292] At block 2805, a base station may transmit a first signal, the first signal including an indication of whether SI is to be requested by a UE. The first signal may, in some examples, be a periodic sync signal, and may indicate to a UE that SI is to be acquired through a fixed periodic broadcast or broad-beam transmission or through an on-demand broadcast, unicast, broad-beam transmission or narrow-beam transmission. The operations at block 2805 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 16, 20, or 21, the SI transmission mode module 1435 described with reference to FIGs. 14 or 15.

[0293] At block 2810, a base station may transmit SI in accordance with the indication and a transmission mode. Thus, if the indication and transmission mode indicates that SI is to be broadcast without a UE requesting the SI, then the base station may transmit the SI in a periodic broadcast or broad-beam transmission. If the indication and transmission mode indicates that SI is to be transmitted in response to a UE request, then the base station may transmit the SI after a UE has submitted a request for the SI. Depending on the transmission

mode, the base station may transmit the SI as either a fixed periodic broadcast or broad-beam transmission, an on-demand periodic broadcast or broad-beam transmission, an on-demand aperiodic broadcast or broad-beam transmission, or an on-demand aperiodic unicast or narrow-beam transmission. The operations at block 2810 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 16, 20, or 21, or the SI transmit module 1445 described with reference to FIGs. 14 or 15.

[0294] At blocks 2815, 2820, 2825, or 2830, the base station may change its transmission mode. Thus, the base station may perform any one or more of blocks 2815, 2820, 2825, or 2830. Changes in transmission mode may be made in response to, for example, changes in the numbers of UEs requesting SI from the base station, network load, congestion status or available radio resources.

[0295] At block 2815, a base station may change the transmission mode to be a broadcast or broad-beam mode targeting a cell edge and having fixed periodic scheduling. Changing of the transmission mode may be based on one or more of a number of UEs requesting SI acquisition, network load, congestion status, or available radio resources. The operations at block 2815 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 16, 20, or 21, the SI transmission mode module 1435 described with reference to FIGs. 14 or 15, or the SI transmission mode determination module 1510 described with reference to FIG. 15.

[0296] At block 2820, a base station may change the transmission mode to be a broadcast or broad-beam mode targeting a cell edge and having an on-demand periodic scheduling triggered by a request for system information in accordance with the indication. Changing of the transmission mode may be based on one or more of a number of UEs requesting SI acquisition, network load, congestion status, or available radio resources. The operations at block 2820 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 16, 20, or 21, the SI transmission mode module 1435 described with reference to FIGs. 14 or 15, or the SI transmission mode determination module 1510 described with reference to FIG. 15.

[0297] At block 2825, a base station may change the transmission mode to be a broadcast or broad-beam mode having an on-demand aperiodic scheduling triggered by a request for system information in accordance with the indication. Changing of the transmission mode

may be based on one or more of a number of UEs requesting SI acquisition, network load, congestion status, or available radio resources. The operations at block 2825 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 16, 20, or 21, the SI transmission mode module 1435 described with reference to FIGs. 14 or 15, or the SI transmission mode determination module 1510 described with reference to FIG. 15.

[0298] At block 2830, a base station may change the transmission mode to be a unicast or narrow-beam mode having an on-demand aperiodic scheduling triggered by a request for system information in accordance with the indication. Changing of the transmission mode may be based on one or more of a number of UEs requesting SI acquisition, network load, congestion status, or available radio resources. The operations at block 2830 may be performed using the SI transmission module 1420 described with reference to FIGs. 14, 15, 16, 20, or 21, the SI transmission mode module 1435 described with reference to FIGs. 14 or 15, or the SI transmission mode determination module 1510 described with reference to FIG. 15.

[0299] The operations at blocks 2815, 2820, 2825, 2830 may all be performed by a base station. Alternatively, a base station may perform any one or more of the operations described at blocks 2815, 2820, 2825, 2830.

[0300] Thus, the method 2800 may provide for wireless communication, and in particular, for SI transmission. It should be noted that the method 2800 is just one implementation and that the operations of the method 2800 may be rearranged or otherwise modified such that other implementations are possible.

[0301] **FIG. 29** is a flow chart illustrating an example of a method 2900 for wireless communication at a UE, in accordance with various aspects of the present disclosure. For clarity, the method 2900 is described below with reference to aspects of one or more of the UEs 115 described with reference to FIGs. 1-13 and 21. In some examples a UE may execute one or more sets of codes to control the functional elements of the UE to perform the functions described below. In some examples, the method 2900 may be performed by a UE receiving system information in a unicast, narrow-beam, broadcast, or broad-beam manner.

[0302] At block 2905, a UE may receive a first set of system information (*e.g.*, master system information, such as master system information included in an MSIB). The operation(s) at block 2905 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the master SI acquisition module 905 described with reference to FIG. 9 or 10.

[0303] At block 2910, the UE may determine, based at least in part on the first set of system information, that additional system information (*e.g.*, non-master system information, such as information included in an OSIB) is available. The operation(s) at block 2910 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the SI processing module 910 described with reference to FIG. 9 or 10.

[0304] At block 2915, the UE may transmit a request (*e.g.*, an OSIB transmission request) for the additional system information. In some examples, the UE may transmit a plurality of requests for the additional system information. In some examples, a single OSIB transmission request may indicate one or a plurality of elements of additional system information that the UE would like to receive (*e.g.*, a binary value in the OSIB transmission request may be set to TRUE for each element of additional system information that the UE would like to receive). In other examples, the UE may request some types of additional system information in different OSIB transmission requests, a plurality of OSIB transmission requests may be transmitted. The operation(s) at block 2915 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the UE SI request module 915 described with reference to FIG. 9 or 10.

[0305] At block 2920, the UE may receive the additional system information. The operation(s) at block 2920 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the other SI acquisition module 920 described with reference to FIG. 9 or 10.

[0306] In some embodiments of the method 2900, receiving the first set of system information may include receiving an indication of one or more sets of additional system information that are available. In some embodiments of the method 2900, transmitting the request for the additional system information may include identifying, in the request for the additional system information, one or more sets of additional system information. In some embodiments, the one or more sets of additional system information identified in the request

for the additional system information may include one or more sets of additional system information indicated in the first set of system information.

[0307] In some embodiments of the method 2900, receiving the additional system information, at block 2920, may include at least one of: receiving system information indicating which RATs are available in a region and how the UE is to select an available RAT; receiving system information indicating which services are available in a region and how the UE is to obtain an available service; receiving system information relating to an MBMS or a PWS service; receiving system information relating to location, positioning, or navigation services; or receiving system information based at least in part on a determined location of the UE.

[0308] In some embodiments of the method 2900, transmitting the request for the additional system information may include including one or more capabilities of the UE in the request. In these embodiments, receiving the additional system information may include receiving system information based at least in part on the one or more capabilities of the UE included in the request.

[0309] In some embodiments of the method 2900, transmitting the request for the additional system information may include including a location of the UE in the request. In these embodiments, receiving the additional system information may include receiving system information based at least in part on the location of the UE included in the request.

[0310] In some embodiments of the method 2900, transmitting the request for the additional system information may include including an identification of the UE in the request. In these embodiments, receiving the additional system information may include receiving the additional system information based at least in part on the identification of the UE included in the request.

[0311] Thus, the method 2900 may provide for wireless communication. It should be noted that the method 2900 is just one implementation and that the operations of the method 2900 may be rearranged or otherwise modified such that other implementations are possible.

[0312] **FIG. 30** is a flow chart illustrating an example of a method 3000 for wireless communication at a UE, in accordance with various aspects of the present disclosure. For clarity, the method 3000 is described below with reference to aspects of one or more of the

UEs 115 described with reference to FIGs. 1-13 and 21. In some examples a UE may execute one or more sets of codes to control the functional elements of the UE to perform the functions described below. In some examples, the method 3000 may be performed by a UE receiving system information in a unicast, narrow-beam, broadcast, or broad-beam manner.

[0313] At block 3005, a UE may decode information received from a downlink channel. The decoded information may indicate that master system information (*e.g.*, an MSIB) is received in response to a master system information request (*e.g.*, an MSIB transmission request). In some examples, the downlink channel may include a synchronization signal. The decoded information may include information decoded from the synchronization signal. The operation(s) at block 3005 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the sync signal processing module 1005 described with reference to FIG. 10.

[0314] At block 3010, the UE may transmit a master system information request in accordance with the information decoded from the downlink channel. The operation(s) at block 3010 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the UE SI request module 915 described with reference to FIG. 9 or 10.

[0315] At block 3015, the UE may receive the master system information. The master system information may include system information that allows the UE to perform an initial access of a network using one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or a network access configuration. The operation(s) at block 3015 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the master SI acquisition module 905 described with reference to FIG. 9 or 10.

[0316] At block 3020, the UE may determine, based at least in part on the master system information, that additional system information is available. The operation(s) at block 3020 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the SI processing module 910 described with reference to FIG. 9 or 10.

[0317] At block 3025, the UE may transmit a request (*e.g.*, an OSIB transmission request) for the additional system information. In some examples, the UE may transmit a plurality of

requests for the additional system information. In some examples, a single OSIB transmission request may indicate one or a plurality of elements of additional system information that the UE would like to receive (*e.g.*, a binary value in the OSIB transmission request may be set to TRUE for each element of additional system information that the UE would like to receive). In other examples, the UE may request some types of additional system information in different OSIB transmission requests, a plurality of OSIB transmission requests may be transmitted. The operation(s) at block 3025 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the UE SI request module 915 described with reference to FIG. 9 or 10.

[0318] At block 3030, the UE may receive the additional system information. The operation(s) at block 3030 may be performed using the SI acquisition module 720 described with reference to FIG. 9, 10, 13, or 21, or the other SI acquisition module 920 described with reference to FIG. 9 or 10.

[0319] In some embodiments of the method 3000, receiving the master system information may include receiving an indication of one or more sets of additional system information that are available. In some embodiments of the method 3000, transmitting the request for the additional system information may include identifying, in the request for the additional system information, one or more sets of additional system information. In some embodiments, the one or more sets of additional system information identified in the request for the additional system information may include one or more sets of additional system information indicated in the master system information.

[0320] Thus, the method 3000 may provide for wireless communication. It should be noted that the method 3000 is just one implementation and that the operations of the method 3000 may be rearranged or otherwise modified such that other implementations are possible.

[0321] **FIG. 31** is a flow chart illustrating an example of a method 3100 for wireless communication at a base station, in accordance with various aspects of the present disclosure. For clarity, the method 3100 is described below with reference to aspects of one or more of the base stations 105 described with reference to FIGs. 1-6 and 14-21. In some examples a base station may execute one or more sets of codes to control the functional elements of the base station to perform the functions described below. In some examples, the method 3100

may be performed by a base station transmitting system information in a unicast, narrow-beam, broadcast, or broad-beam manner.

[0322] At block 3105, a base station may transmit a first set of system information (*e.g.*, master system information, such as master system information included in an MSIB). The operation(s) at block 3105 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the master SI transmission management module 1605 described with reference to FIG. 16 or 17.

[0323] At block 3110, the base station may receive a request for additional system information (*e.g.*, non-master system information, such as information included in an OSIB). The operation(s) at block 3110 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the SI request processing module 1610 described with reference to FIG. 16 or 17.

[0324] At block 3115, the base station may transmit the additional system information based at least in part on the request. The operation(s) at block 3115 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the other SI transmission management module 1615 described with reference to FIG. 16 or 17.

[0325] In some embodiments of the method 3100, transmitting the first set of system information may include transmitting an indication of one or more sets of additional system information that are available. In some embodiments of the method 3100, receiving the request for the additional system information may include receiving multiple requests for additional system information corresponding to multiple sets of additional system information to be transmitted. For example, the method 3100 may include receiving a single OSIB transmission request indicating one or a plurality of elements of additional system information that a UE would like to receive (*e.g.*, a binary value in the OSIB transmission request may be set to TRUE for each element of additional system information that the UE would like to receive). In other examples, the method 3100 may include receiving requests for some types of additional system information in different OSIB transmission requests.

[0326] In some embodiments of the method 3100, transmitting the additional system information, at block 3115, may include at least one of: transmitting system information indicating which RATs are available in a region and how a UE is to select an available RAT;

transmitting system information indicating which services are available in a region and how a UE is to obtain an available service; transmitting system information relating to an MBMS or a PWS service; transmitting system information relating to location, positioning, or navigation services; or transmitting system information based at least in part on a determined location of a UE.

[0327] In some embodiments of the method 3100, receiving the request for the additional system information may include receiving, in the request, one or more capabilities of a UE transmitting the request. In these embodiments, transmitting the additional system information may include transmitting system information based at least in part on the one or more capabilities of the UE included in the request.

[0328] In some embodiments of the method 3100, receiving the request for the additional system information may include receiving, in the request, a location of a UE transmitting the request. In these embodiments, the method 3100 may include identifying the additional system information to transmit based at least in part on the location of the UE included in the request. Alternatively, the method 3100 may include determining a location of a UE transmitting the request, and identifying the additional system information to transmit based at least in part on the location of the UE.

[0329] In some embodiments of the method 3100, receiving the request for the additional system information may include receiving, in the request, an identification of a UE transmitting the request. In these embodiments, the method 3100 may include identifying the additional system information to transmit based at least in part on the identification of the UE included in the request. In some cases, the additional system information may be identified by accessing a database that includes the identification of the UE transmitting the request and one or more capabilities of the UE.

[0330] Thus, the method 3100 may provide for wireless communication. It should be noted that the method 3100 is just one implementation and that the operations of the method 3100 may be rearranged or otherwise modified such that other implementations are possible.

[0331] **FIG. 32** is a flow chart illustrating an example of a method 3200 for wireless communication at a base station, in accordance with various aspects of the present disclosure. For clarity, the method 3200 is described below with reference to aspects of one or more of

the base stations 105 described with reference to FIGs. 1-6 and 14-21. In some examples a base station may execute one or more sets of codes to control the functional elements of the base station to perform the functions described below. In some examples, the method 3200 may be performed by a base station transmitting system information in a unicast, narrow-beam, broadcast, or broad-beam manner.

[0332] At block 3205, the base station may broadcast information on a downlink channel. The information may indicate that master system information (*e.g.*, an MSIB) is transmitted in response to a master system information request (*e.g.*, an MSIB transmission request) received from a UE. In some examples, the downlink channel may include a synchronization signal. The information may be included in (or associated with) the synchronization signal. The operation(s) at block 3205 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the sync signal transmission management module 1705 described with reference to FIG. 17.

[0333] At block 3210, the base station may receive a master system information request (*e.g.*, in accordance with the information broadcast on the downlink channel). In some cases, receiving the master system information request may include receiving, in the request, an identification of one or more capabilities of a UE transmitting the request. The operation(s) at block 3210 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the SI request processing module 1610 described with reference to FIG. 16 or 17.

[0334] At block 3215, the base station may transmit, in response to receiving the master system information request, the master system information. In some cases, the master system information may include system information that allows a UE to perform an initial access of a network using one or more of an identification of the network, an identification of the base station, cell selection configuration and access restrictions, or a network access configuration. The operation(s) at block 3215 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the master SI transmission management module 1605 described with reference to FIG. 16 or 17.

[0335] At block 3220, the base station may receive a request for additional system information. The operation(s) at block 3220 may be performed using the SI transmission

module 1420 described with reference to FIG. 16, 17, 20, or 21, or the SI request processing module 1610 described with reference to FIG. 16 or 17.

[0336] At block 3225, the base station may transmit the additional system information based at least in part on the request for the additional system information. In some cases, the additional system information may be identified based at least in part on one or more capabilities of the UE identified in the master system information request. The additional system information may also be identified based at least in part on information received in the request for additional system information, or in other ways (*e.g.*, as described with reference to FIG. 30). The operation(s) at block 3225 may be performed using the SI transmission module 1420 described with reference to FIG. 16, 17, 20, or 21, or the other SI transmission management module 1615 described with reference to FIG. 16 or 17.

[0337] In some embodiments of the method 3200, transmitting the master system information may include transmitting an indication of one or more sets of additional system information that are available. In some embodiments of the method 3200, receiving the request for the additional system information may include receiving multiple requests for additional system information corresponding to multiple sets of additional system information to be transmitted. For example, the method 3200 may include receiving a single OSIB transmission request indicating one or a plurality of elements of additional system information that a UE would like to receive (*e.g.*, a binary value in the OSIB transmission request may be set to TRUE for each element of additional system information that the UE would like to receive). In other examples, the method 3100 may include receiving requests for some types of additional system information in different OSIB transmission requests.

[0338] Thus, the method 3200 may provide for wireless communication. It should be noted that the method 3200 is just one implementation and that the operations of the method 3200 may be rearranged or otherwise modified such that other implementations are possible.

[0339] **FIG. 33** is a flow chart illustrating an example of a method 3300 for wireless communication at a UE, in accordance with various aspects of the present disclosure. For clarity, the method 3300 is described below with reference to aspects of one or more of the UEs 115 described with reference to FIGs. 1-13 and 21. In some examples a UE may execute one or more sets of codes to control the functional elements of the UE to perform the functions described below.

[0340] At block 3305, a UE may receive a first signal (*e.g.*, a sync signal, a paging message, or another type of transmission (*e.g.*, an MSIB)). At the time of receiving the first signal, the UE may communicate with a network using first system information. The first signal may include an indication of whether system information is to be requested by the UE. The operation(s) at block 3305 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the signal processing module 1105 described with reference to FIG. 11 or 12.

[0341] At block 3310, the UE may determine, based at least in part on the first signal, to request updated system information. The operation(s) at block 3310 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the signal processing module 1105 described with reference to FIG. 11 or 12.

[0342] At block 3315, the UE may request updated system information based at least in part on the determining. The operation(s) at block 3315 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the UE SI request module 1110 described with reference to FIG. 11 or 12.

[0343] In some embodiments of the method 3300, receiving the first signal may include receiving an indication that at least a portion of the first system information has changed. In some examples, the indication may include a modification flag. The modification flag may indicate, by a counter value or Boolean variable (*e.g.*, a binary value), that a corresponding portion of system information has changed. In some examples, the indication may include one or more value tags, as described in more detail with reference to FIG. 6 or 35.

[0344] In some embodiments of the method 3300, determining to request updated system information, at block 3310, may include at least one of: identifying that the UE has moved into a zone using second system information that is different from the first system information; identifying that the network has changed at least a portion of the first system information; or identifying that the UE has moved more than a predetermined distance from a location where the UE obtained the first system information a previous time (*e.g.*, from the location where the UE obtained the first system information last time).

[0345] In some embodiments of the method 3300, receiving the first signal, at block 3305, may include receiving a zone identifier (*e.g.*, an area code, a BSIC, or another cell identifier).

In some cases, the zone identifier may be received as part of a synchronization signal. In these embodiments, the method 3300 may include using the zone identifier to identify that the UE has moved from a first zone to a second zone.

[0346] In some embodiments of the method 3300, determining to request updated system information, at block 3310, may include identifying a distance between a current location of the UE and a location where the UE obtained the first system information a previous time (*e.g.*, the last time), and determining that the identified distance exceeds a predetermined threshold. In some cases, the predetermined threshold may be received from the network. In some cases, a location signal identifying a location of the UE may also be received. The location signal may be received, for example, as part of receiving the first signal. The location signal may also be received in other ways, such as via a GNSS (*e.g.*, GPS, Galileo, GLONASS or BeiDou).

[0347] Thus, the method 3300 may provide for wireless communication. It should be noted that the method 3300 is just one implementation and that the operations of the method 3300 may be rearranged or otherwise modified such that other implementations are possible.

[0348] **FIG. 34** is a flow chart illustrating an example of a method 3400 for wireless communication at a UE, in accordance with various aspects of the present disclosure. For clarity, the method 3400 is described below with reference to aspects of one or more of the UEs 115 described with reference to FIGs. 1-13 and 21. In some examples a UE may execute one or more sets of codes to control the functional elements of the UE to perform the functions described below.

[0349] At block 3405, a UE may receive a first signal (*e.g.*, a sync signal, a paging message, or another type of transmission (*e.g.*, an MSIB)). At the time of receiving the first signal, the UE may communicate with a network using first system information. The first signal may include an indication of whether system information is to be requested by the UE. The first signal may include an indication that at least a portion of the first system information has changed. The operation(s) at block 3405 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the signal processing module 1105 described with reference to FIG. 11 or 12.

[0350] At block 3410, the UE may receive one or more modification flags, each of which indicates, by a counter value or Boolean variable (*e.g.*, a binary value), that a corresponding portion of the first system information has changed. In some examples, the corresponding portion of the first system information may include a portion of master system information, such as an MSIB or element of an MSIB. In other examples, the corresponding portion of the first system information may include additional non-master system information, such as an OSIB or element of an OSIB. The master system information may include one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or network access configuration information. The master system information may also or alternatively include, for example, one or more other elements of the master system information described with reference to FIG. 3. The additional non-master system information may include one or more elements of the other system information described with reference to FIG. 4 or 6. In some embodiments, the modification flag received at block 3410 may be received with (or as part of) the first signal received at block 3405. The operation(s) at block 3410 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, the signal processing module 1105 described with reference to FIG. 11 or 12, or the modification flag or value tag processing module 1205 described with reference to FIG. 12.

[0351] At block 3415, the UE may determine, based at least in part on the first signal or a modification flag (*e.g.*, when a modification flag is set to TRUE), to request updated system information. The operation(s) at block 3415 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, the signal processing module 1105 described with reference to FIG. 11 or 12, or the modification flag or value tag processing module 1205 described with reference to FIG. 12.

[0352] At block 3420, the UE may request updated system information (*e.g.*, an updated MSIB or OSIB) based at least in part on the determining. The operation(s) at block 3420 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the UE SI request module 1110 described with reference to FIG. 11 or 12.

[0353] Thus, the method 3400 may provide for wireless communication. It should be noted that the method 3400 is just one implementation and that the operations of the method 3400 may be rearranged or otherwise modified such that other implementations are possible.

[0354] **FIG. 35** is a flow chart illustrating an example of a method 3500 for wireless communication at a UE, in accordance with various aspects of the present disclosure. For clarity, the method 3500 is described below with reference to aspects of one or more of the UEs 115 described with reference to FIGs. 1-13 and 21. In some examples a UE may execute one or more sets of codes to control the functional elements of the UE to perform the functions described below.

[0355] At block 3505, a UE may receive a first signal (*e.g.*, a sync signal, a paging message, or another type of transmission (*e.g.*, an MSIB)). At the time of receiving the first signal, the UE may communicate with a network using first system information. The first signal may include an indication of whether system information is to be requested by the UE. The first signal may include an indication that at least a portion of the first system information has changed. The operation(s) at block 3505 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the signal processing module 1105 described with reference to FIG. 11 or 12.

[0356] At block 3510, the UE may receive one or more value tags corresponding to at least a portion (or different portions) of the first system information that have changed. In some examples, the one or more value tags may correspond to one or more portions of master system information, one or more portions of additional non-master system information, or a combination thereof. The master system information may include one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or network access configuration information. The master system information may also or alternatively include, for example, one or more other elements of the master system information described with reference to FIG. 3. The additional non-master system information may include one or more elements of the other system information described with reference to FIG. 4 or 6. In some embodiments, one or more value tags received at block 3510 may be received with (or as part of) the first signal received at block 3505. The operation(s) at block 3510 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, the signal processing module 1105 described with reference to FIG. 11 or 12, or the modification flag or value tag processing module 1205 described with reference to FIG. 12.

[0357] At block 3515, the UE may determine, based at least in part on the first signal or the one or more value tags, to request updated system information. In some cases, determining to request updated system information may include comparing a received value tag (*e.g.*, a received value tag associated with an element of non-master system information included in an OSIB) with a previously received value tag (*e.g.*, a previously received value tag for the element of non-master system information), and determining to request the updated system information based at least in part on the comparison (*e.g.*, determining to request the updated system information when the value tags do not match). When a received value tag corresponds to an element of system information that the UE is not monitoring, the UE may not compare the value tag to a previously received value tag, or may not request the element of system information. The operation(s) at block 3515 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, the signal processing module 1105 described with reference to FIG. 11 or 12, or the modification flag or value tag processing module 1205 described with reference to FIG. 12.

[0358] At block 3520, the UE may request updated system information (*e.g.*, a particular OSIB or element of an OSIB) based at least in part on the determining. The operation(s) at block 3520 may be performed using the SI acquisition module 720 described with reference to FIG. 11, 12, 13, or 21, or the UE SI request module 1110 described with reference to FIG. 11 or 12.

[0359] Thus, the method 3500 may provide for wireless communication. It should be noted that the method 3500 is just one implementation and that the operations of the method 3500 may be rearranged or otherwise modified such that other implementations are possible.

[0360] **FIG. 36** is a flow chart illustrating an example of a method 3600 for wireless communication at a base station, in accordance with various aspects of the present disclosure. For clarity, the method 3600 is described below with reference to aspects of one or more of the base stations 105 described with reference to FIG. 1, 2, 4, 6, 14, 15, 16, 17, 18, 19, 20, or 21. In some examples a base station may execute one or more sets of codes to control the functional elements of the base station to perform the functions described below.

[0361] At block 3605, the method 3600 may include transmitting a first signal (*e.g.*, a sync signal, a paging message, or another type of transmission (*e.g.*, an MSIB)) from a base station to a UE. At the time of transmission of the first signal, the UE may communicate with a

network using first system information. The first signal may include an indication of whether system information is to be requested by the UE. The first signal may include information to allow the UE to determine to request updated system information. The operation(s) at block 3605 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI transmission management module 1805 described with reference to FIG. 18 or 19.

[0362] At block 3610, the method 3600 may include receiving a request from the UE for updated system information. The operation(s) at block 3610 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI request processing module 1810 described with reference to FIG. 18 or 19.

[0363] At block 3615, the method 3600 may include transmitting the updated system information based at least in part on the request. The operation(s) at block 3615 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI transmission management module 1805 described with reference to FIG. 18 or 19.

[0364] In some embodiments of the method 3600, transmitting the first signal may include transmitting an indication that at least a portion of the first system information has changed. In some examples, the indication may include a modification flag. The modification flag may indicate, by a counter value or Boolean variable (*e.g.*, a binary value), that a corresponding portion of system information has changed. In some examples, the indication may include one or more value tags, as described in more detail with reference to FIG. 38.

[0365] In some embodiments of the method 3600, transmitting the first signal, at block 3605, may include transmitting a zone identifier (*e.g.*, an area code, a BSIC, or another cell identifier). In some cases, the zone identifier may be transmitted as part of a synchronization signal.

[0366] Thus, the method 3600 may provide for wireless communication. It should be noted that the method 3600 is just one implementation and that the operations of the method 3600 may be rearranged or otherwise modified such that other implementations are possible.

[0367] **FIG. 37** is a flow chart illustrating an example of a method 3700 for wireless communication at a base station, in accordance with various aspects of the present disclosure.

For clarity, the method 3700 is described below with reference to aspects of one or more of the base stations 105 described with reference to FIG. 1, 2, 4, 6, 14, 15, 16, 17, 18, 19, 20, or 21. In some examples a base station may execute one or more sets of codes to control the functional elements of the base station to perform the functions described below.

[0368] At block 3705, the method 3700 may include transmitting a first signal (*e.g.*, a sync signal, a paging message, or another type of transmission (*e.g.*, an MSIB)) from a base station to a UE. At the time of transmission of the first signal, the UE may communicate with a network using first system information. The first signal may include an indication of whether system information is to be requested by the UE. The first signal may include information to allow the UE to determine to request updated system information. The first signal may also include an indication that at least a portion of the first system information has changed. The operation(s) at block 3705 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI transmission management module 1805 described with reference to FIG. 18 or 19.

[0369] At block 3710, the method 3700 may include transmitting one or more modification flags, each of which indicates, by a counter value or Boolean variable (*e.g.*, a binary value), that a corresponding portion of the first system information has changed. In some examples, the corresponding portion of the first system information may include a portion of master system information, such as an MSIB or element of an MSIB. In other examples, the corresponding portion of the first system information may include additional non-master system information, such as an OSIB or element of an OSIB. The master system information may include one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or network access configuration information. The master system information may also or alternatively include, for example, one or more other elements of the master system information described with reference to FIG. 3. The additional non-master system information may include one or more elements of the other system information described with reference to FIG. 4 or 6. In some embodiments, the modification flag transmitted at block 3710 may be transmitted with (or as a part of) the first signal transmitted at block 3705. The operation(s) at block 3710 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, the SI transmission management module 1805 described with reference to FIG. 18

or 19, or the modification flag or value tag transmission management module 1905 described with reference to FIG. 19.

[0370] At block 3715, the method 3700 may include receiving a request from the UE for updated system information (*e.g.*, an updated MSIB or OSIB). The operation(s) at block 3715 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI request processing module 1810 described with reference to FIG. 18 or 19.

[0371] At block 3720, the method 3700 may include transmitting the updated system information based at least in part on the request. The operation(s) at block 3720 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI transmission management module 1805 described with reference to FIG. 18 or 19.

[0372] Thus, the method 3700 may provide for wireless communication. It should be noted that the method 3700 is just one implementation and that the operations of the method 3700 may be rearranged or otherwise modified such that other implementations are possible.

[0373] **FIG. 38** is a flow chart illustrating an example of a method 3800 for wireless communication at a base station, in accordance with various aspects of the present disclosure. For clarity, the method 3800 is described below with reference to aspects of one or more of the base stations 105 described with reference to FIG. 1, 2, 4, 6, 14, 15, 16, 17, 18, 19, 20, or 21. In some examples a base station may execute one or more sets of codes to control the functional elements of the base station to perform the functions described below.

[0374] At block 3805, the method 3800 may include transmitting a first signal (*e.g.*, a sync signal, a paging message, or another type of transmission (*e.g.*, an MSIB)) from a base station to a UE. At the time of transmission of the first signal, the UE may communicate with a network using first system information. The first signal may include an indication of whether system information is to be requested by the UE. The first signal may include information to allow the UE to determine to request updated system information. The first signal may also include an indication that at least a portion of the first system information has changed. The operation(s) at block 3805 may be performed using the SI transmission module 1420

described with reference to FIG. 18, 19, 20, or 21, or the SI transmission management module 1805 described with reference to FIG. 18 or 19.

[0375] At block 3810, the method 3800 may include transmitting one or more value tags corresponding to at least a portion (or different portions) of the first system information that has/have changed. In some examples, the one or more value tags may correspond to one or more portions of master system information, one or more portions of additional non-master system information, or a combination thereof. The master system information may include one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or network access configuration information. The master system information may also or alternatively include, for example, one or more other elements of the master system information described with reference to FIG. 3. The additional non-master system information may include one or more elements of the other system information described with reference to FIG. 4 or 6. In some embodiments, one or more value tags transmitted at block 3810 may be transmitted with (or as a part of) the first signal transmitted at block 3805. The operation(s) at block 3810 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, the SI transmission management module 1805 described with reference to FIG. 18 or 19, or the modification flag or value tag transmission management module 1905 described with reference to FIG. 19.

[0376] At block 3815, the method 3800 may include receiving a request from the UE for updated system information (*e.g.*, a particular OSIB or element of an OSIB). The operation(s) at block 3815 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI request processing module 1810 described with reference to FIG. 18 or 19.

[0377] At block 3820, the method 3800 may include transmitting the updated system information based at least in part on the request. The operation(s) at block 3820 may be performed using the SI transmission module 1420 described with reference to FIG. 18, 19, 20, or 21, or the SI transmission management module 1805 described with reference to FIG. 18 or 19.

[0378] Thus, the method 3800 may provide for wireless communication. It should be noted that the method 3800 is just one implementation and that the operations of the method 3800 may be rearranged or otherwise modified such that other implementations are possible.

[0379] The detailed description set forth above in connection with the appended drawings describes examples and does not represent the only examples that may be implemented or that are within the scope of the claims. The terms "example" and "exemplary," when used in this description, mean "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other examples." The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, well-known structures and apparatuses are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

[0380] Information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0381] The various illustrative blocks and modules described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a digital signal processor (DSP), an ASIC, an FPGA, an SoC, or another programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0382] The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a non-transitory computer-readable medium. Other examples and

implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described above can be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at various positions, including being distributed such that portions of functions are implemented at different physical locations. Also, as used herein, including in the claims, "or" as used in a list of items prefaced by "at least one of" indicates a disjunctive list such that, for example, a list of "at least one of A, B, or C" means A or B or C or AB or AC or BC or ABC (*i.e.*, A and B and C).

[0383] Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage medium may be any available medium that can be accessed by a general purpose or special purpose computer. By way of example, and not limitation, computer-readable media can comprise RAM, ROM, electrically erasable programmable ROM (EEPROM), compact disk ROM (CD-ROM) or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code means in the form of instructions or data structures and that can be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

[0384] The previous description of the disclosure is provided to enable a person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the common principles defined herein may be applied

to other variations without departing from the scope of the disclosure. Throughout this disclosure the term "example" or "exemplary" indicates an example or instance and does not imply or require any preference for the noted example. Thus, the disclosure is not to be limited to the examples and designs described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A method for wireless communication, comprising:

receiving, at a user equipment (UE), a first set of system information;

determining, based at least in part on the first set of system information, that additional system information is available;

transmitting a request for the additional system information; and

receiving the additional system information at the UE.

2. The method of claim 1, wherein receiving the first set of system information comprises:

receiving an indication of one or more sets of additional system information that are available.

3. The method of claim 1, wherein transmitting the request comprises:

identifying, in the request, one or more sets of additional system information.

4. The method of claim 1, wherein receiving the first set of system information comprises:

receiving master system information, wherein the master system information includes system information that allows the UE to perform an initial access of a network using one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or network access configuration information.

5. The method of claim 1, wherein receiving the additional system information comprises one of:

receiving system information indicating which radio access technologies (RATs) are available in a region and how the UE is to select an available RAT;

receiving system information indicating which services are available in a region and how the UE is to obtain an available service;

receiving system information relating to a multimedia broadcast multicast service (MBMS) or a public warning system (PWS) service; or

receiving system information relating to location, positioning, or navigation services.

6. The method of claim 1, wherein receiving the first set of system information comprises:

receiving the first set of system information in response to a master system information request.

7. The method of claim 6, further comprising:

sending the master system information request in accordance with information decoded from a downlink channel indicating that master system information is received via request.

8. The method of claim 7, wherein the downlink channel includes a synchronization signal.

9. The method of claim 1, wherein transmitting the request comprises:

including one or more capabilities of the UE in the request.

10. The method of claim 9, wherein receiving the additional system information comprises:

receiving the additional system information based at least in part on the one or more capabilities of the UE included in the request.

11. The method of claim 1, wherein transmitting the request comprises:

including a location of the UE in the request.

12. The method of claim 11, wherein receiving the additional system information comprises:

receiving the additional system information based at least in part on the location of the UE included in the request.

13. The method of claim 1, wherein receiving the additional system information comprises:

receiving the additional system information based at least in part on a determined location of the UE.

14. The method of claim 1, further comprising:

receiving a location signal identifying a determined location of the UE; and

transmitting the request for the additional system information based at least in part on the determined location of the UE.

15. The method of claim 1, wherein determining that additional system information is available comprises:

identifying a distance between a current location of the UE and a location where the UE obtained the first set of system information; and

determining that the identified distance exceeds a predetermined threshold.

16. The method of claim 1, wherein transmitting the request comprises:

including an identification of the UE in the request.

17. The method of claim 16, wherein receiving the additional system information comprises:

receiving the additional system information based at least in part on the identification of the UE included in the request.

18. The method of claim 1, wherein transmitting the request comprises:

transmitting a plurality of requests for the additional system information.

19. An apparatus for wireless communication, comprising:

means for receiving, at a user equipment (UE), a first set of system information;

means for determining, based at least in part on the first set of system information, that additional system information is available;

means for transmitting a request for the additional system information; and

means for receiving the additional system information at the UE.

20. The apparatus of claim 19, wherein the means for receiving the first set of system information comprises:

means for receiving an indication of one or more sets of additional system information that are available.

21. The apparatus of claim 19, wherein the means for transmitting the request comprises:

means for identifying, in the request, one or more sets of additional system information.

22. The apparatus of claim 19, wherein the means for receiving the first set of system information comprises:

means for receiving master system information, wherein the master system information includes system information that allows the UE to perform an initial access of a network using one or more of an identification of the network, an identification of a base station in the network, cell selection configuration and access restrictions, or network access configuration information.

23. The apparatus of claim 19, wherein the means for receiving the additional system information comprises one of:

means for receiving system information indicating which radio access technologies (RATs) are available in a region and how the UE is to select an available RAT;

means for receiving system information indicating which services are available in a region and how the UE is to obtain an available service;

means for receiving system information relating to a multimedia broadcast multicast service (MBMS) or a public warning system (PWS) service; or

means for receiving system information relating to location, positioning, or navigation services.

24. The apparatus of claim 19, wherein the means for receiving the first set of system information comprises:

means for receiving the first set of system information in response to a master system information request.

25. The apparatus of claim 24, further comprising:

means for sending the master system information request in accordance with information decoded from a downlink channel indicating that master system information is received via request.

26. The apparatus of claim 25, wherein the downlink channel includes a synchronization signal.

27. The apparatus of claim 19, wherein the means for transmitting the request comprises:

means for including one or more capabilities of the UE in the request.

28. The apparatus of claim 27, wherein the means for receiving the additional system information comprises:

means for receiving the additional system information based at least in part on the one or more capabilities of the UE included in the request.

29. The apparatus of claim 19, wherein the means for transmitting the request comprises:

means for including a location of the UE in the request.

30. The apparatus of claim 29, wherein the means for receiving the additional system information comprises:

means for receiving the additional system information based at least in part on the location of the UE included in the request.

31. The apparatus of claim 19, wherein the means for receiving the additional system information comprises:

means for receiving the additional system information based at least in part on a determined location of the UE.

32. The apparatus of claim 19, further comprising:

means for receiving a location signal identifying a determined location of the UE; and

means for transmitting the request for the additional system information based at least in part on the determined location of the UE

33. The apparatus of claim 19, wherein the means for determining that additional system information is available comprises:

means for identifying a distance between a current location of the UE and a location where the UE obtained the first set of system information; and

means for determining that the identified distance exceeds a predetermined threshold.

34. The apparatus of claim 19, wherein the means for transmitting the request comprises:

means for including an identification of the UE in the request.

35. The apparatus of claim 34, wherein the means for receiving the additional system information comprises:

means for receiving the additional system information based at least in part on the identification of the UE included in the request.

36. The apparatus of claim 19, wherein the means for transmitting the request comprises:

means for transmitting a plurality of requests for the additional system information.

37. An apparatus for wireless communication, comprising:

a processor;

memory in electronic communication with the processor; and

instructions stored in the memory, the instructions being executable by the processor to:

receive, at a user equipment (UE), a first set of system information;

determine, based at least in part on the first set of system information, that additional system information is available;

transmit a request for the additional system information, and

receive the additional system information at the UE.

38. The apparatus of claim 37, wherein the instructions executable by the processor to receive the first set of system information comprise instructions executable by the processor to:

receive an indication of one or more sets of additional system information that are available.

39. The apparatus of claim 37, wherein the instructions executable by the processor to transmit the request comprise instructions executable by the processor to:

identify, in the request, one or more sets of additional system information.

40. A method for wireless communication, comprising:

transmitting, from a base station, a first set of system information;

receiving a request for additional system information; and

transmitting the additional system information based at least in part on the request.

41. The method of claim 40, wherein transmitting the first set of system information comprises one of:

transmitting an indication of one or more sets of additional system information that are available: or

transmitting the first set of system information in response to receiving a master system information request.

42. The method of claim 40, wherein receiving the request comprises one of:

receiving multiple requests for additional system information corresponding to multiple sets of additional system information to be transmitted;

receiving, in the request, one or more capabilities of a user equipment (UE) transmitting the request;

receiving, in the request, a location of a user equipment (UE) transmitting the request; or

receiving, in the request, an identification of a user equipment (UE) transmitting the request.

43. The method of claim 40, wherein transmitting the first set of system information comprises:

transmitting master system information, wherein the master system information includes system information that allows a user equipment (UE) an initial access of a network using one or more of an identification of the network, an identification of the base station, cell selection configuration and access restrictions, or network access configuration.

44. The method of claim 40, wherein transmitting the additional system information comprises one of:

transmitting system information indicating which radio access technologies (RATs) are available in a region and how a user equipment (UE) is to select an available RAT;

transmitting system information indicating which services are available in a region and how a user equipment (UE) is to obtain an available service; or

transmitting system information relating to location, positioning, or navigation services.

45. The method of claim 42, further comprising:

identifying the additional system information to transmit based at least in part on the one or more capabilities of the UE included in the request.

46. The method of claim 42, further comprising:

identifying the additional system information to transmit based at least in part on the location of the UE included in the request.

47. The method of claim 40, further comprising:

determining a location of a user equipment (UE) transmitting the request; and

identifying the additional system information to transmit based at least in part on the location of the UE.

48. An apparatus for wireless communication, comprising:

means for transmitting, from a base station, a first set of system information;

means for receiving a request for additional system information; and

means for transmitting the additional system information based at least in part on the request.

49. The apparatus of claim 48, wherein the means for transmitting the first set of system information comprises one of:

means for transmitting an indication of one or more sets of additional system information that are available: or

means for transmitting the first set of system information in response to receiving a master system information request.

50. The apparatus of claim 48, wherein the means for receiving the request comprises one of:

means for receiving multiple requests for additional system information corresponding to multiple sets of additional system information to be transmitted;

means for receiving, in the request, one or more capabilities of a user equipment (UE) transmitting the request;

means for receiving, in the request, a location of a user equipment (UE) transmitting the request; or

means for receiving, in the request, an identification of a user equipment (UE) transmitting the request.

51. The apparatus of claim 48, wherein the means for transmitting the first set of system information comprises:

means for transmitting master system information, wherein the master system information includes system information that allows a user equipment (UE) an initial access of a network using one or more of an identification of the network, an identification of the base station, cell selection configuration and access restrictions, or network access configuration.

52. The apparatus of claim 48, wherein the means for transmitting the additional system information comprises one of:

means for transmitting system information indicating which radio access technologies (RATs) are available in a region and how a user equipment (UE) is to select an available RAT;

means for transmitting system information indicating which services are available in a region and how a user equipment (UE) is to obtain an available service; or

means for transmitting system information relating to location, positioning, or navigation services.

53. The apparatus of claim 50, further comprising:

means for identifying the additional system information to transmit based at least in part on the one or more capabilities of the UE included in the request.

54. The apparatus of claim 50, further comprising:

means for identifying the additional system information to transmit based at least in part on the location of the UE included in the request.

55. The apparatus of claim 48, further comprising:

means for determining a location of a user equipment (UE) transmitting the request; and

means for identifying the additional system information to transmit based at least in part on the location of the UE.

56. An apparatus for wireless communication, comprising:

a processor;

memory in electronic communication with the processor; and

instructions stored in the memory, the instructions being executable by the processor to:

transmit, from a base station, a first set of system information;

receive a request for additional system information; and

transmit the additional system information based at least in part on the request.

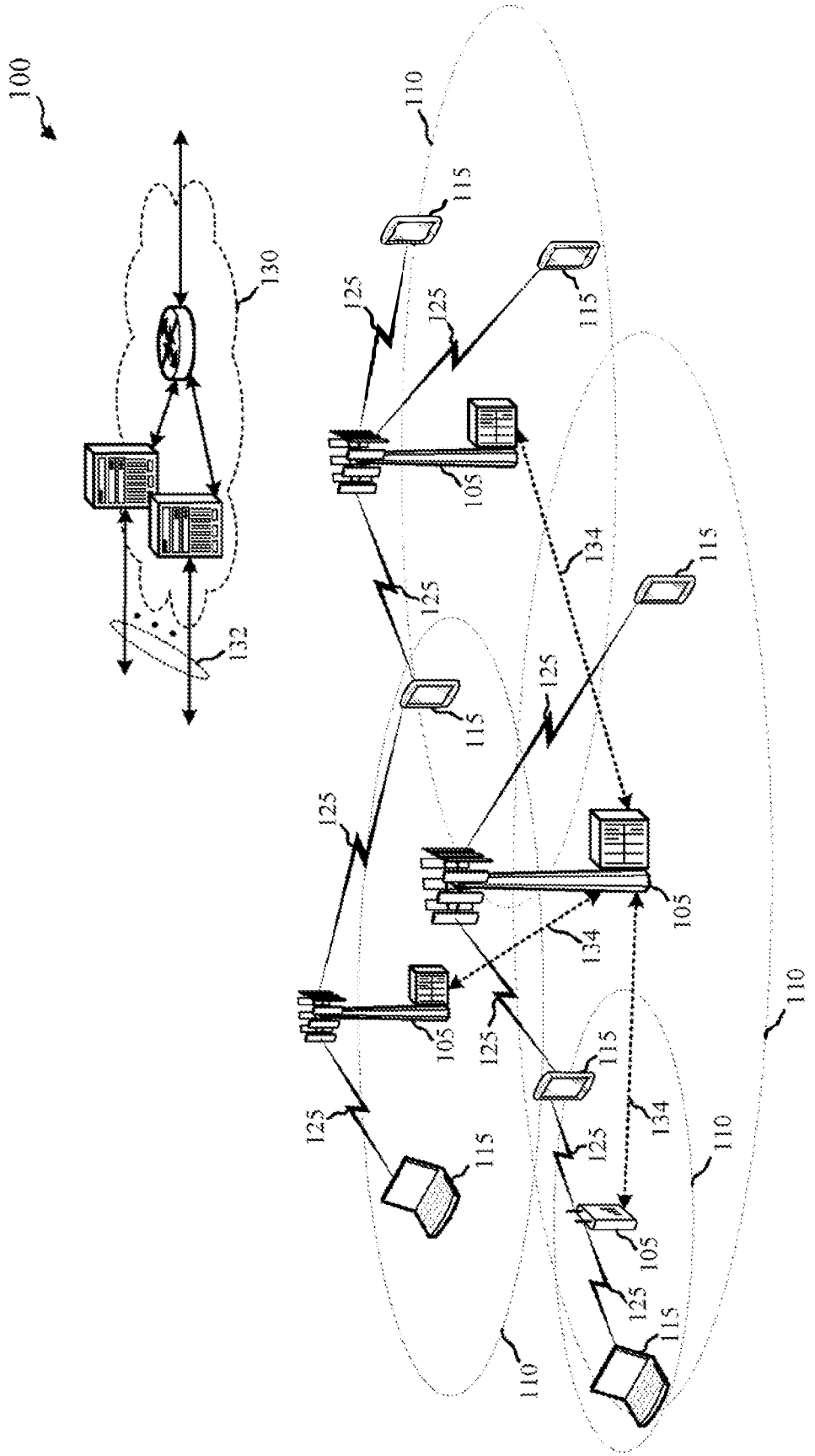

FIG. 1

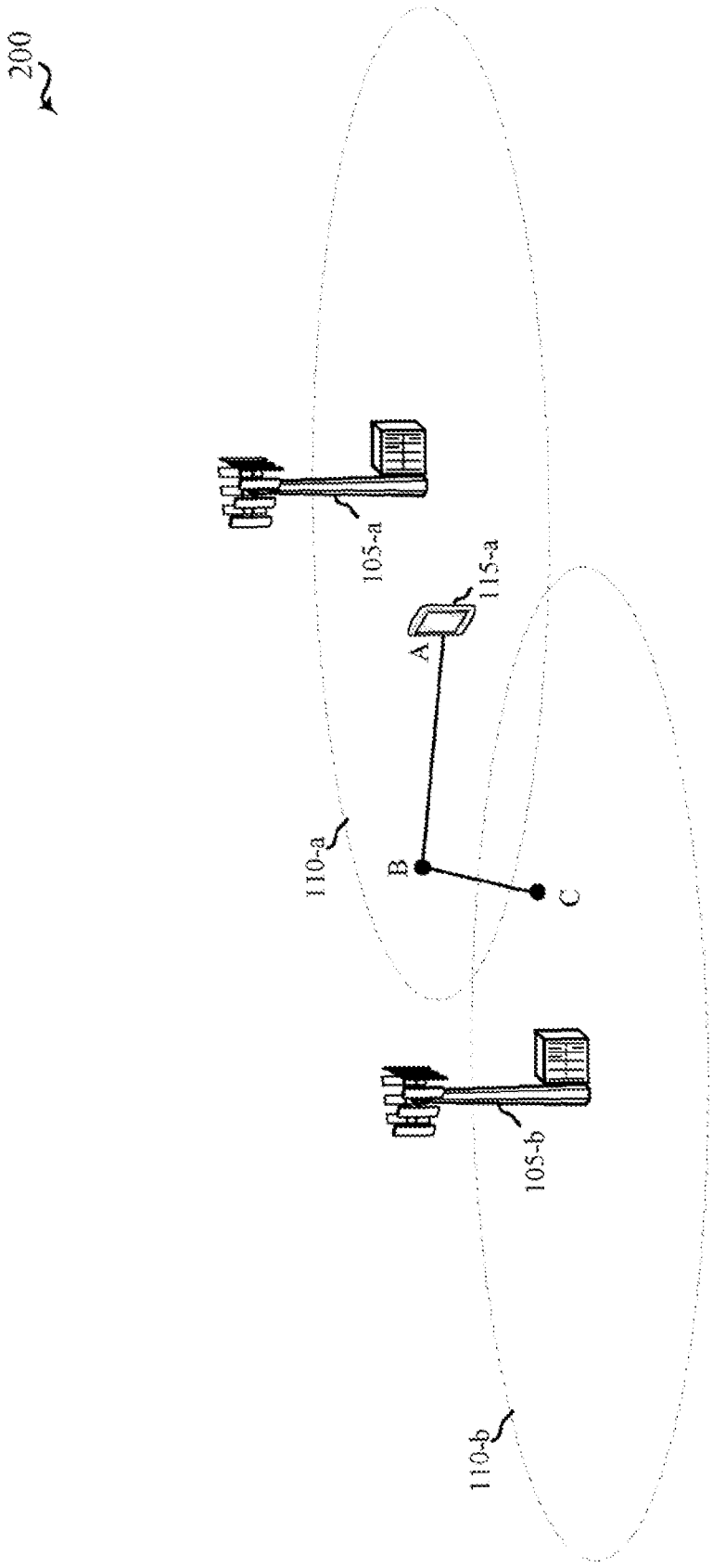

FIG. 2

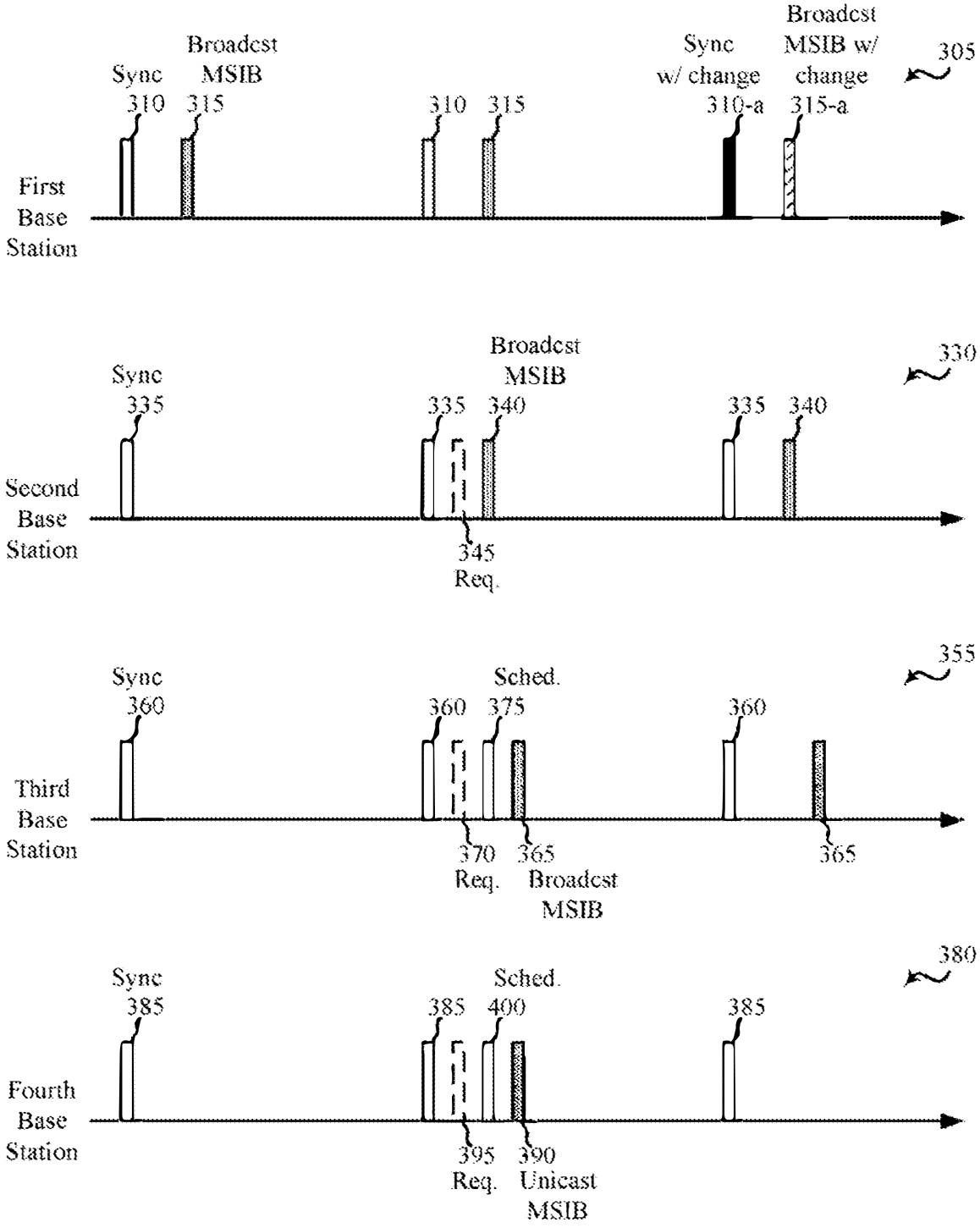
First Base Station
Sync 310
Broadcst MSIB 315
310 315
Sync w/ change 310-a
Broadcst MSIB w/ change 315-a
305
Second Base Station
Sync 335
Broadcst MSIB
335 340
335 340
330
345 Req.
Third Base Station
Sync 360
Sched.
360 375
360
355
370 Req.
365 Broadcst MSIB
365
Fourth Base Station
Sync 385
Sched.
385 400
385
380
395 Req.
390 Unicast MSIB

FIG. 3

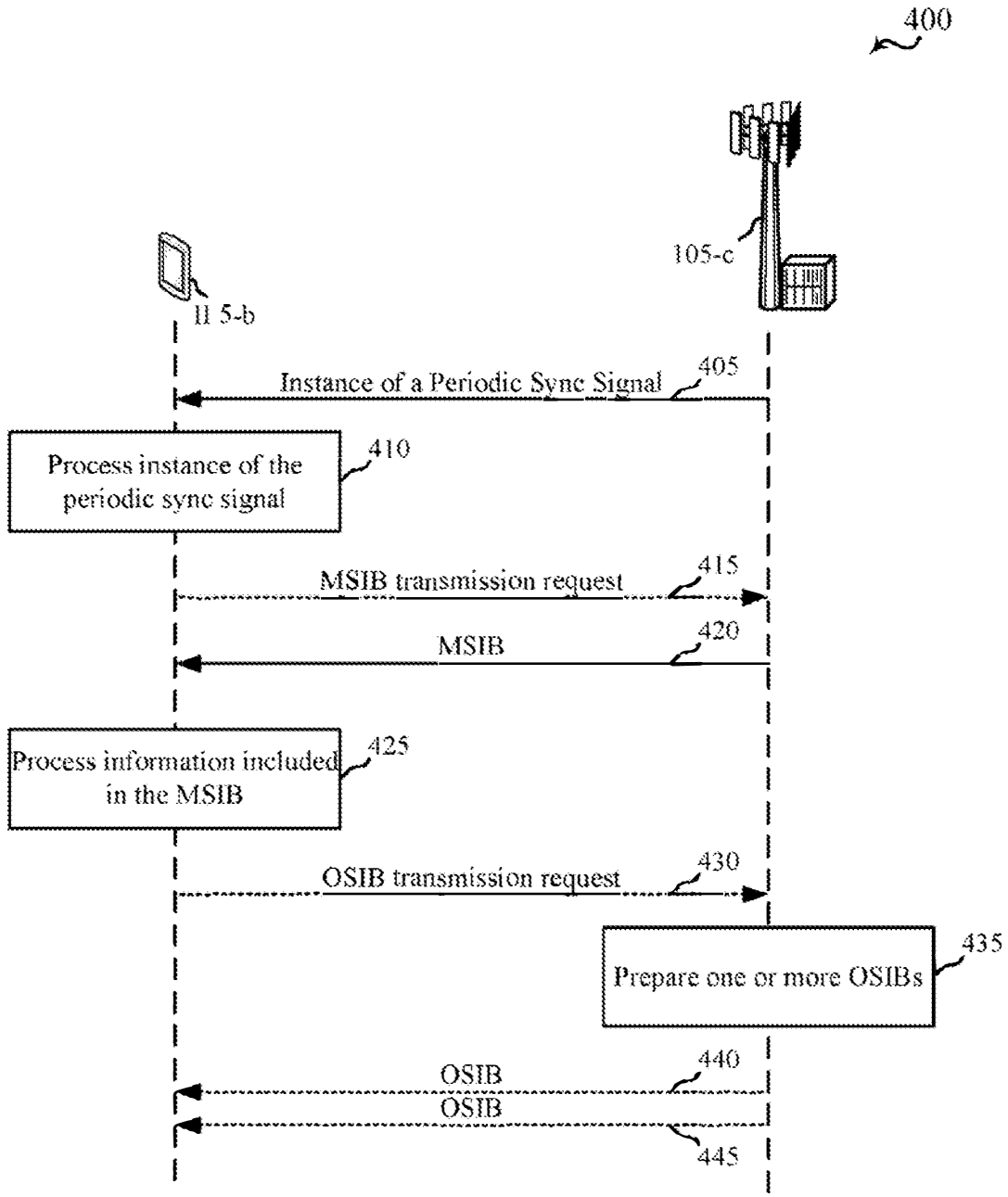
400
105-c
II 5-b
Instance of a Periodic Sync Signal
405
Process instance of the periodic sync signal
410
MSIB transmission request
415
MSIB
420
Process information included in the MSIB
425
OSIB transmission request
430
Prepare one or more OSIBs
435
OSIB
440
OSIB
445

FIG. 4

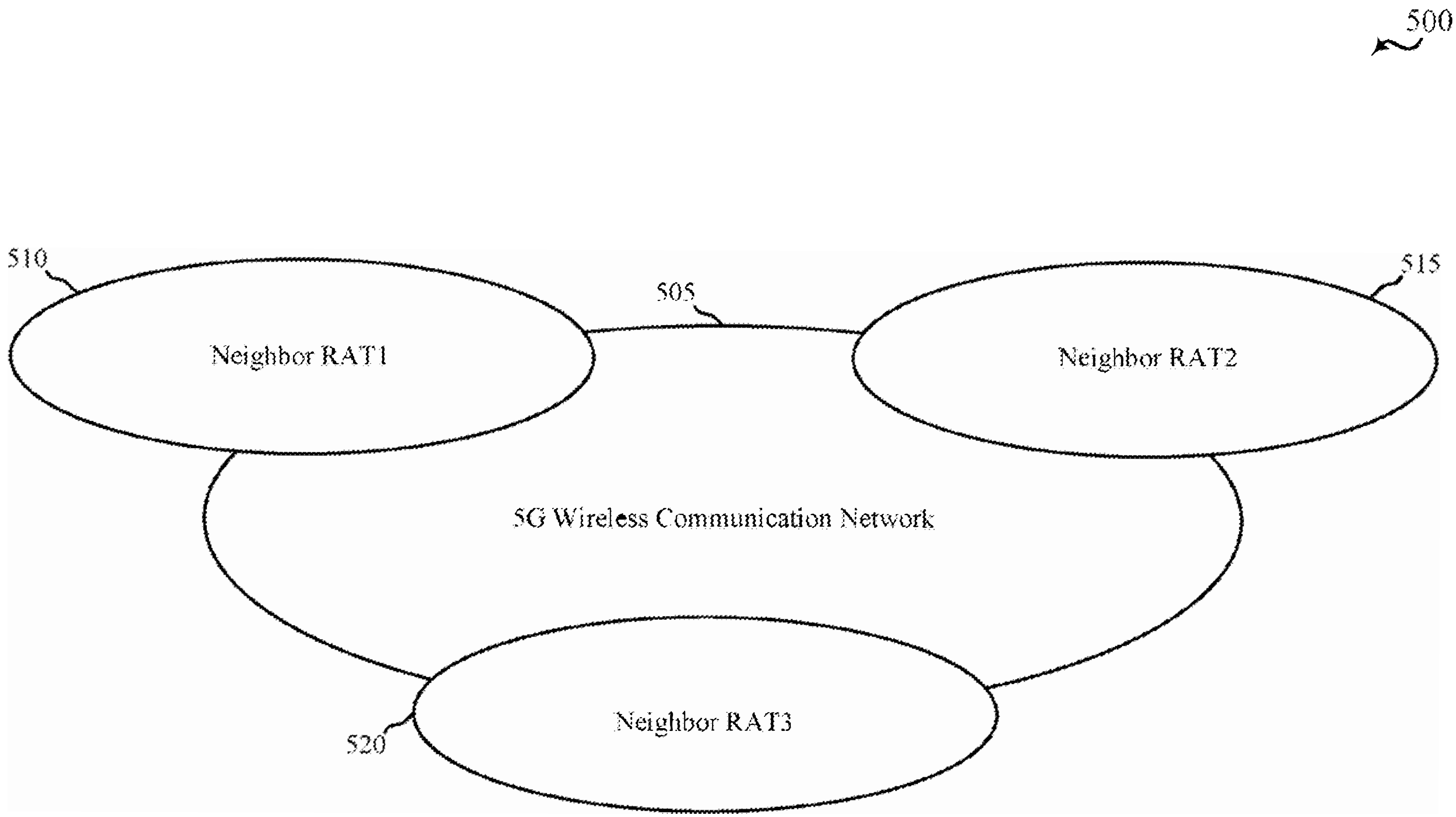
500
510
505
515
Neighbor RAT1
Neighbor RAT2
5G Wireless Communication Network
Neighbor RAT3
520

FIG. 5

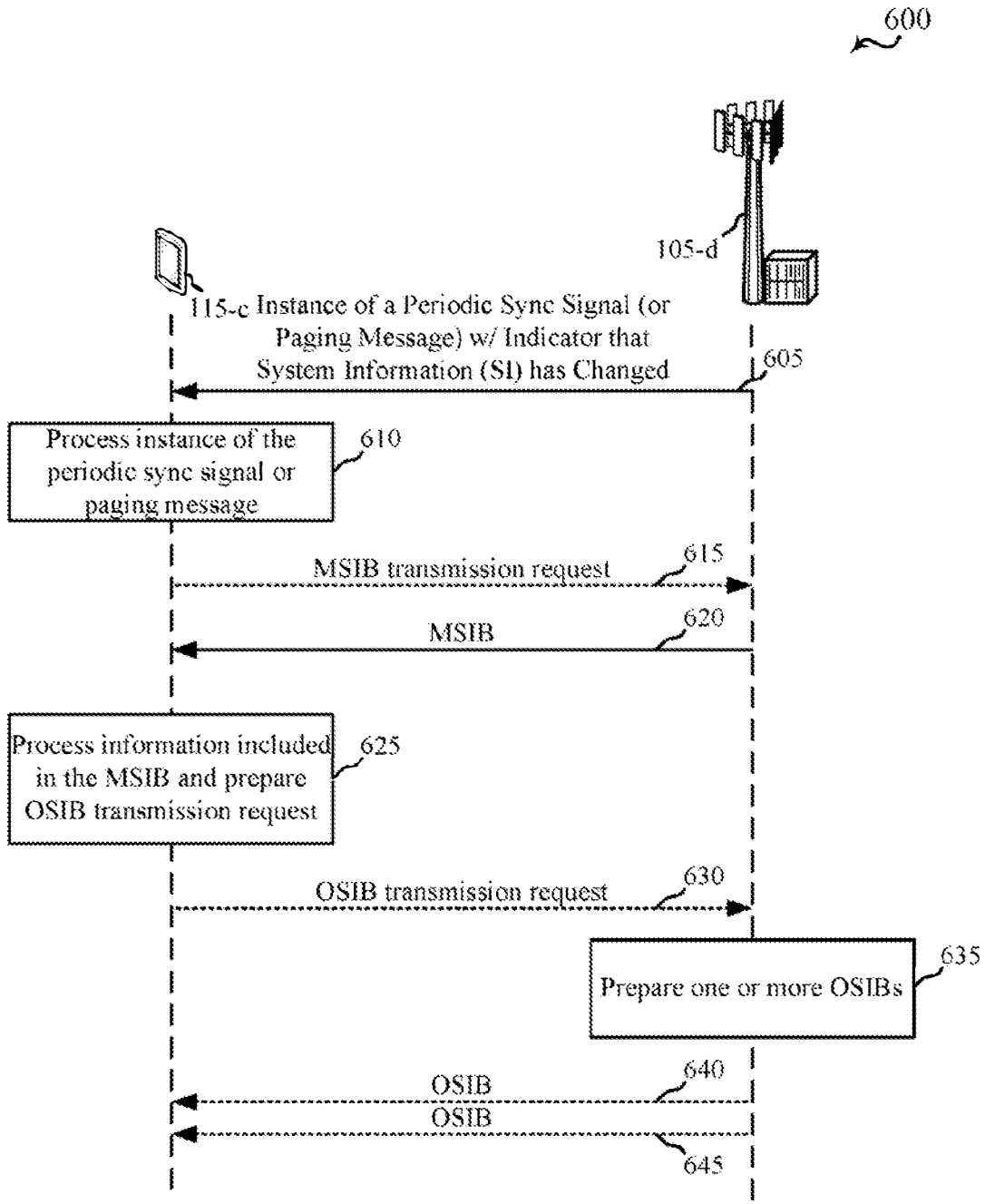
600
105-d
115-c
Instance of a Periodic Sync Signal (or Paging Message) w/ Indicator that System Information (SI) has Changed
605
Process instance of the periodic sync signal or paging message
610
MSIB transmission request
615
MSIB
620
Process information included in the MSIB and prepare OSIB transmission request
625
OSIB transmission request
630
Prepare one or more OSIBs
635
OSIB
640
OSIB
645

FIG. 6

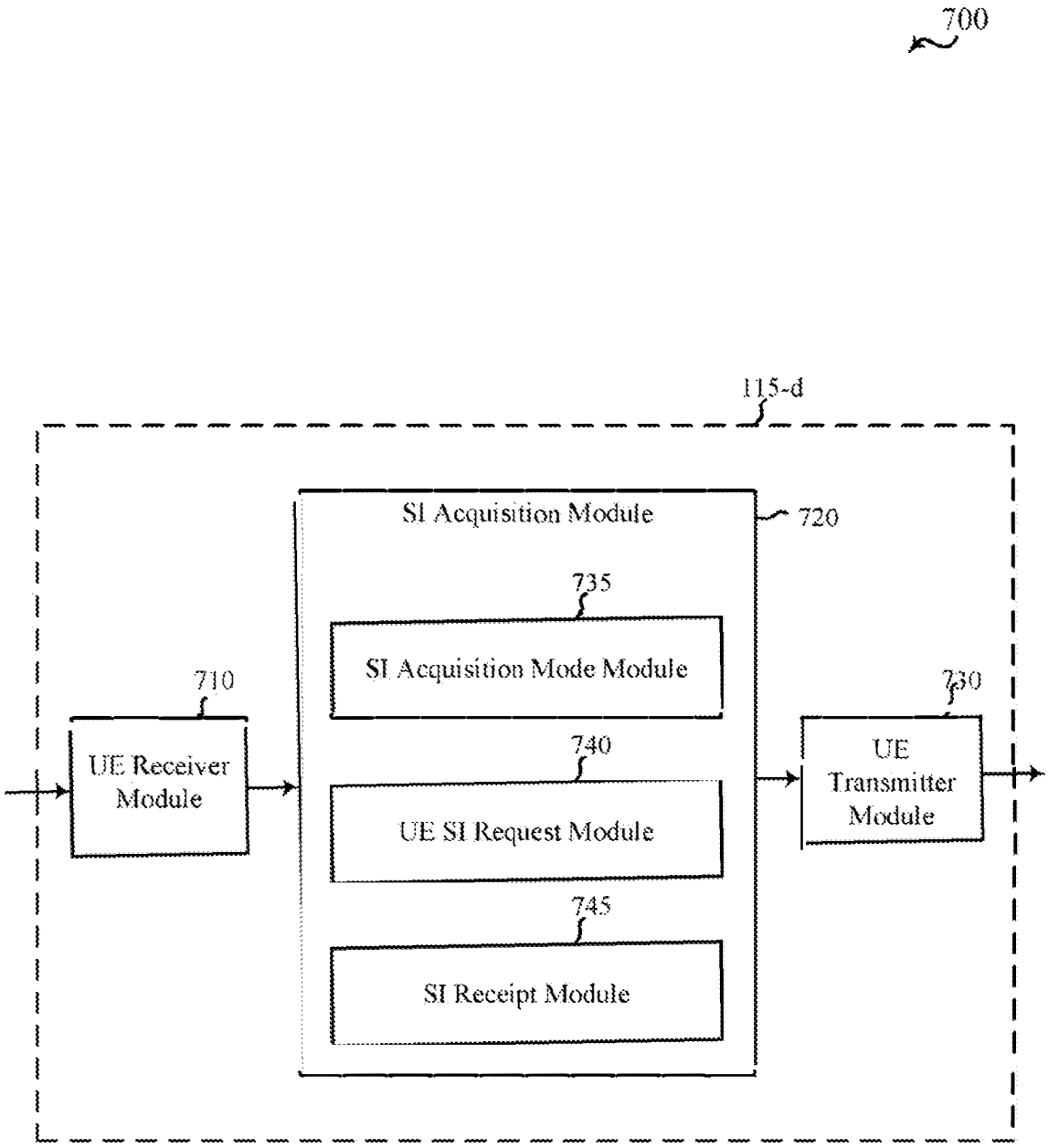
700
115-d
SI Acquisition Module
720
735
SI Acquisition Mode Module
710
UE Receiver Module
740
UE SI Request Module
730
UE Transmitter Module
745
SI Receipt Module

FIG. 7

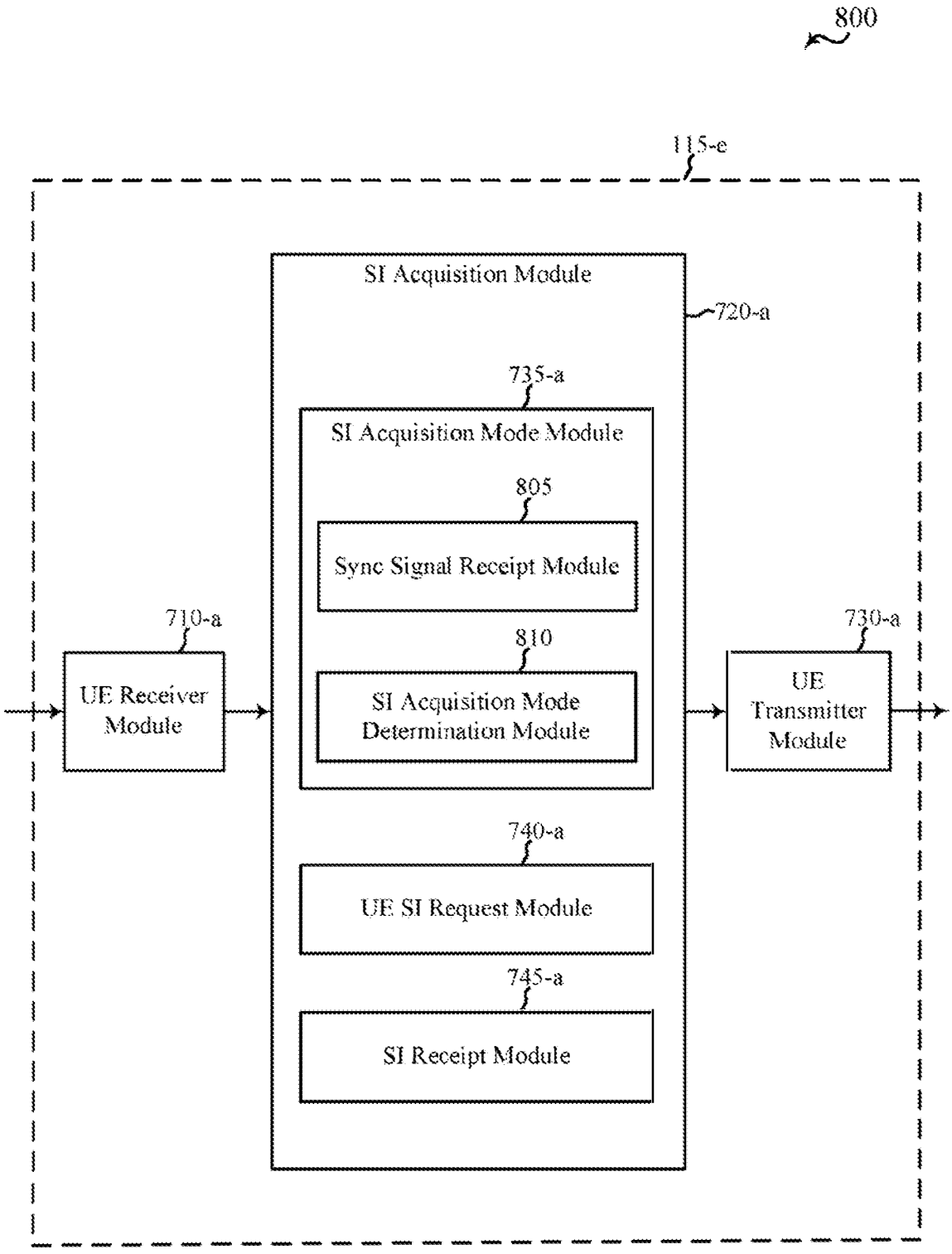
800
115-e
SI Acquisition Module
720-a
735-a
SI Acquisition Mode Module
805
Sync Signal Receipt Module
810
SI Acquisition Mode Determination Module
710-a
UE Receiver Module
730-a
UE Transmitter Module
740-a
UE SI Request Module
745-a
SI Receipt Module

FIG. 8

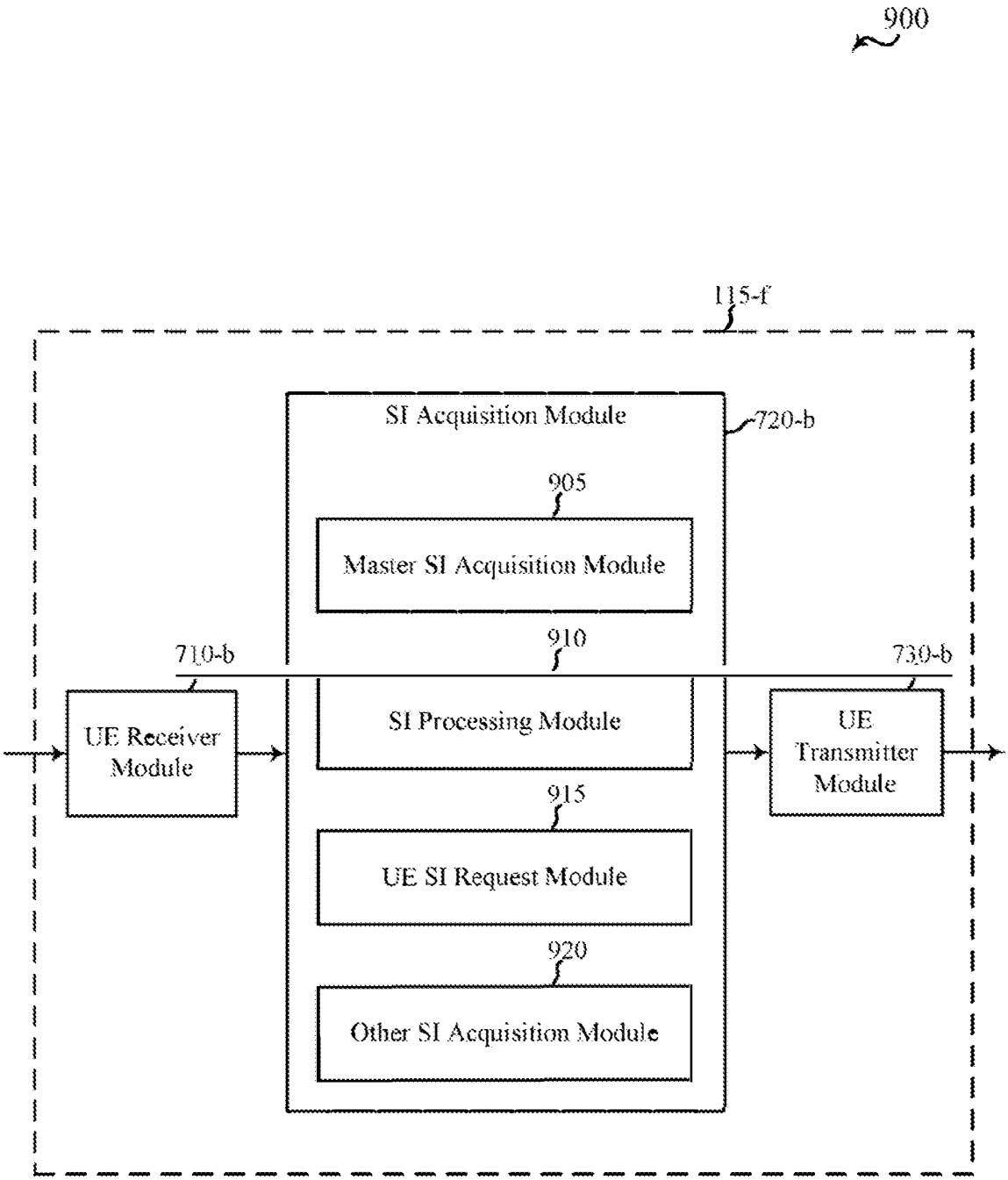
900
115-f
SI Acquisition Module
720-b
905
Master SI Acquisition Module
910
710-b
730-b
UE Receiver Module
SI Processing Module
UE Transmitter Module
915
UE SI Request Module
920
Other SI Acquisition Module

FIG. 9

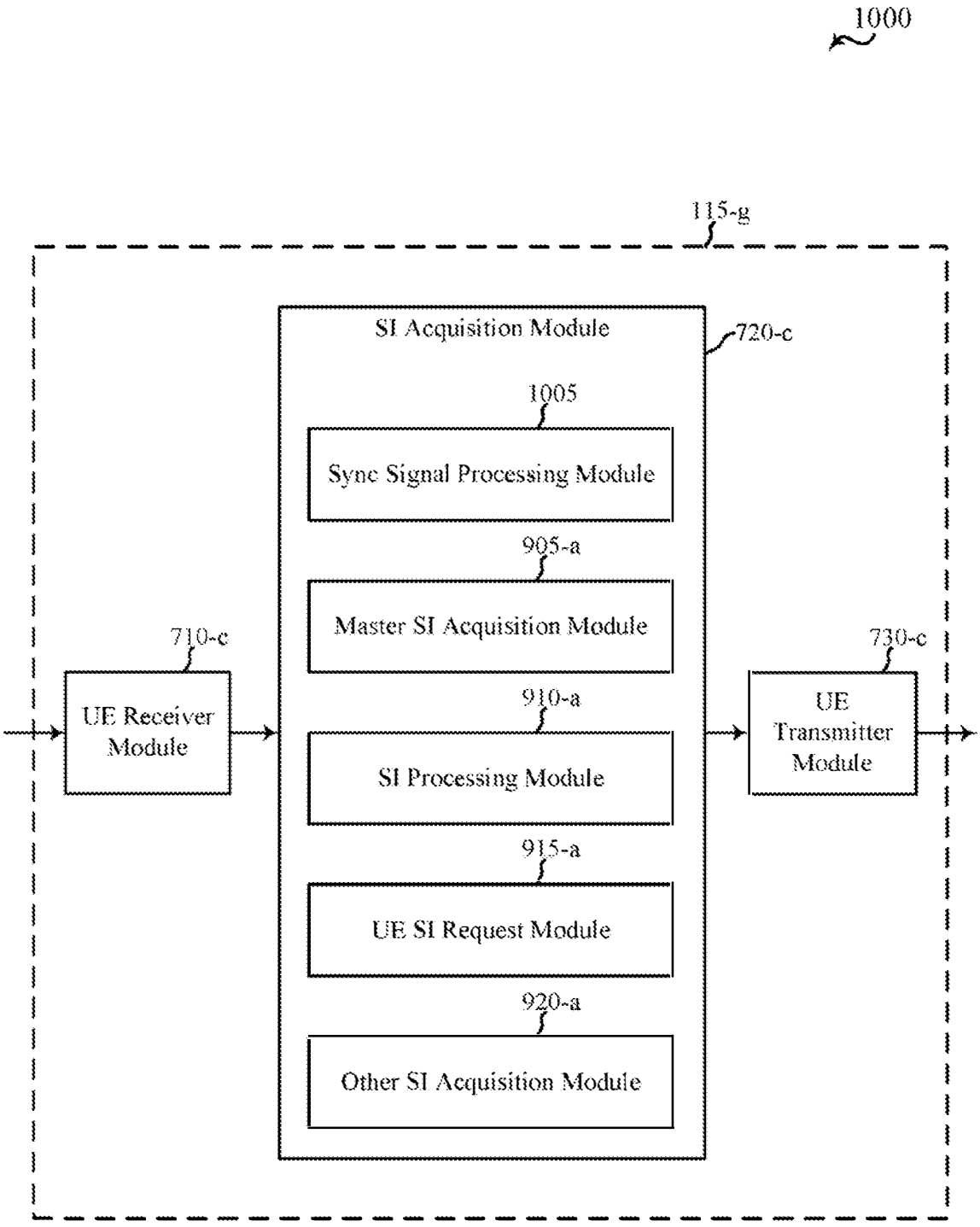
1000
115-g
SI Acquisition Module
720-c
1005
Sync Signal Processing Module
905-a
Master SI Acquisition Module
710-c
730-c
UE Receiver Module
910-a
SI Processing Module
UE Transmitter Module
915-a
UE SI Request Module
920-a
Other SI Acquisition Module

FIG. 10

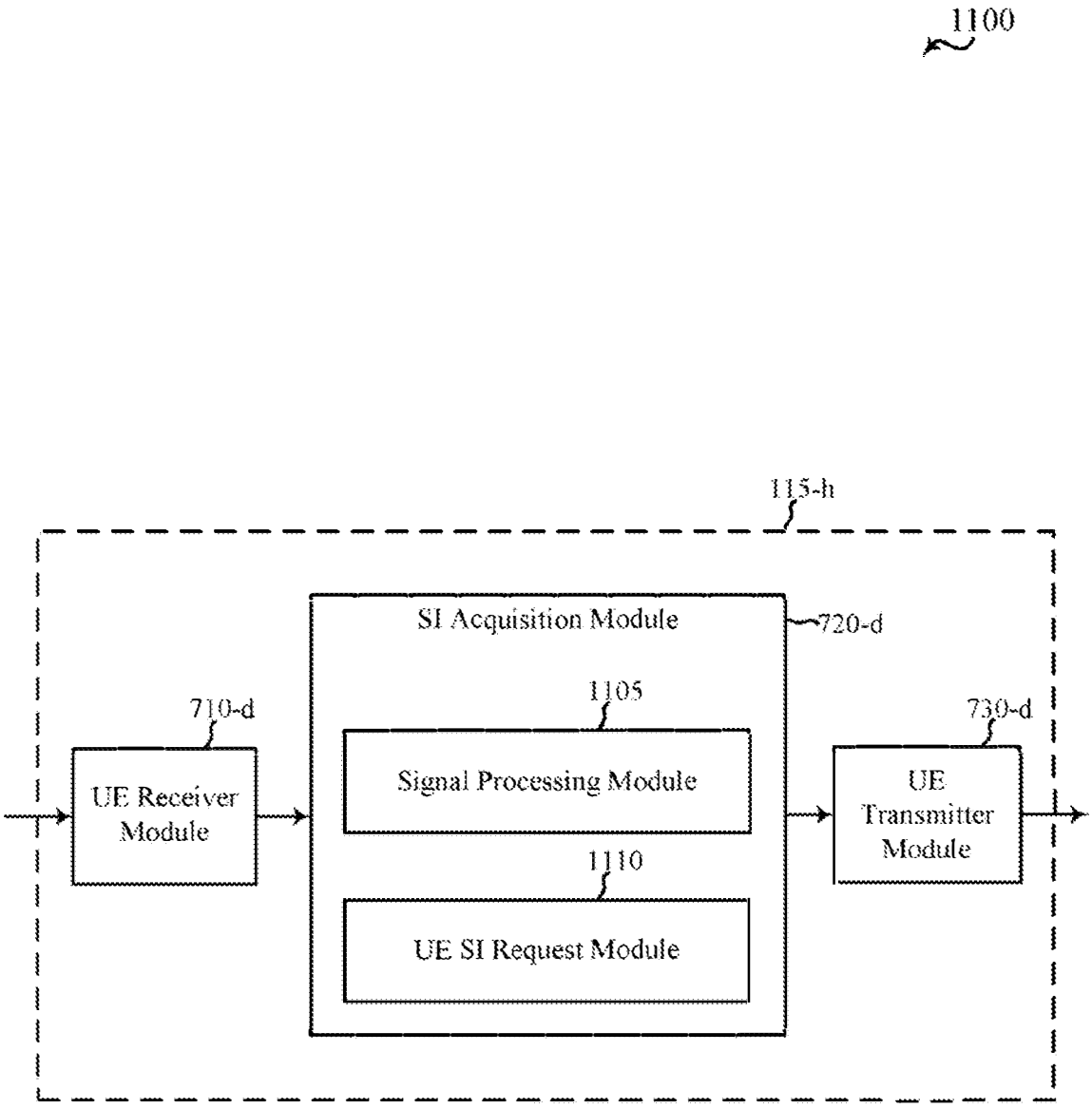
1100
115-h
SI Acquisition Module
720-d
1105
710-d
730-d
UE Receiver Module
Signal Processing Module
UE Transmitter Module
1110
UE SI Request Module

FIG. 11

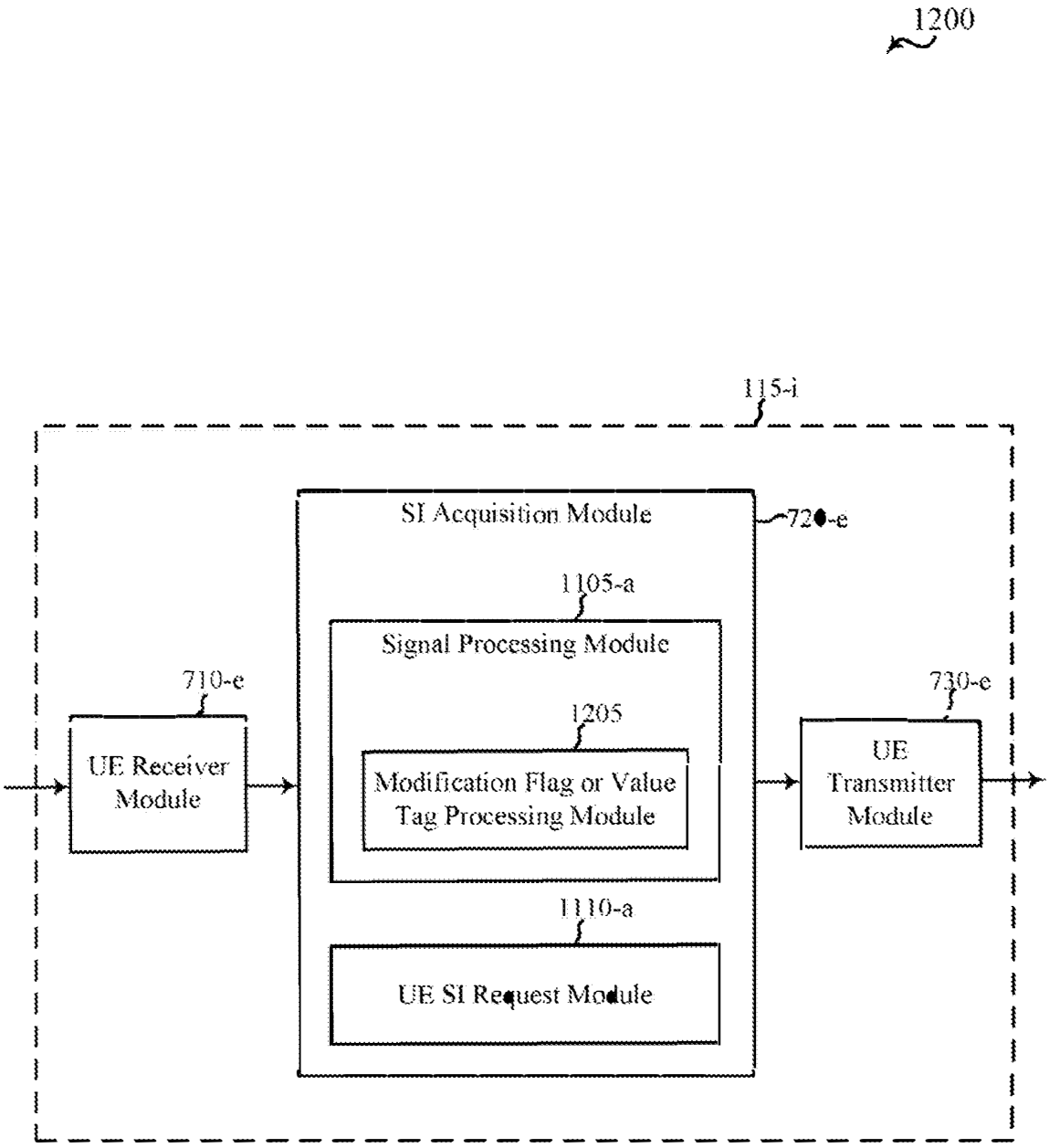
1200
115-i
SI Acquisition Module
720-e
1105-a
Signal Processing Module
1205
Modification Flag or Value Tag Processing Module
1110-a
UE SI Request Module
710-e
UE Receiver Module
730-e
UE Transmitter Module

FIG. 12

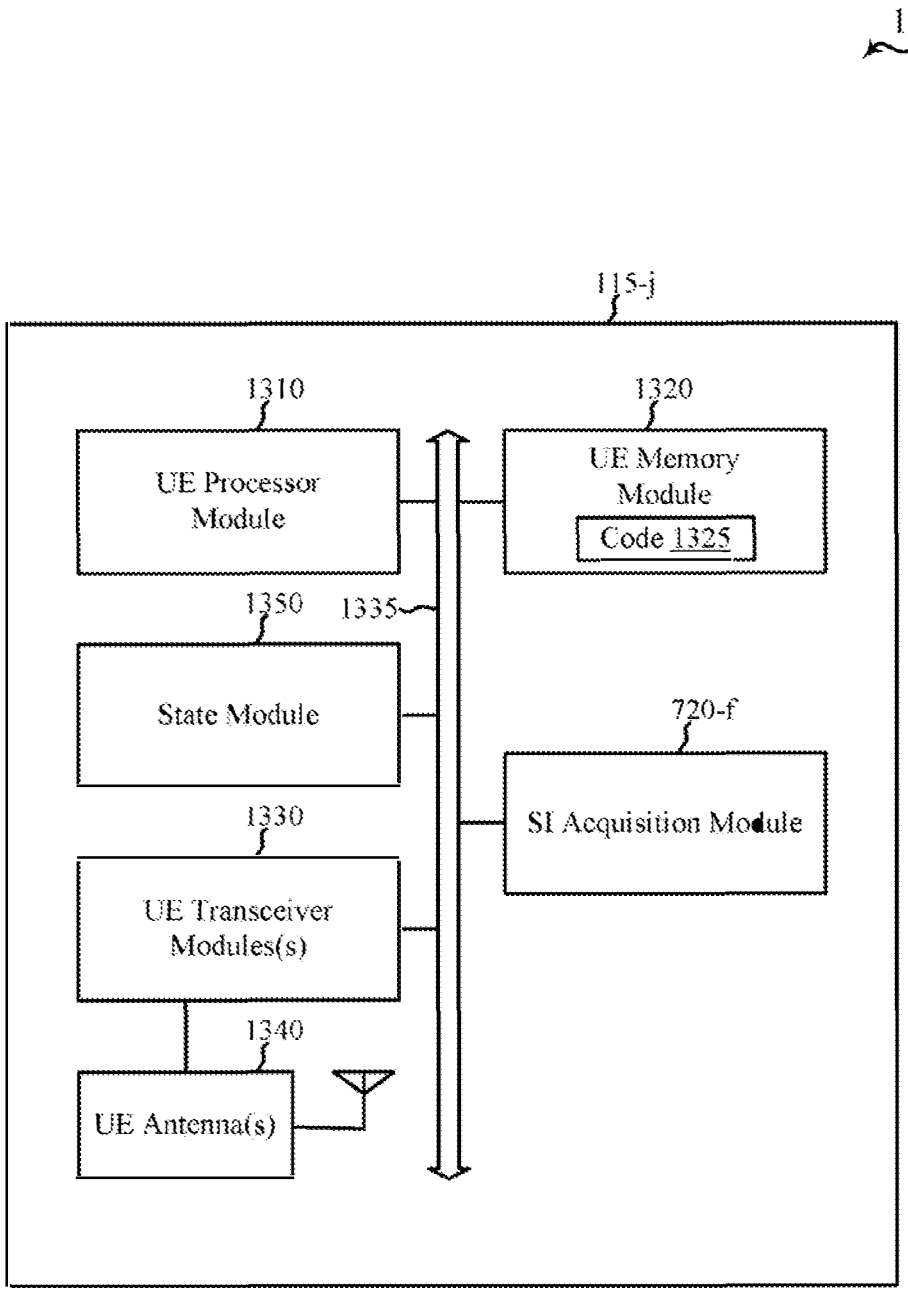
1300
115-j
1310
UE Processor Module
1320
UE Memory Module
Code 1325
1350
1335
State Module
720-f
SI Acquisition Module
1330
UE Transceiver Modules(s)
1340
UE Antenna(s)

FIG. 13

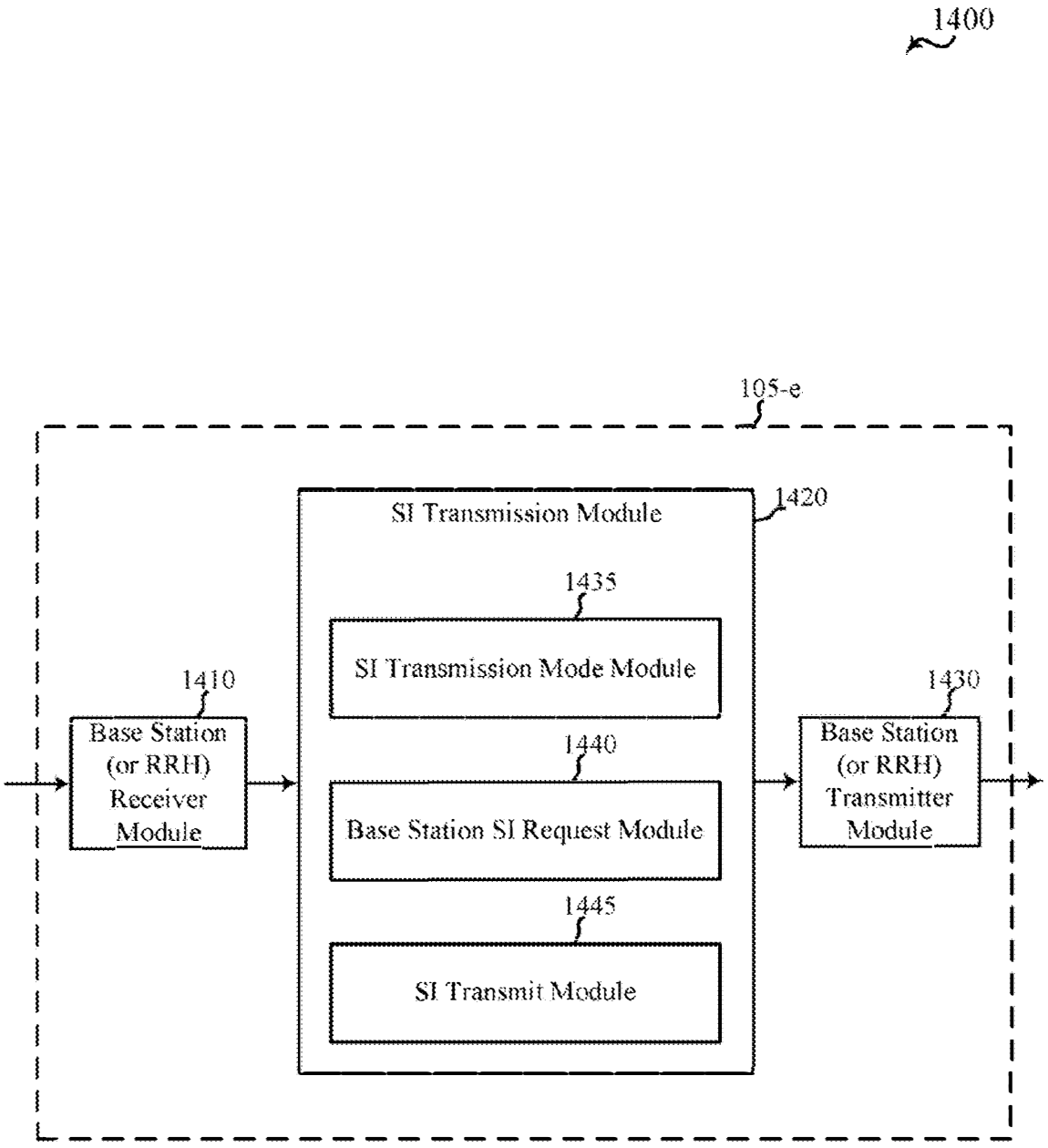
1400
105-e
SI Transmission Module
1420
1435
SI Transmission Mode Module
1410
Base Station (or RRH) Receiver Module
1440
Base Station SI Request Module
1430
Base Station (or RRH) Transmitter Module
1445
SI Transmit Module

FIG. 14

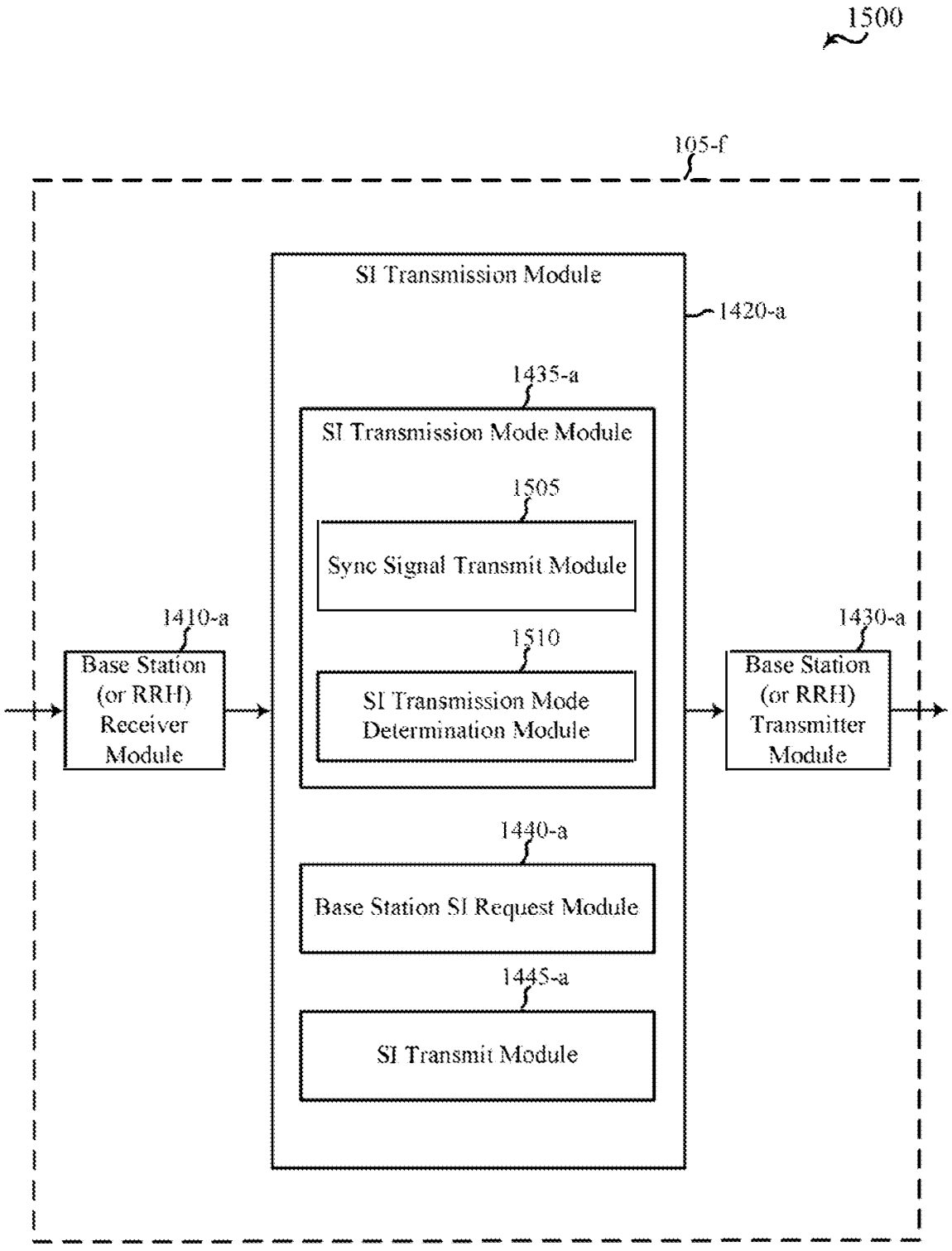
1500
105-f
SI Transmission Module
1420-a
1435-a
SI Transmission Mode Module
1505
Sync Signal Transmit Module
1410-a
Base Station (or RRH) Receiver Module
1510
SI Transmission Mode Determination Module
1430-a
Base Station (or RRH) Transmitter Module
1440-a
Base Station SI Request Module
1445-a
SI Transmit Module

FIG. 15

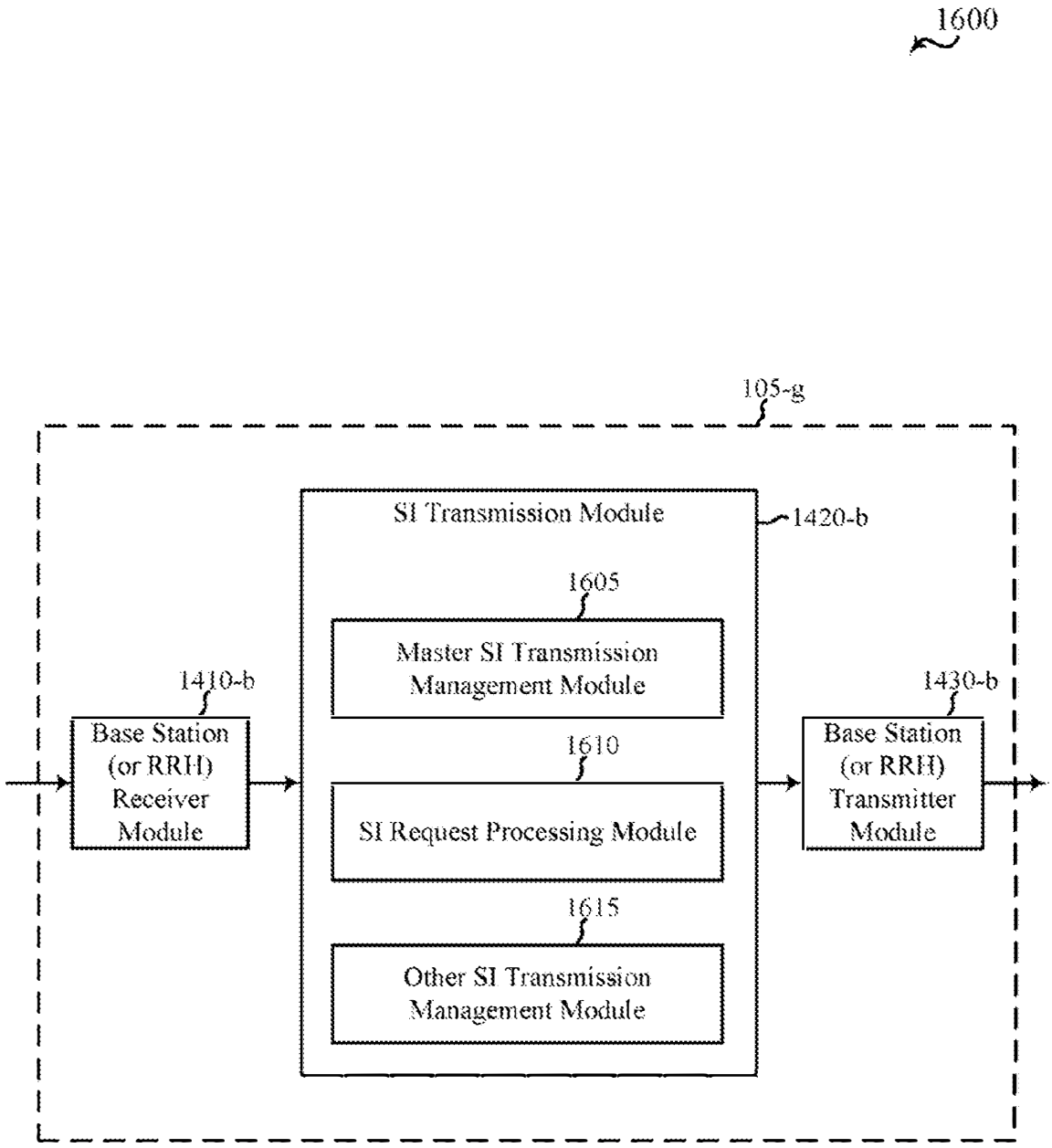
1600
105-g
SI Transmission Module
1420-b
1605
Master SI Transmission Management Module
1410-b
Base Station (or RRH) Receiver Module
1610
SI Request Processing Module
1430-b
Base Station (or RRH) Transmitter Module
1615
Other SI Transmission Management Module

FIG. 16

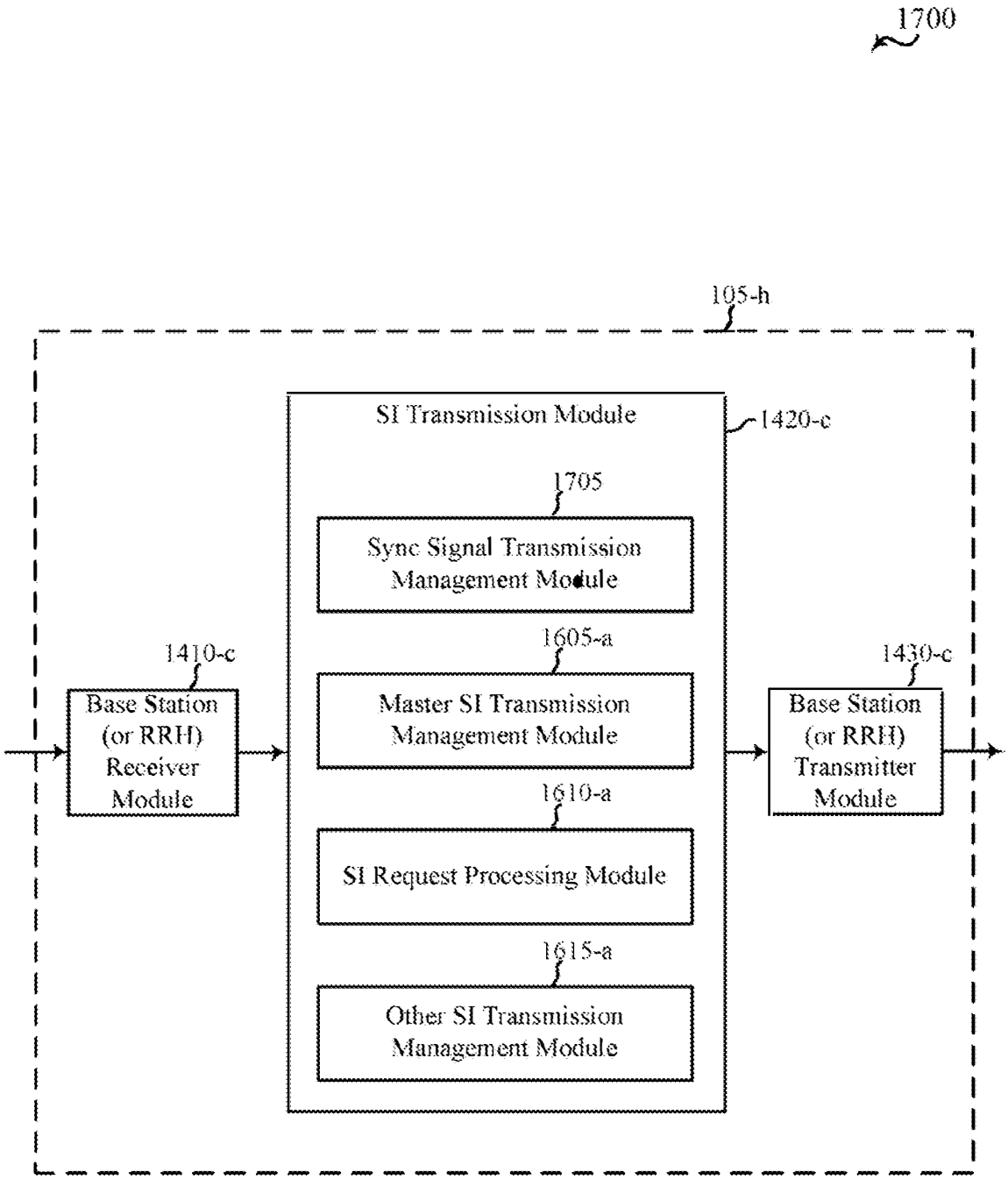
1700
105-h
SI Transmission Module
1420-c
1705
Sync Signal Transmission Management Module
1605-a
Master SI Transmission Management Module
1610-a
SI Request Processing Module
1615-a
Other SI Transmission Management Module
1410-c
Base Station (or RRH) Receiver Module
1430-c
Base Station (or RRH) Transmitter Module

FIG. 17

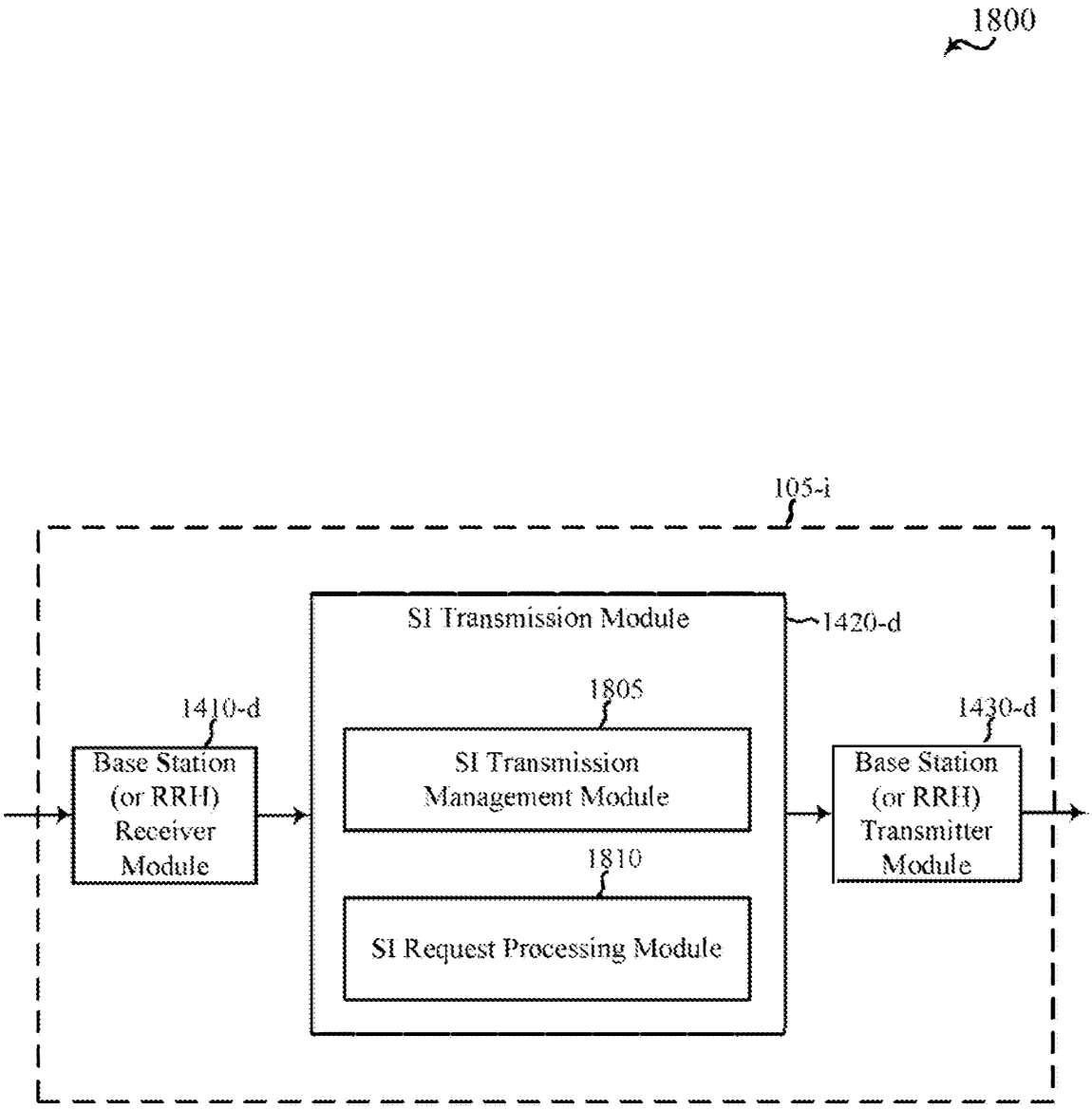
1800
105-i
SI Transmission Module
1420-d
1805
1410-d
1430-d
Base Station (or RRH) Receiver Module
SI Transmission Management Module
Base Station (or RRH) Transmitter Module
1810
SI Request Processing Module

FIG. 18

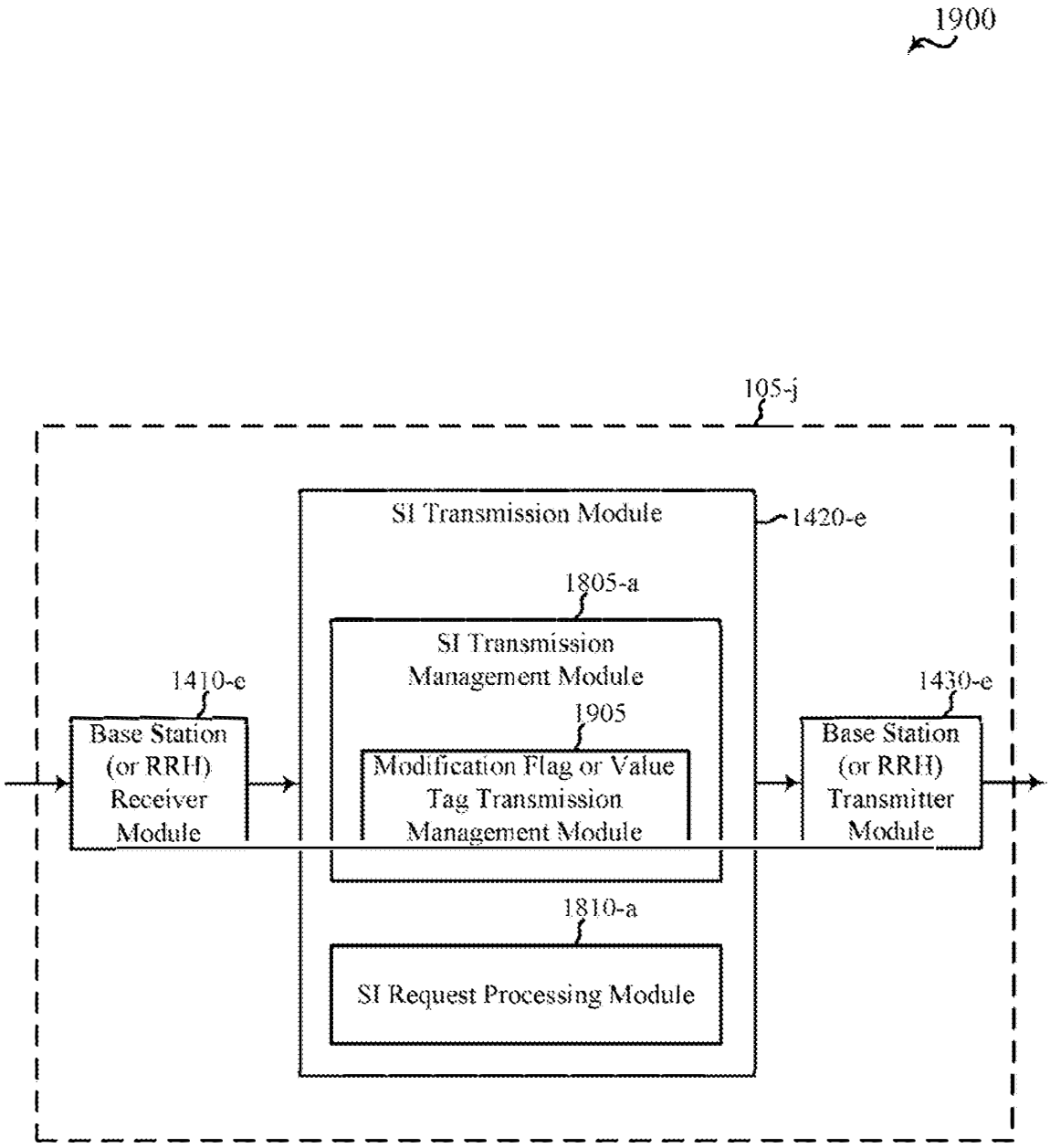
1900
105-j
SI Transmission Module
1420-e
1805-a
SI Transmission Management Module
1905
Modification Flag or Value Tag Transmission Management Module
1410-e
Base Station (or RRH) Receiver Module
1430-e
Base Station (or RRH) Transmitter Module
1810-a
SI Request Processing Module

FIG. 19

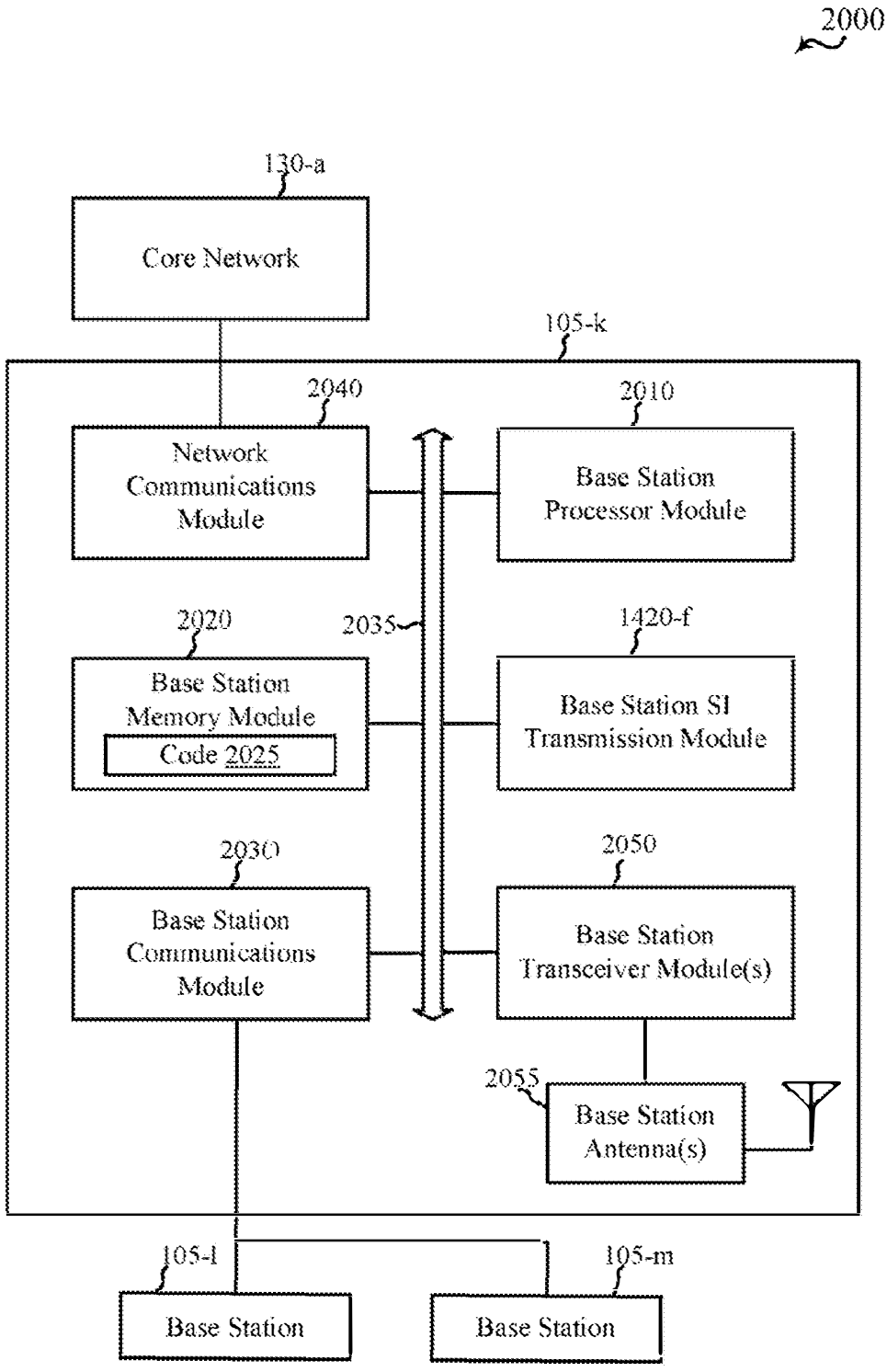
2000
130-a
Core Network
105-k
2040
Network Communications Module
2010
Base Station Processor Module
2020
Base Station Memory Module
Code 2025
2035
1420-f
Base Station SI Transmission Module
2030
Base Station Communications Module
2050
Base Station Transceiver Module(s)
2055
Base Station Antenna(s)
105-l
Base Station
105-m
Base Station

FIG. 20A

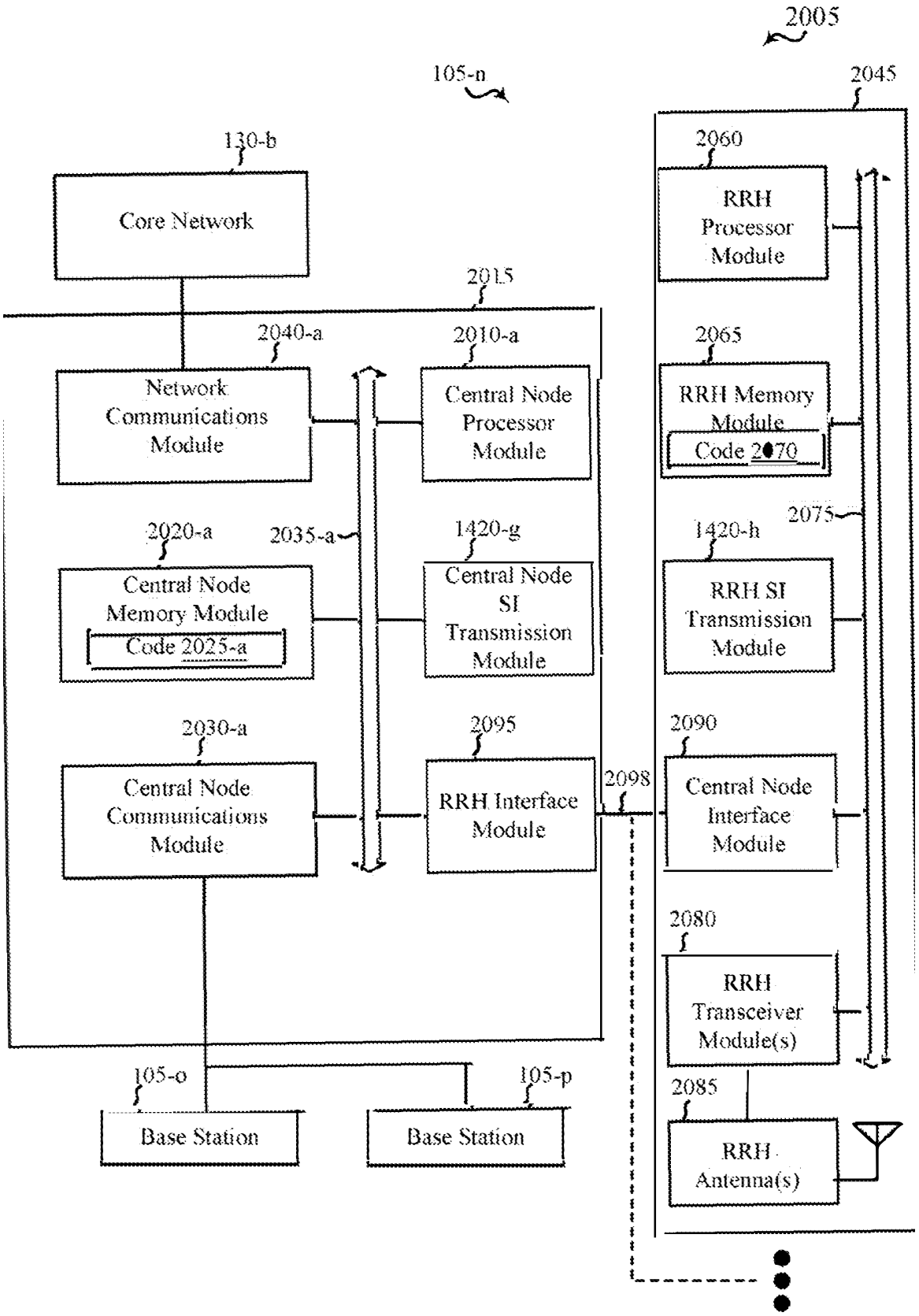
2005
105-n
2045
130-b
2060
Core Network
RRH Processor Module
2015
2040-a
2010-a
2065
Network Communications Module
Central Node Processor Module
RRH Memory Module
Code 2070
2075
2020-a
2035-a
1420-g
1420-h
Central Node Memory Module
Code 2025-a
Central Node SI Transmission Module
RRH SI Transmission Module
2030-a
2095
2090
2098
Central Node Communications Module
RRH Interface Module
Central Node Interface Module
2080
RRH Transceiver Module(s)
105-o
105-p
2085
Base Station
Base Station
RRH Antenna(s)

FIG. 20B

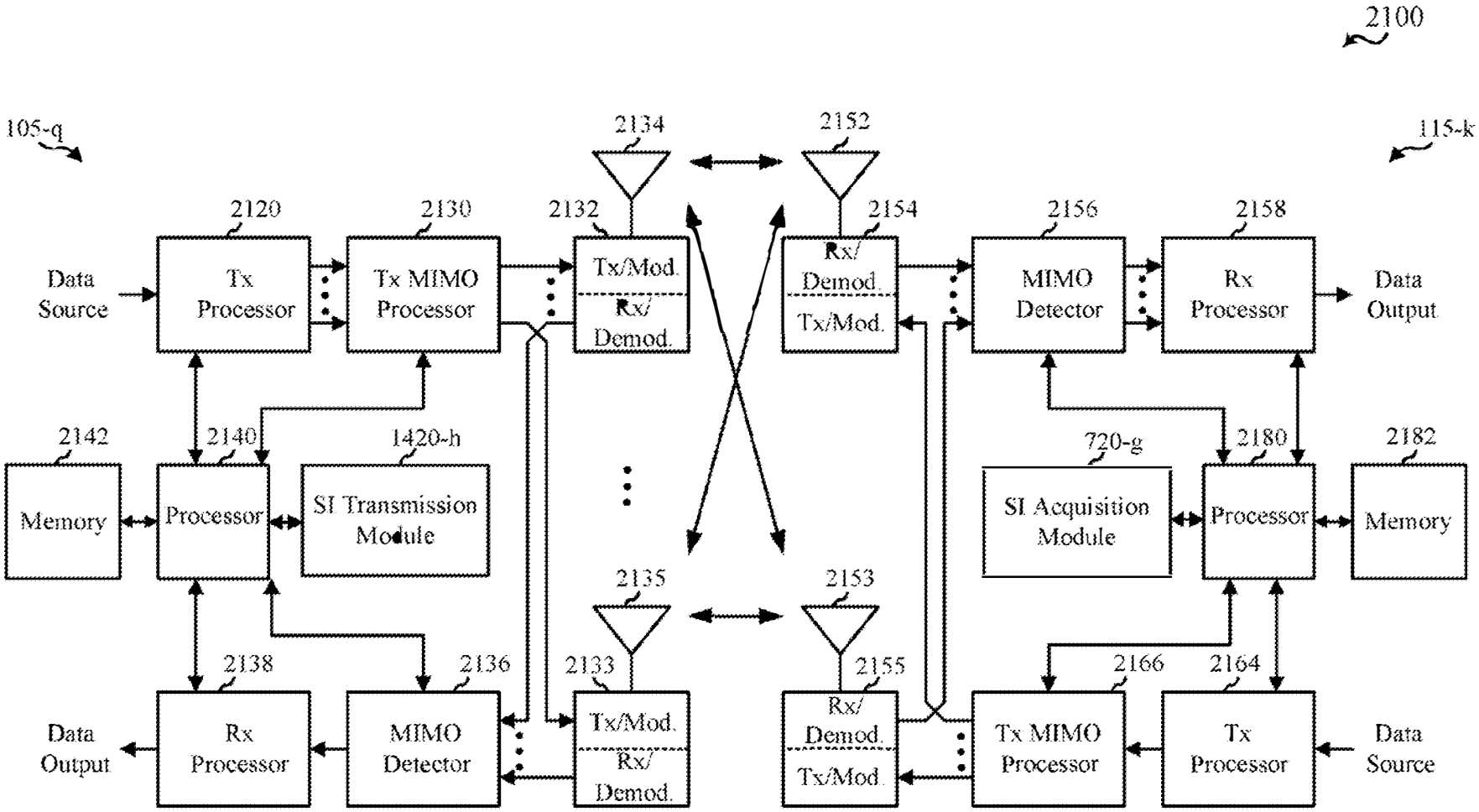
2100
105-q
115-k
2134
2152
2120
2130
2132
2154
2156
2158
Data Source
Tx Processor
Tx MIMO Processor
Tx/Mod.
Rx/ Demod.
Rx/ Demod.
Tx/Mod.
MIMO Detector
Rx Processor
Data Output
2142
2140
1420-h
720-g
2180
2182
Memory
Processor
SI Transmission Module
SI Acquisition Module
Processor
Memory
2135
2153
2138
2136
2133
2155
2166
2164
Data Output
Rx Processor
MIMO Detector
Tx/Mod.
Rx/ Demod.
Rx/ Demod.
Tx/Mod.
Tx MIMO Processor
Tx Processor
Data Source

FIG. 21

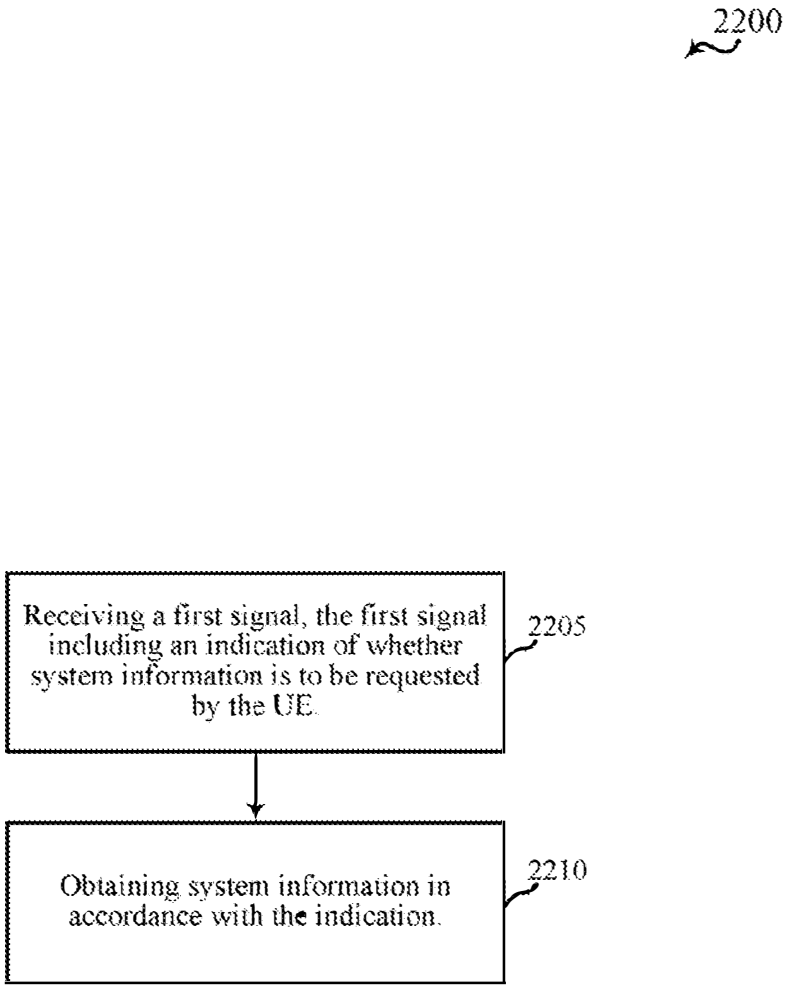
2200
Receiving a first signal, the first signal including an indication of whether system information is to be requested by the UE.
2205
Obtaining system information in accordance with the indication.
2210

FIG. 22

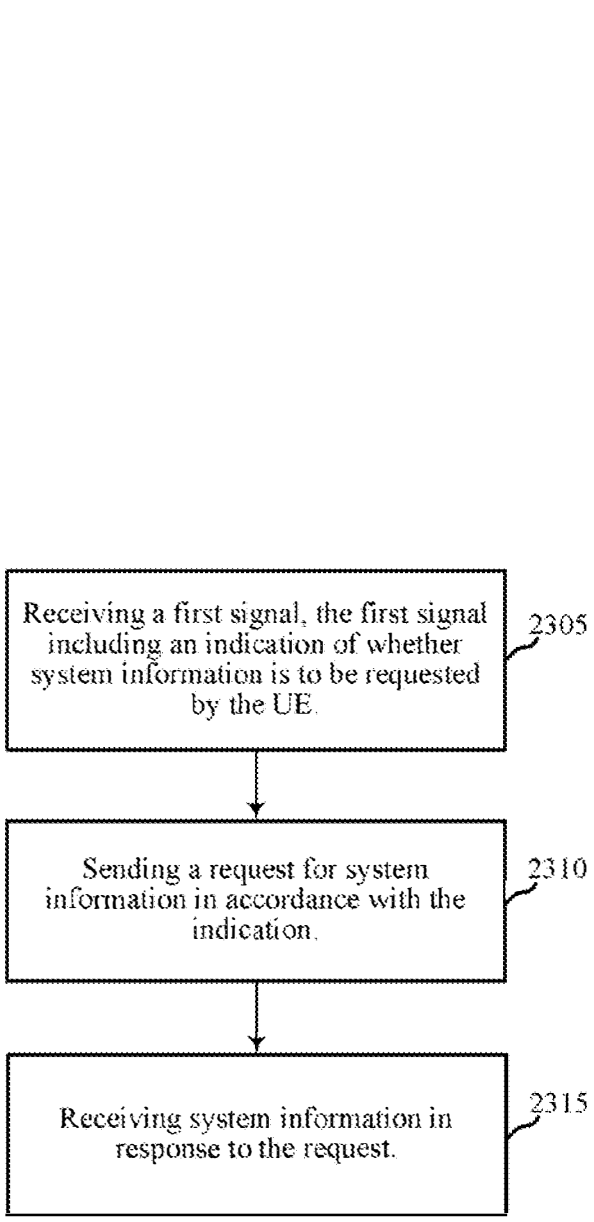
2300
Receiving a first signal, the first signal including an indication of whether system information is to be requested by the UE.
2305
Sending a request for system information in accordance with the indication.
2310
Receiving system information in response to the request.
2315

FIG. 23

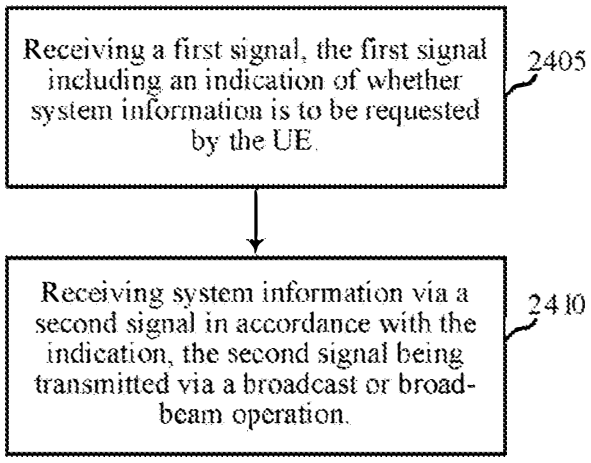
2400
Receiving a first signal, the first signal including an indication of whether system information is to be requested by the UE.
2405
Receiving system information via a second signal in accordance with the indication, the second signal being transmitted via a broadcast or broad-beam operation.
2410

FIG. 24

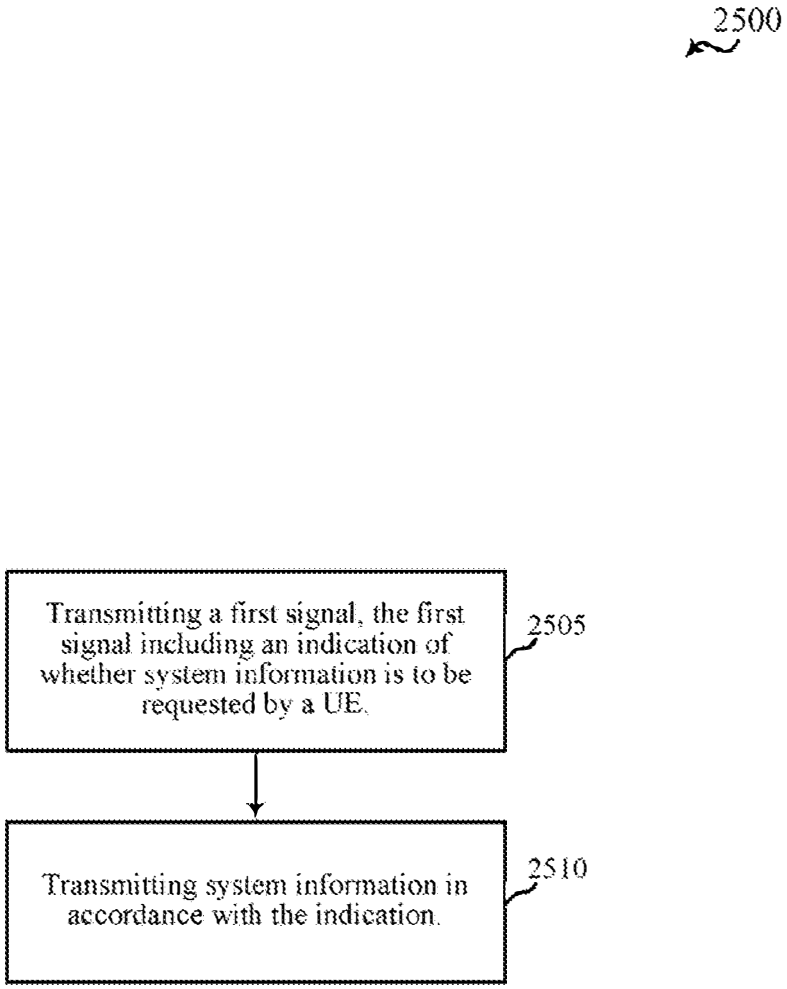
2500
Transmitting a first signal, the first signal including an indication of whether system information is to be requested by a UE.
2505
Transmitting system information in accordance with the indication.
2510

FIG. 25

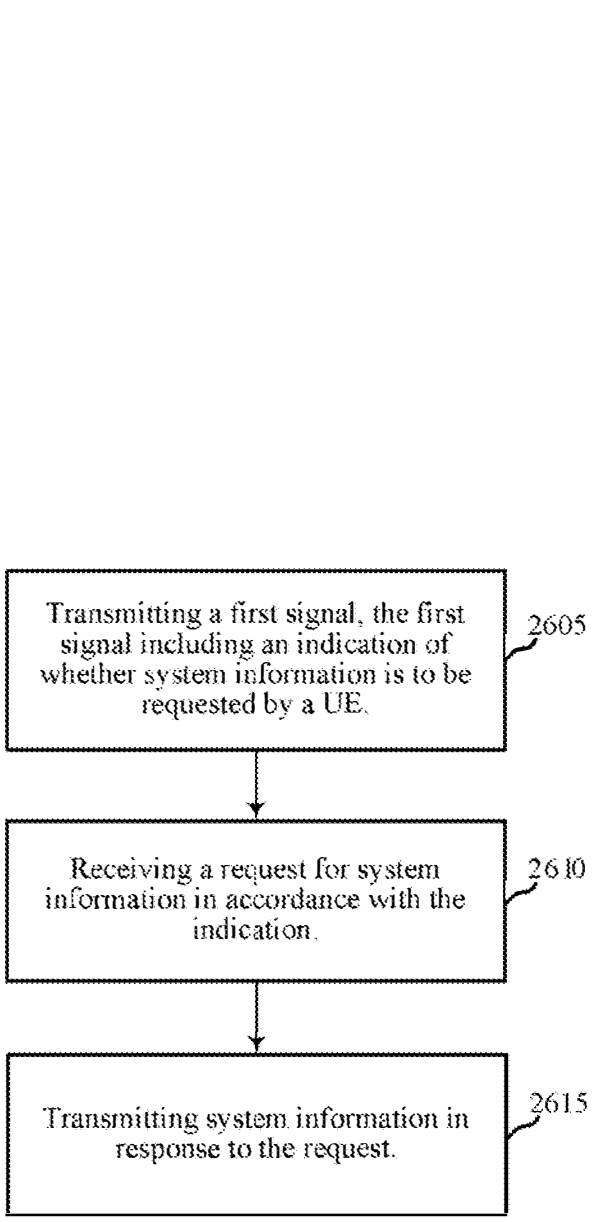
2600
Transmitting a first signal, the first signal including an indication of whether system information is to be requested by a UE.
2605
Receiving a request for system information in accordance with the indication.
2610
Transmitting system information in response to the request.
2615

FIG. 26

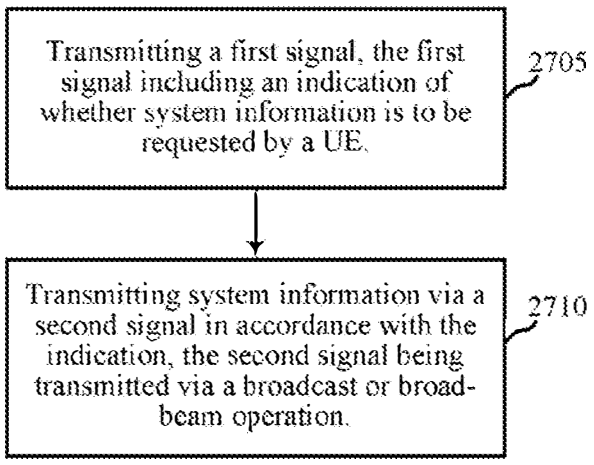
2700
Transmitting a first signal, the first signal including an indication of whether system information is to be requested by a UE.
2705
Transmitting system information via a second signal in accordance with the indication, the second signal being transmitted via a broadcast or broad-beam operation.
2710

FIG. 27

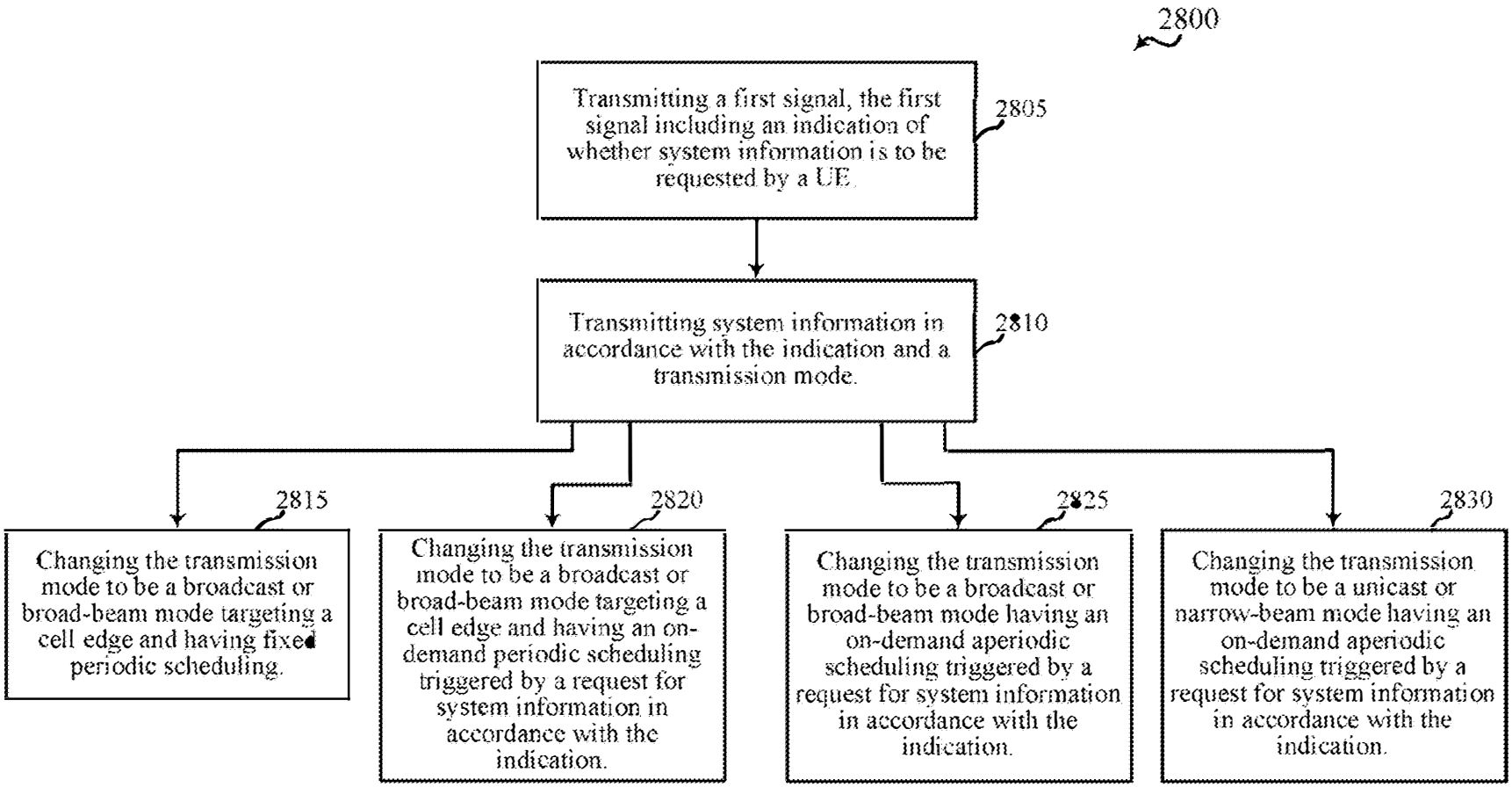
2800
Transmitting a first signal, the first signal including an indication of whether system information is to be requested by a UE.
2805
Transmitting system information in accordance with the indication and a transmission mode.
2810
2815
Changing the transmission mode to be a broadcast or broad-beam mode targeting a cell edge and having fixed periodic scheduling.
2820
Changing the transmission mode to be a broadcast or broad-beam mode targeting a cell edge and having an on-demand periodic scheduling triggered by a request for system information in accordance with the indication.
2825
Changing the transmission mode to be a broadcast or broad-beam mode having an on-demand aperiodic scheduling triggered by a request for system information in accordance with the indication.
2830
Changing the transmission mode to be a unicast or narrow-beam mode having an on-demand aperiodic scheduling triggered by a request for system information in accordance with the indication.

FIG. 28

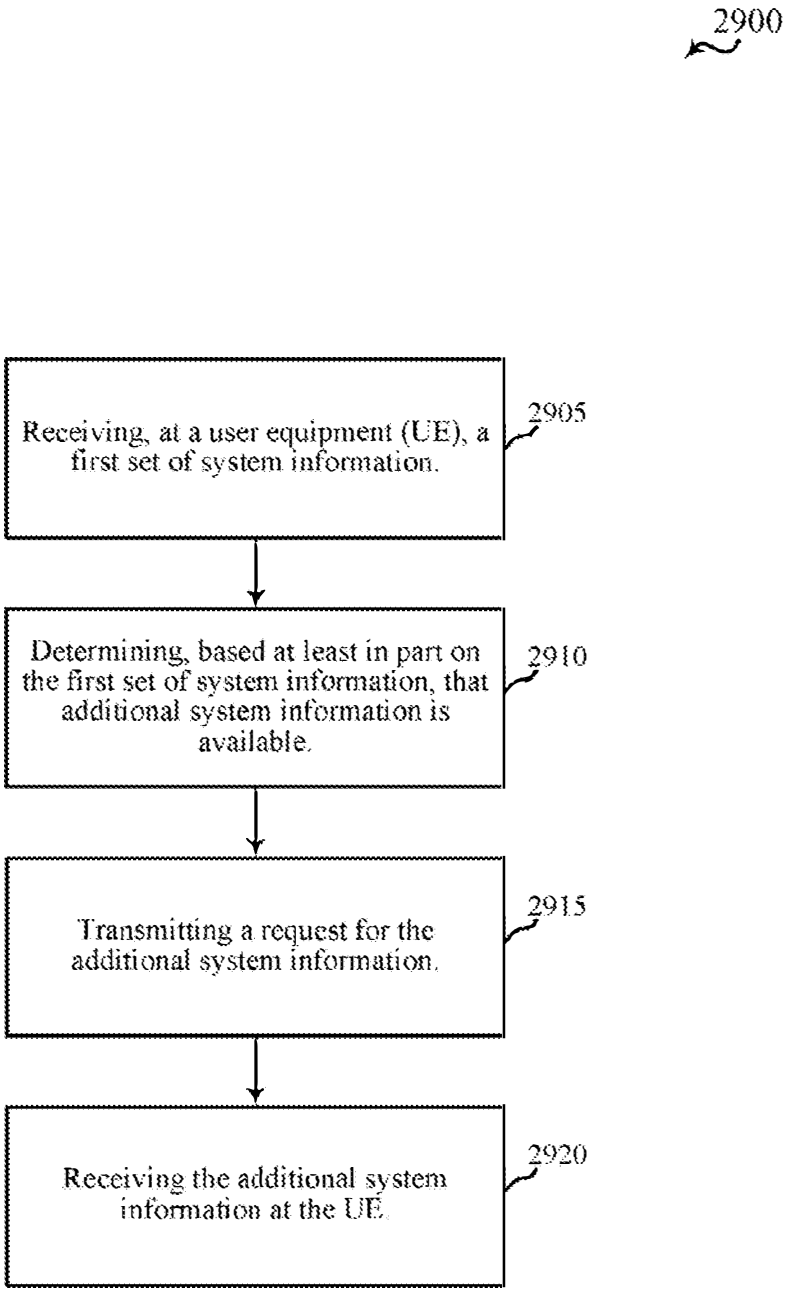
2900
Receiving, at a user equipment (UE), a first set of system information.
2905
Determining, based at least in part on the first set of system information, that additional system information is available.
2910
Transmitting a request for the additional system information.
2915
Receiving the additional system information at the UE.
2920

FIG. 29

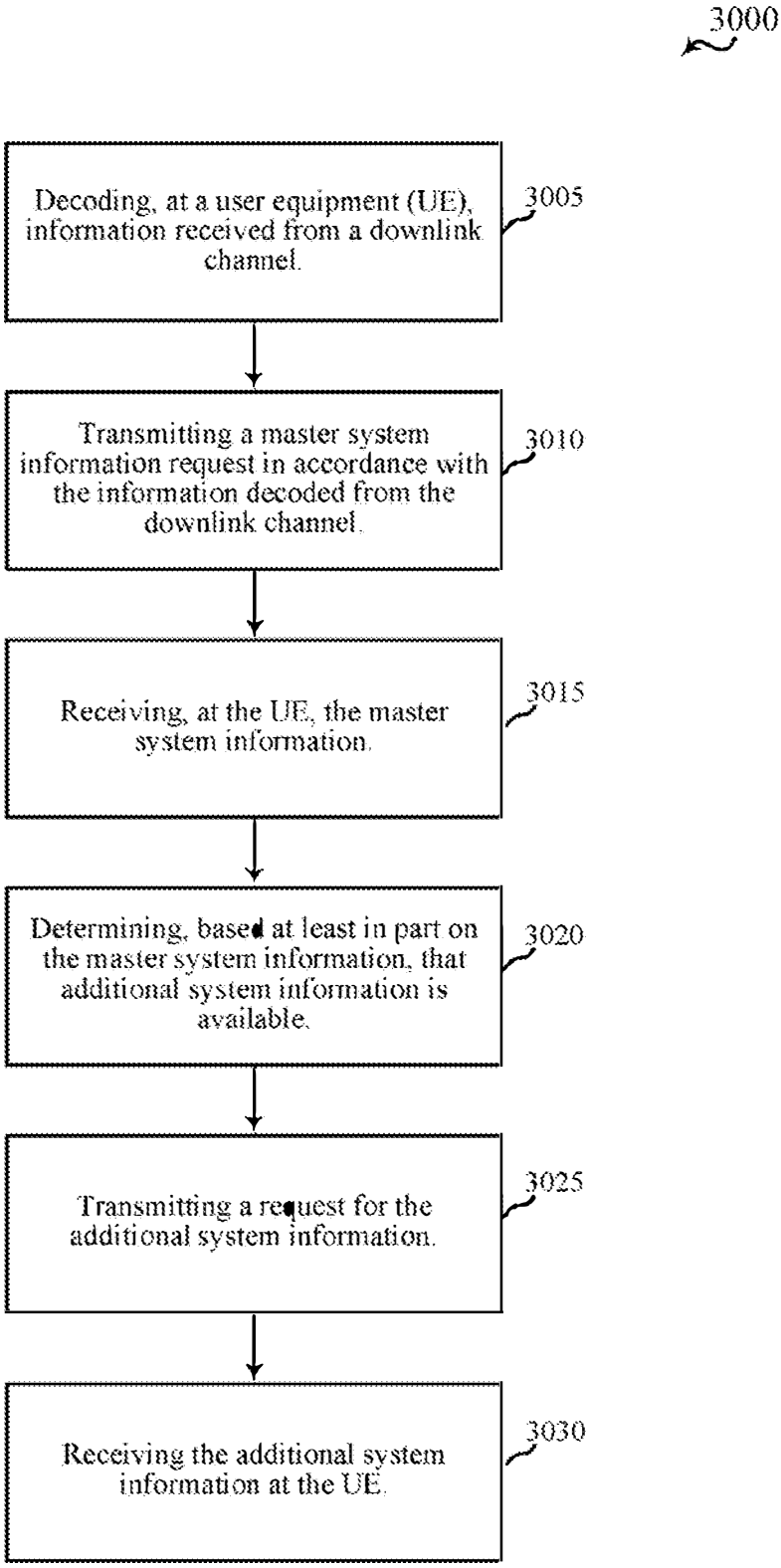
3000
Decoding, at a user equipment (UE), information received from a downlink channel.
3005
Transmitting a master system information request in accordance with the information decoded from the downlink channel.
3010
Receiving, at the UE, the master system information.
3015
Determining, based at least in part on the master system information, that additional system information is available.
3020
Transmitting a request for the additional system information.
3025
Receiving the additional system information at the UE.
3030

FIG. 30

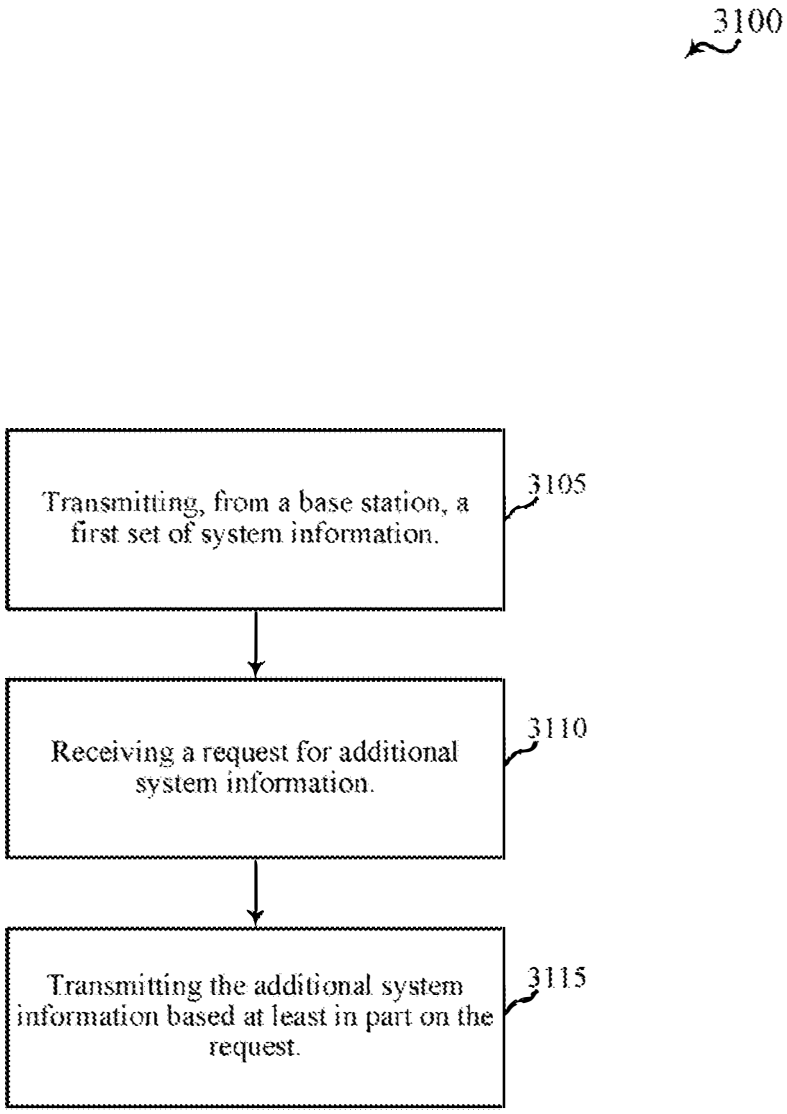
3100
Transmitting, from a base station, a first set of system information.
3105
Receiving a request for additional system information.
3110
Transmitting the additional system information based at least in part on the request.
3115

FIG. 31

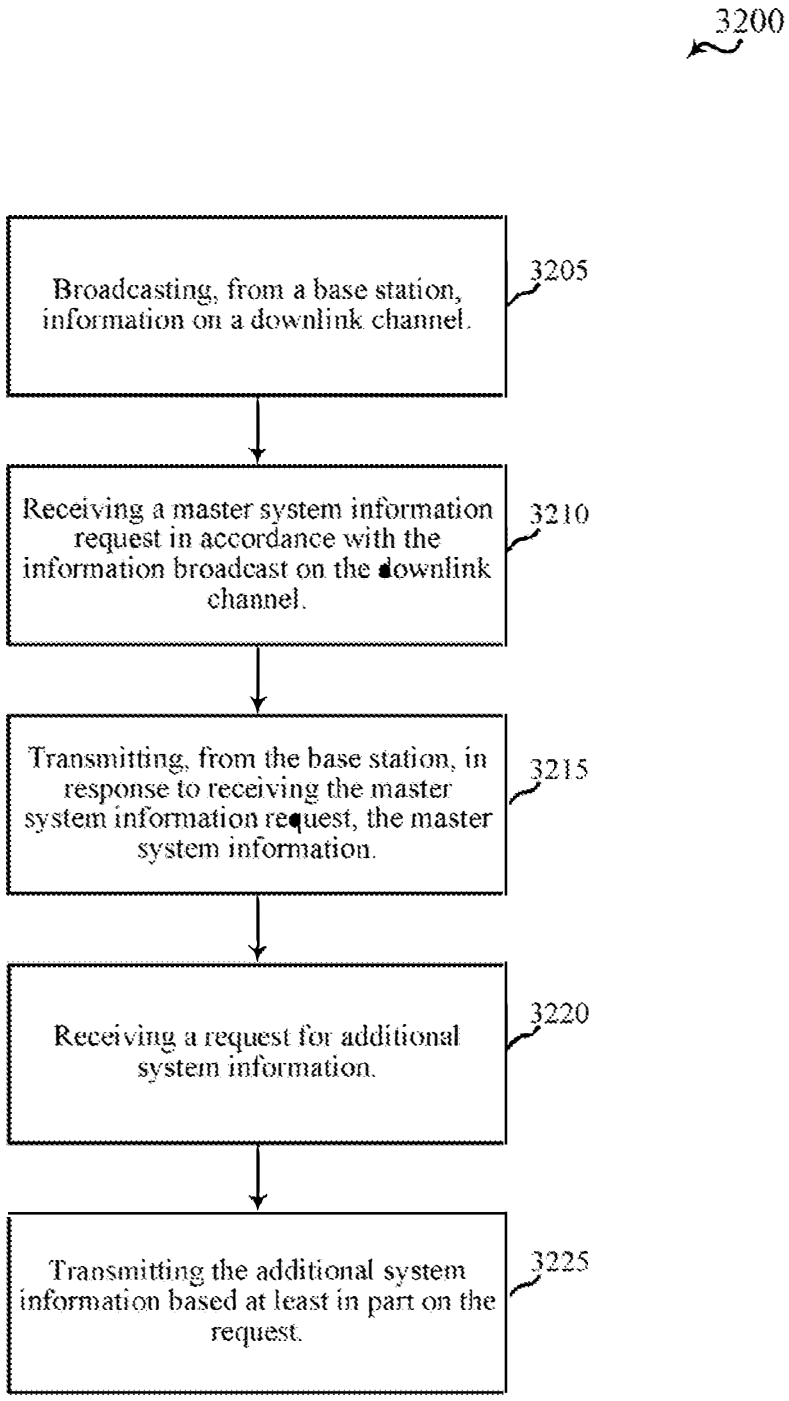
3200
Broadcasting, from a base station, information on a downlink channel.
3205
Receiving a master system information request in accordance with the information broadcast on the downlink channel.
3210
Transmitting, from the base station, in response to receiving the master system information request, the master system information.
3215
Receiving a request for additional system information.
3220
Transmitting the additional system information based at least in part on the request.
3225

FIG. 32

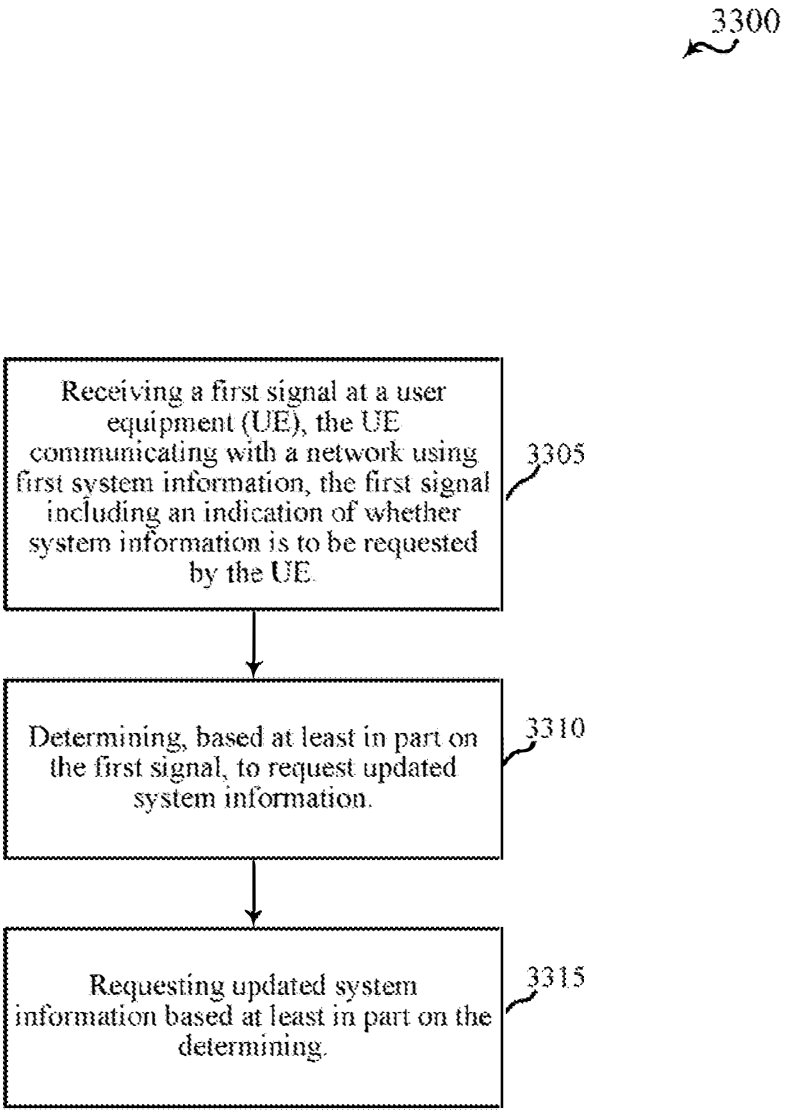
3300
Receiving a first signal at a user equipment (UE), the UE communicating with a network using first system information, the first signal including an indication of whether system information is to be requested by the UE.
3305
Determining, based at least in part on the first signal, to request updated system information.
3310
Requesting updated system information based at least in part on the determining.
3315

FIG. 33

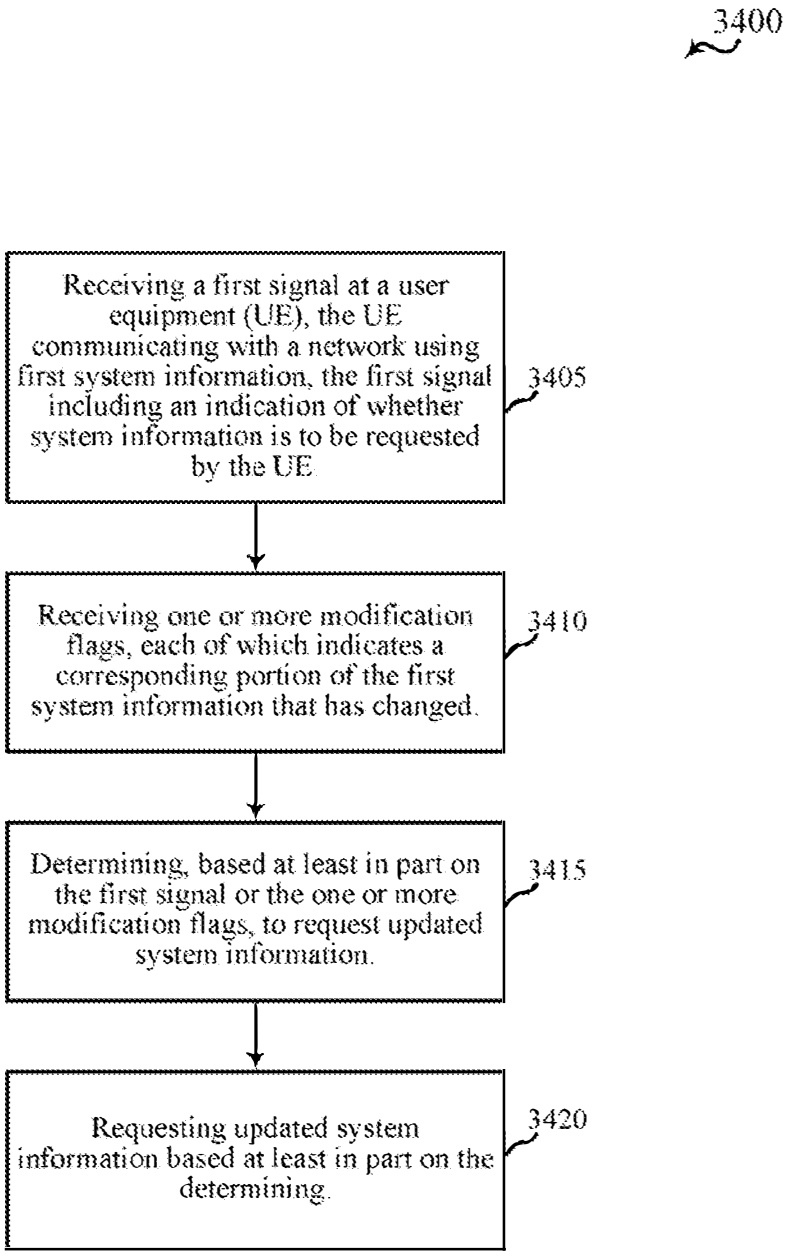
3400
Receiving a first signal at a user equipment (UE), the UE communicating with a network using first system information, the first signal including an indication of whether system information is to be requested by the UE
3405
Receiving one or more modification flags, each of which indicates a corresponding portion of the first system information that has changed.
3410
Determining, based at least in part on the first signal or the one or more modification flags, to request updated system information.
3415
Requesting updated system information based at least in part on the determining.
3420

FIG. 34

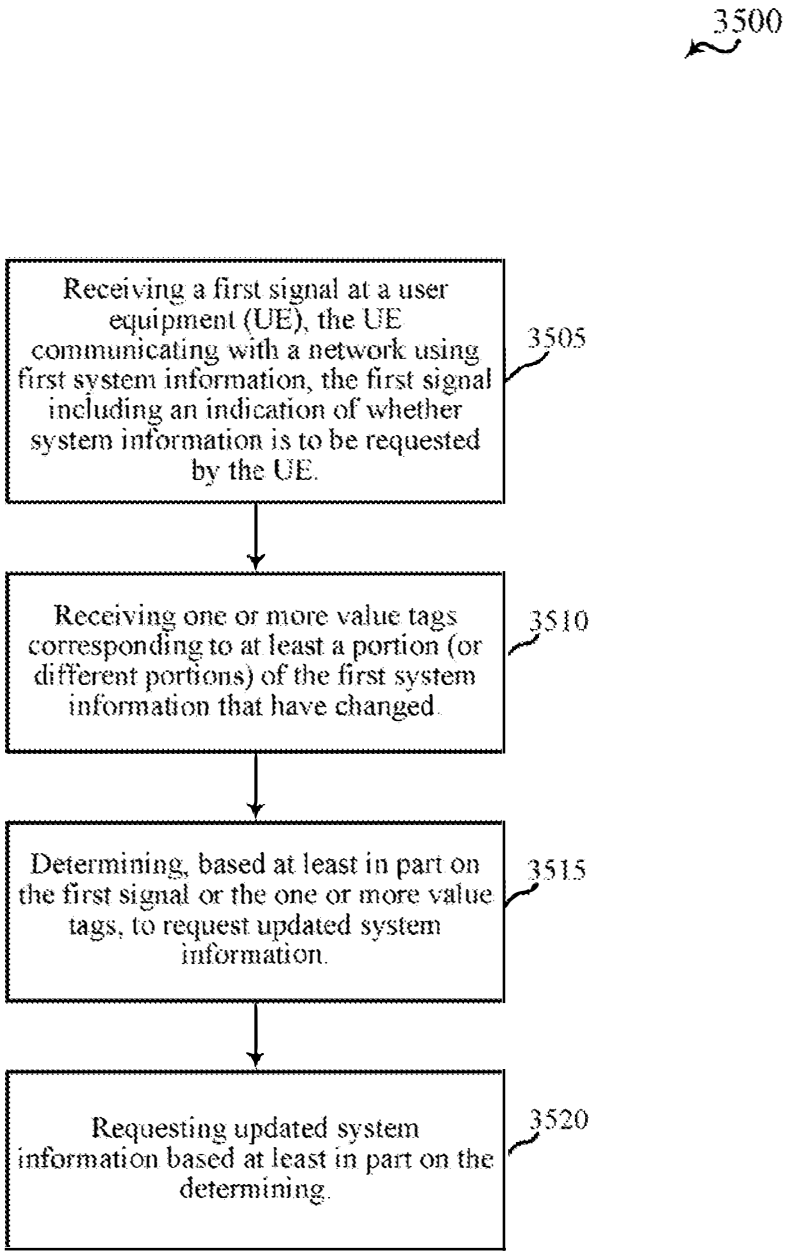
3500
Receiving a first signal at a user equipment (UE), the UE communicating with a network using first system information, the first signal including an indication of whether system information is to be requested by the UE.
3505
Receiving one or more value tags corresponding to at least a portion (or different portions) of the first system information that have changed.
3510
Determining, based at least in part on the first signal or the one or more value tags, to request updated system information.
3515
Requesting updated system information based at least in part on the determining.
3520

FIG. 35

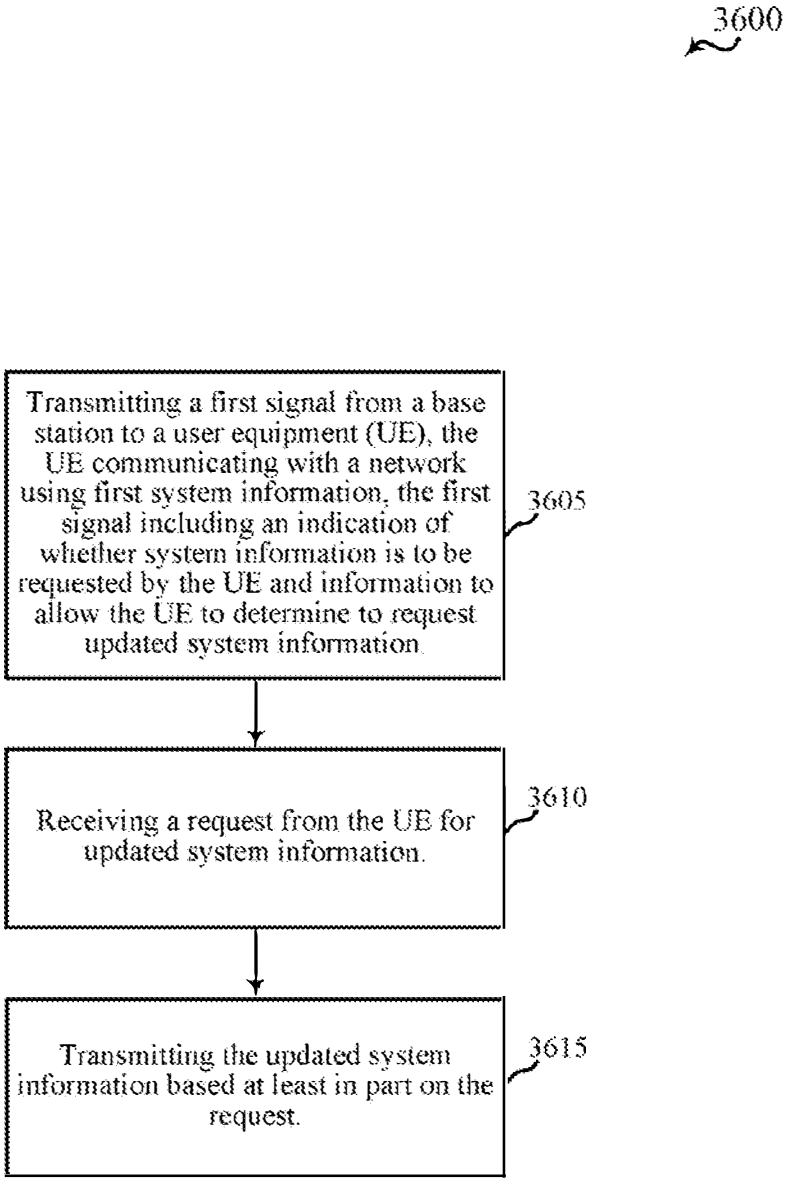
3600
Transmitting a first signal from a base station to a user equipment (UE), the UE communicating with a network using first system information, the first signal including an indication of whether system information is to be requested by the UE and information to allow the UE to determine to request updated system information.
3605
Receiving a request from the UE for updated system information.
3610
Transmitting the updated system information based at least in part on the request.
3615

FIG. 36

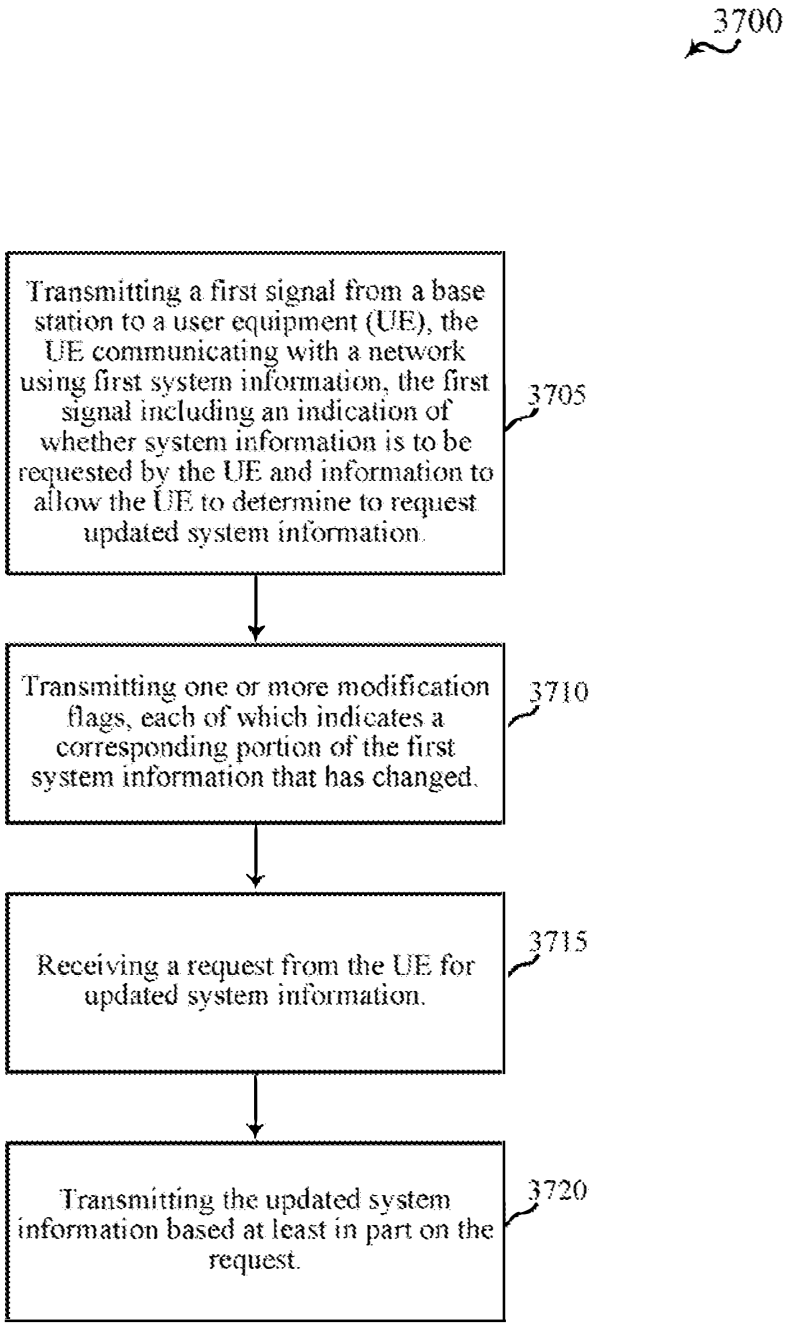
3700
Transmitting a first signal from a base station to a user equipment (UE), the UE communicating with a network using first system information, the first signal including an indication of whether system information is to be requested by the UE and information to allow the UE to determine to request updated system information.
3705
Transmitting one or more modification flags, each of which indicates a corresponding portion of the first system information that has changed.
3710
Receiving a request from the UE for updated system information.
3715
Transmitting the updated system information based at least in part on the request.
3720

FIG. 37

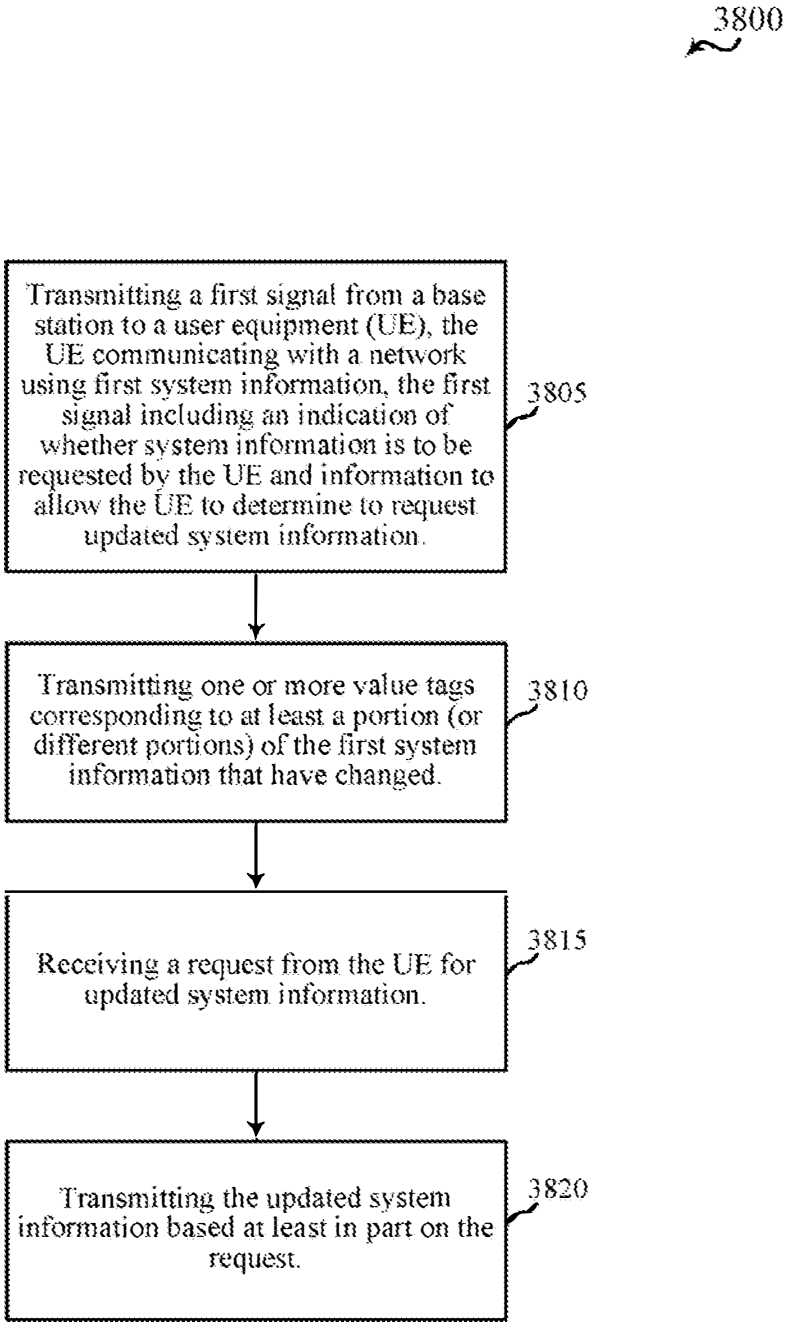
3800
Transmitting a first signal from a base station to a user equipment (UE), the UE communicating with a network using first system information, the first signal including an indication of whether system information is to be requested by the UE and information to allow the UE to determine to request updated system information.
3805
Transmitting one or more value tags corresponding to at least a portion (or different portions) of the first system information that have changed.
3810
Receiving a request from the UE for updated system information.
3815
Transmitting the updated system information based at least in part on the request.
3820

FIG. 38

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/015993

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/14
ADD.

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 2014/070048 A1 (ERICSSON TELEFON AB L M [SE]) 8 May 2014 (2014-05-08) abstract page 10, lines 16-30;page 11, line 14 - page 12, lines 30; page 14, lines 4-14; page 15, lines 27-30; page 16, lines 15-21; claims 1,3,4; figures 2A,2B --- -/--	1-56

[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
18 May 2016	25/05/2016

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	Delucchi, Cecilia

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/015993

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 323 426 A1 (HUAWEI TECH CO LTD [CN]) 18 May 2011 (2011-05-18)	1,2, 11-14, 19,20, 29-32, 37,38, 40,41, 48,49,56
A	abstract paragraphs [0021] - [0022], [0036] - [0040], [0084] - [0085], [0090] - [0091]; claims 1,4-6	3-10, 21-28, 33-36, 42-47, 50-55
A	US 2008/212522 A1 (KO MIN-SUK [KR] ET AL) 4 September 2008 (2008-09-04) abstract paragraphs [0006] - [0012], [0034], [0044]; claims 1,2,3	1-56
A	WO 2013/068368 A1 (KONINKL KPN NV [NL]; TNO [NL]) 16 May 2013 (2013-05-16) page 2, line 18 - page 3, line 9; page 20, lines 9-12	1-56
A	WO 2014/014317 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 23 January 2014 (2014-01-23) abstract paragraphs [0028] - [0030], [0044], [0039], [0044]	1-56
A	US 2011/096697 A1 (ANANTHARAMAN KARTHIK [US] ET AL) 28 April 2011 (2011-04-28) abstract paragraphs [0028] - [0031]; claim 12; figure 3	1-56

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/015993

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014070048 A1	08-05-2014	EP 2912891 A1	02-09-2015
		US 2015256995 A1	10-09-2015
		WO 2014070048 A1	08-05-2014
EP 2323426 A1	18-05-2011	CN 101686580 A	31-03-2010
		EP 2323426 A1	18-05-2011
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		CN 101542915 A	23-09-2009
		EP 2087599 A1	12-08-2009
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WO 2013068368 A1	16-05-2013	CN 103931239 A	16-07-2014
		EP 2777329 A1	17-09-2014
		WO 2013068368 A1	16-05-2013
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		WO 2014014317 A1	23-01-2014
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		US 2011096697 A1	28-04-2011
		WO 2011056677 A2	12-05-2011

Form PCT/ISA/210 (patent family annex) (April 2005)

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(19) 世界知的所有権機関
国際事務局

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2015 年 4 月 2 日(02.04.2015)

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H04W 72/04 (2009.01) *H04W 16/28* (2009.01)

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(30) 優先権データ:
特願 2013-197005 2013 年 9 月 24 日(24.09.2013) JP

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(74) 代理人: 亀谷 美明, 外 (KAMEYA, Yoshiaki et al.); 〒1600004 東京都新宿区四谷 3 － 1 － 3 第一冨澤ビル はづき国際特許事務所 四谷オフィス Tokyo (JP).

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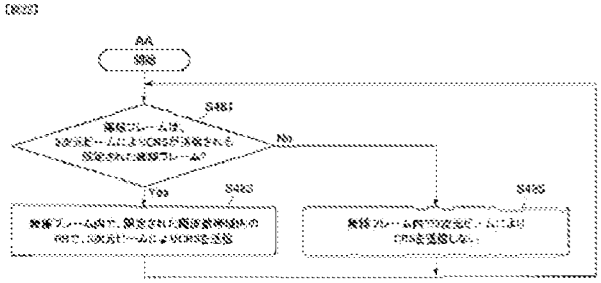
添付公開書類:

— 国際調査報告 (条約第 21 条(3))

(54) **Title**: COMMUNICATION CONTROL DEVICE, COMMUNICATION CONTROL METHOD, TERMINAL DEVICE, AND INFORMATION PROCESSING DEVICE

(54) 発明の名称 : 通信制御装置、通信制御方法、端末装置及び情報処理装置



AA ... START
S481 ... IS THE WIRELESS FRAME A SPECIFIC WIRELESS FRAME IN WHICH A CRS IS TO BE TRANSMITTED VIA A 3D BEAM?
S483 ... TRANSMIT A CRS VIA A 3D BEAM USING AN RB IN A SPECIFIC FREQUENCY BAND OF THE WIRELESS FRAME
S485 ... DO NOT TRANSMIT A CRS VIA A 3D BEAM IN THIS WIRELESS FRAME

(57) **Abstract**: [Problem] To make it possible to keep interference from increasing while reducing the load associated with beamforming. [Solution] This invention provides a communication control device provided with the following: an acquisition unit that acquires cell-identifying information allocated to an individual 3D beam formed by a directional antenna that is capable of forming 3D beams; and a control unit that that, on the basis of said cell-identifying information, controls the transmission of a reference signal via the aforementioned individual 3D beam. The control unit controls said transmission such that the reference signal is transmitted using a specific resource block from the set of available resource blocks.

(57) 要約:

[続葉有]

WO 2015/045658 A1

【課題】ビームフォーミングに関連する負荷を軽減しつつ干渉の増加を抑えることを可能にする。【解決手段】３次元ビームを形成可能な指向性アンテナにより形成される個別の３次元ビームに割り当てられるセル識別情報を取得する取得部と、　上記セル識別情報に基づいて、上記個別の３次元ビームによるリファレンス信号の送信を制御する制御部と、を備える通信制御装置が提供される。上記制御部は、使用可能なリソースブロックのうちの限定されたリソースブロックで上記リファレンス信号が送信されるように、上記送信を制御する。

明 細 書

発明の名称 :

通信制御装置、通信制御方法、端末装置及び情報処理装置

技術分野

[0001] 本開示は、通信制御装置、通信制御方法、端末装置及び情報処理装置に関する。

[0002] 近年、複数のアンテナ素子を有する基地局が当該複数のアンテナ素子を使用して端末装置へのビームを形成するビームフォーミングという技術が広く知られている。例えば、ＬＴＥ(Long Term Evolution)のリリース１０では、基地局が８本のアンテナを搭載することが規格化されている。

[0003] ビームフォーミングでは、各アンテナ素子の信号に重み係数を乗算することにより、所望の方向へのビームが形成される。例えば、ＬＴＥにおいて、端末装置が、基地局により送信されるリファレンス信号の受信に応じて、コードブックに含まれる重み係数のセット（即ち、プリコーディング行列）のうちの推奨セットを選択し、基地局に通知する。あるいは、基地局が、端末装置により送信されるリファレンス信号の受信に応じて、重み係数のセットを算出する。

[0004] 例えば、特許文献１には、端末装置が、コードブックに含まれる重み係数のセットの中から望ましいセットを選択し、当該望ましいセットを基地局にフィードバックすることにより、重み係数のセットを柔軟に決定することを可能にする技術が、開示されている。

先行技術文献

特許文献

[0005] 特許文献1：特表２０１０－５３７５９５号公報

発明の概要

発明が解決しようとする課題

[0006] しかし、上記特許文献１に開示されている技術を含む従来の技術では、基

地局が有するアンテナ素子の数の増加に伴い、ビームフォーミングに関連する負荷も増大し得る。例えば、アンテナ素子の数の増加に伴い、重み係数の数も増加するので、重み係数のセットを算出するための処理が増大する。

[0007] 上記負荷の増大を抑えるために、個別のビームにセルＩＤを割り当てることにより、ビームに対応する通信領域（即ち、ビームが届く領域）を仮想的なセルとして扱うことも、考えられる。しかし、セルごとに送信されるＣＲＳ（Cell-Specific Reference Signal）についてのリソース割当てパターン（即ち、リソースブロック内におけるＣＲＳへのリソースエレメントの割当てのパターン）の数は限られているので、ＣＲＳ間での干渉が発生し得る。一例として、ビームにより送信されるＣＲＳと隣接セルで送信されるＣＲＳとの干渉が生じ得る。

[0008] そこで、ビームフォーミングに関連する負荷を軽減しつつ干渉の増加を抑えることを可能にする仕組みが提供されることが望ましい。

課題を解決するための手段

[0009] 本開示によれば、３次元ビームを形成可能な指向性アンテナにより形成される個別の３次元ビームに割り当てられるセル識別情報を取得する取得部と、

上記セル識別情報に基づいて、上記個別の３次元ビームによるリファレンス信号の送信を制御する制御部と、を備える通信制御装置が提供される。上記制御部は、使用可能なリソースブロックのうちの限定されたリソースブロックで上記リファレンス信号が送信されるように、上記送信を制御する。

[0010] また、本開示によれば、３次元ビームを形成可能な指向性アンテナにより形成される個別の３次元ビームに割り当てられるセル識別情報を取得することと、上記セル識別情報に基づいて、上記個別の３次元ビームによるリファレンス信号の送信をプロセッサにより制御することと、を含む通信制御方法が提供される。上記リファレンス信号は、使用可能なリソースブロックのうちの限定されたリソースブロックで送信される。

[0011] また、本開示によれば、３次元ビームを形成可能な指向性アンテナにより

形成される個別の３次元ビームに割り当てられるセル識別情報に基づいて上記個別の３次元ビームによるリファレンス信号の送信を制御する基地局により、使用可能なリソースブロックのうちの上記リファレンス信号が送信される限定されたリソースブロックを特定するための情報が送信されると、当該情報を取得する取得部と、上記限定されたリソースブロックで送信される上記リファレンス信号についての測定を行う通信制御部と、を備える端末装置が提供される。

[0012] また、本開示によれば、３次元ビームを形成可能な指向性アンテナにより形成される個別の３次元ビームに割り当てられるセル識別情報に基づいて上記個別の３次元ビームによるリファレンス信号の送信を制御する基地局により、使用可能なリソースブロックのうちの上記リファレンス信号が送信される限定されたリソースブロックを特定するための情報が送信されると、当該情報を取得することと、上記限定されたリソースブロックで送信される上記リファレンス信号についての測定をプロセッサにより行うことと、を含む通信制御方法が提供される。

[0013] また、本開示によれば、プログラムを記憶するメモリと、上記プログラムを実行可能な１つ以上のプロセッサと、を備える情報処理装置が提供される。上記プログラムは、３次元ビームを形成可能な指向性アンテナにより形成される個別の３次元ビームに割り当てられるセル識別情報に基づいて上記個別の３次元ビームによるリファレンス信号の送信を制御する基地局により、使用可能なリソースブロックのうちの上記リファレンス信号が送信される限定されたリソースブロックを特定するための情報が送信されると、当該情報を取得することと、上記限定されたリソースブロックで送信される上記リファレンス信号についての測定を行うことと、を実行させるためのプログラムである。

発明の効果

[0014] 以上説明したように本開示によれば、ビームフォーミングに関連する負荷を軽減しつつ干渉の増加を抑えることが可能となる。なお、上記の効果は必

ずしも限定的なものではなく、上記効果とともに、又は上記効果に代えて、本明細書に示されたいずれかの効果、又は本明細書から把握され得る他の効果が奏されてもよい。

図面の簡単な説明

[0015] [図1]各アンテナ素子の位置とビームの３次元方向との関係を説明するための説明図である。

[図2]ビームフォーミングのための重み係数の利用手法の一例を説明するための説明図である。

[図3]セクタアンテナにより形成されるセルの一例を説明するための説明図である。

[図4]ビームによるゲインの向上の例を説明するための説明図である。

[図5]アンテナ素子数とアンテナゲインのピークとの関係の例を説明するための説明図である。

[図6]ＣＲＳについてのリソース割当てパターンの第１の例を説明するための説明図である。

[図7]ＣＲＳについてのリソース割当てパターンの第２の例を説明するための説明図である。

[図8]３次元ビームにより信号が送信されない場合のセルを説明するための説明図である。

[図9]３次元ビームにより信号が送信される場合のセルを説明するための説明図である。

[図10]本開示の実施形態に係る通信システムの概略的な構成の一例を示す説明図である。

[図11]基地局により形成される３次元ビームの例を説明するための説明図である。

[図12]３次元ビームによる信号の送受信の例を説明するための説明図である。

[図13]本開示の実施形態に係る基地局の構成の一例を示すブロック図である

。

[図14]３次元ビームによりＣＲＳが送信される無線フレームの例を説明するための説明図である。

[図15]３次元ビームによりＣＲＳが送信される周波数帯域の例を説明するための説明図である。

[図16]本開示の実施形態に係る端末装置の構成の一例を示すブロック図である。

[図17]、本開示の実施形態に係る基地局側の第１の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図18]、本開示の実施形態に係る基地局側の第２の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図19]、本開示の実施形態に係る基地局側の第３の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図20]、本開示の実施形態に係る基地局側の第４の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図21]、本開示の実施形態に係る基地局側の第５の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図22]、本開示の実施形態に係る基地局側の第６の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図23]、本開示の実施形態に係る端末装置側の通信制御処理の概略的な流れの一例を示すフローチャートである。

[図24]本開示に係る技術が適用され得るｅＮＢの概略的な構成の第１の例を示すブロック図である。

[図25]本開示に係る技術が適用され得るｅＮＢの概略的な構成の第２の例を示すブロック図である。

[図26]本開示に係る技術が適用され得るスマートフォンの概略的な構成の一例を示すブロック図である。

[図27]本開示に係る技術が適用され得るカーナビゲーション装置の概略的な

構成の一例を示すブロック図である。

発明を実施するための形態

[0016] 以下に添付の図面を参照しながら、本開示の好適な実施の形態について詳細に説明する。なお、本明細書及び図面において、実質的に同一の機能構成を有する要素については、同一の符号を付することにより重複説明を省略する。

[0017] また、本明細書及び図面において、実質的に同一の機能構成を有する要素を、同一の符号の後に異なるアルファベットを付して区別する場合もある。例えば、実質的に同一の機能構成を有する複数の要素を、必要に応じて端末装置２００Ａ、２００Ｂ及び２００Ｃのように区別する。ただし、実質的に同一の機能構成を有する複数の要素の各々を特に区別する必要がない場合、同一符号のみを付する。例えば、端末装置２００Ａ、２００Ｂ及び２００Ｃを特に区別する必要が無い場合には、単に端末装置２００と称する。

[0018] なお、説明は以下の順序で行うものとする。

１．はじめに

２．通信システムの概略的な構成

３．基地局の構成

４．端末装置の構成

５．処理の流れ

６．応用例

６．１．基地局に関する応用例

６．２．端末装置に関する応用例

７．まとめ

[0019] ＜＜１．はじめに＞＞

まず、図１～図９を参照して、ビームフォーミングに関する動向、ビームフォーミングに関するいくつかの考察、及びビームフォーミングに関する課題を説明する。

[0020] （ビームフォーミングに関する動向）

近年の移動体データ通信端末の普及により、爆発的に増加するトラフィックへの対応が急務となっている。そのため、３ＧＰＰ（Third Generation Partnership Project）では、ＭＵ－ＭＩＭＯ（Multi-User Multiple-Input and Multiple-Output）、ＣｏＭＰ（Coordinated Multipoint transmission/reception）等の、通信容量を増加させるための技術が検討されている。

[0021] ＬＴＥのリリース１０では、基地局が８本のアンテナを搭載することが規格化されている。よって、当該アンテナによれば、ＳＵ－ＭＩＭＯ（Single-User Multiple-Input and Multiple-Output）の場合に８レイヤのＭＩＭＯを実現することができる。８レイヤのＭＩＭＯとは、独立な８つのストリームを空間的に多重する技術である。また、４ユーザに２レイヤのＭＵ－ＭＩＭＯを実現することもできる。

[0022] 端末装置ではアンテナの配置のためのスペースが小さいこと、及び端末装置の処理能力には限界があることに起因して、端末装置のアンテナを増やすことは難しい。しかし、近年のアンテナ実装技術の進歩により、基地局に１００本程度のアンテナを配置することは不可能ではなくなってきている。

[0023] このように１００本程度のアンテナを基地局が備えることにより、アンテナにより形成されるビームの半値幅（－３ｄＢのアンテナゲインを伴う角度）は、狭くなることが予想される。即ち、鋭いビームを形成することが可能になることが予想される。さらに、アンテナ素子を平面に配置することにより、所望の３次元方向へのビームを形成することが可能になる。このような３次元方向へのビームで、基地局よりも高い位置にある特定のビルに向けて信号を送信することが、提案されている。

[0024] また、アンテナ本数が増えるので、ＭＵ－ＭＩＭＯでのユーザ数を増やすことが可能になる。端末装置のアンテナ数が２本である場合には、１つの端末装置についての空間的に独立したストリームの数は２本であるので、１つの端末装置についてのストリーム数を増やすよりも、ＭＵ－ＭＩＭＯのユーザ数を増やす方が合理的である。以上の様な理由でＬＴＥのダウンリンクに

おけるビームフォーミングの高度化が期待されている。

[0025] アンテナ本数が多くなるほど鋭いビームが形成でき、多くのセクタを形成できることので、基地局当たりのユーザの多重数を多くできる。

[0026] （３次元ビームフォーミングの重み係数の算出手法）

ビームフォーミングのための各アンテナ素子の重み係数は、複素数として表される。この点について図１を参照して具体的に説明する。

[0027] 図１は、各アンテナ素子の位置とビームの３次元方向との関係を説明するための説明図である。図１を参照すると、格子状に配置されたアンテナ素子が示されている。また、アンテナ素子が配置された平面上の直行する２つの軸ｘ、ｙ、及び、当該平面に直行する１つの軸ｚも示されている。ここで、形成すべきビームの方向は、例えば、角度phi（ギリシャ文字）及び角度theta（ギリシャ文字）で表される。角度phi（ギリシャ文字）は、ビーム方向のうちのｘｙ平面の成分とｘ軸とのなす角度である。また、角度theta（ギリシャ文字）は、ビーム方向とｚ軸とのなす角度である。この場合に、例えば、ｘ軸方向においてｍ番目に配置され、ｙ軸方向においてｎ番目に配置されるアンテナ素子の重み係数$V_{m,n}$は、以下のように表され得る。

[0028] [数1]

$$V_{m,n}(\theta,\varphi,f) = exp\left(j2\pi f/c\left\{(m-1)d_x\sin(\theta)cos(\varphi) + (n-1)d_y\sin(\theta)sin(\varphi)\right\}\right)$$

[0029] ｆは周波数であり、ｃは光速である。また、ｊは複素数における虚数単位である。また、d_xは、ｘ軸方向におけるアンテナ素子の間隔であり、d_yは、ｙ軸方向におけるアンテナ素子間の間隔である。なお、アンテナ素子の座標は、以下のように表される。

[0030] [数2]

$$x = (m-1)d_x,\quad y = (n-1)d_y$$

[0031] 所望の３次元方向が決定されると、当該方向及び周波数ｆに基づいて、各アンテナ素子の重み係数を上述した式により求めることができる。このよう

な重み係数は例えば図２に示されるように用いられる。

[0032] 図２は、ビームフォーミングのための重み係数の利用手法の一例を説明するための説明図である。図２を参照すると、各アンテナ素子７１に対応する送信信号７３には、各アンテナ素子７１の重み係数７５が複素乗算される。そして、重み係数７５が複素乗算された当該送信信号が、アンテナ素子７１から送信される。例えば、重み係数７５の複素乗算は、デジタル信号に対して行われる。

[0033] 重み係数の算出の手法の一例を説明したが、重み係数の算出手法はこれに限られない。様々な算出手法が適用され得る。

[0034] （ＬＴＥにおけるビームフォーミング）

ＬＴＥにおけるビームフォーミングは、コードブックに基づくプリコーディングを使用する方式と、コードブックに基づかないプリコーディングを使用する方式とに大別される。また、コードブックに基づくプリコーディングを使用する方式には、閉ループによる手法と開ループによる手法とがある。

[0035] （３次元ビームによる仮想的なセルの形成）

一般的なビームフォーミングでは、基地局が有するアンテナ素子の数の増加に伴い、ビームフォーミングに関連する負荷も増大し得る。例えば、アンテナ素子の数の増加に伴い、重み係数の数も増加するので、重み係数のセットを算出するための処理が増大する。即ち、端末装置又は基地局の処理の観点での負荷が増大する。また、例えば、アンテナ素子の数の増加に伴い、コードブックのサイズが大きくなるので、重み係数の推奨セットの通知のためにより多くの無線リソースが必要になり、その結果オーバーヘッドが増大する。即ち、無線リソースの観点での負荷が増大する。

[0036] 上記負荷の増大を抑えるために、個別の３次元ビーム（即ち、３次元方向へのビーム）にセルＩＤを割り当てることにより、３次元ビームに対応する通信領域（即ち、ビームが届く領域）を仮想的なセルとして扱うことも、考えられる。この場合に、例えば、基地局が個別の３次元ビームのためのＣＲＳを当該個別の３次元ビームにより送信することが考えられる。さらに、例

えば、基地局が上記個別の３次元ビームのための同期信号又はシステム情報などを当該個別の３次元ビームにより送信することも考えられる。上記同期信号は、例えば、ＰＳＳ（Primary Synchronization Signal）及びＳＳＳ（Secondary Synchronization Signal）を含む。また、上記システム情報は、例えば、マスタ情報ブロック（Master Information Block：ＭＩＢ）及びシステム情報ブロック（System Information Block：ＳＩＢ）を含む。

[0037] 例えば、端末装置は、３次元ビームに対応する通信領域（即ち、仮想的なセル）に入ると、３次元ビームにより送信される同期信号を用いて同期し、３次元ビームにより送信されるシステム情報を取得する。そして、端末装置は、３次元ビームにより送信されるＣＲＳについての測定（measurement）を行い、当該測定の結果が所定の条件を満たすと、基地局への当該測定の報告を行う。その後、例えば、基地局は、上記通信領域（即ち、仮想的なセル）への上記端末装置のハンドオーバを行う。

[0038] 例えば、基地局は、３次元ビームに対応する仮想的なセルに属する端末装置へのダウンリンク信号に重み係数を乗算することにより、当該ダウンリンク信号を上記３次元ビームにより送信する。なお、基地局は、上記端末装置からのアップリンク信号に重み係数を乗算することにより、アップリンクのビームフォーミング処理を行ってもよい。

[0039] （基地局のセルの大きさ）

従来の基地局のサービスエリアの大きさ（即ち、セルの大きさ）は、使用される周波数帯域における伝搬損失特性から求められる。なお、許容伝搬損失は、端末装置の所要受信電力、基地局の送信電力、及び送受信アンテナゲインなどから求められる。

[0040] 基地局がダウンリンクで送信するＣＲＳは、基地局ごとに割り当てられるセルＩＤに応じて一意に決まる信号系列で構成される。端末装置は、基地局によりダウンリンクで送信されるＣＲＳの受信強度を測定し、例えばあるセルについての当該受信強度が所定の強度を超える場合に基地局に報告する。

そして、基地局は、例えば、上記端末装置の上記あるセルへのハンドオーバを決定する。即ち、ＣＲＳの送信電力は、サービスエリアの大きさに影響する。

[0041] （無指向性エリア）

例えば、セルの中心に配置され、当該セル全体にサービスを提供する基地局は、無指向性アンテナを有する。無指向性アンテナとは、水平面での指向性を有さず、どの方向にも一様に電波を放射するアンテナである。無指向性アンテナにより形成されるサービスエリアの大きさは、基地局の送信電力と伝搬損失とによって決まる。

[0042] また、例えば、市街地のような多数の端末装置が存在するエリアでは、セルの中心に基地局を配置するのではなく、３つのセル（セクタとも呼ばれる）が接する位置に基地局が配置される。これにより、１つの基地局が、３つのセルでサービスを提供することが可能になる。このような場合に、基地局は、上記３つのセルに電波を放射するセクタアンテナを有する。セクタアンテナは、ダイポールアンテナの背面に金属製の反射器を配置することにより実現される。以下、図３を参照して、セクタアンテナにより形成されるセルの具体例を説明する。

[0043] 図３は、セクタアンテナにより形成されるセルの一例を説明するための説明図である。図３を参照すると、３つのセル（セクタ）を形成するセクタアンテナのビーム幅（－６０度～６０度）が示されている。当該ビーム幅は、アンテナゲインが－３ｄＢとなる幅として定義される。このようなビームが３つの方向に向けられることにより、３つのセルが形成される。形成される３つのセルの大きさも、基地局の送信電力と伝搬損失とにより決まる。

[0044] なお、本明細書では、ビームフォーミングを伴わない電波に対応するサービスエリアを無指向性エリアと呼ぶ。当該電波は、例えば、無指向性アンテナにより放射される無指向性の電波であってもよく、又はセクタアンテナにより放射されるセクタビームであってもよい。あるいは、上記電波は、指向性アンテナが有する複数のアンテナ素子の一部により放射される電波であっ

てもよい。なお、上記無指向性エリアは、送信電力及び伝搬損失から大きさが決まるサービスエリアとも言える。

[0045] （指向性エリア）

本明細書では、３次元ビームのような鋭いビームに対応するサービスエリア（通信領域）を指向性エリアと呼ぶ。無指向性エリア内の電波強度は、セルの中心に近いほど強く、セルの周辺に近いほど弱いが、指向性エリア内の電波強度は、比較的一定に保たれている。

[0046] （３次元ビームによるダウンリンクでの干渉）

３次元ビームは高い位置（例えば、高層ビルの高い位置）に向けて放射されることが想定されている。そのため、例えば３次元ビームは、隣接セル内の高い位置（例えば、隣接セル内の高層ビルの高い位置）にも到達し得る。即ち、上記３次元ビームは、隣接セルの無指向性エリア、又は隣接セルの指向性エリアに到達し得る。そのため、３次元ビームに起因して、隣接セルにおいて干渉が発生し、通信品質、及びユーザの通信容量などが低下し得る。

[0047] （ビーム幅とアンテナゲイン）

ビームが鋭くなると、放射される電波のエネルギーが集中するので、ゲインが上がる。以下、図４を参照してよりこの点をより詳細に説明する。

[0048] 図４は、ビームによるゲインの向上の例を説明するための説明図である。図４を参照すると、アンテナが配置される位置７７が示されている。例えば、無指向性アンテナが位置７７に配置される場合に、当該無指向性アンテナにより放射される電波は、球状の領域７８に到達する。一方、３次元ビームを形成可能な指向性アンテナが位置７７に配置される場合に、当該指向性アンテナにより放射される放射角theta（ギリシャ文字）の電波（即ち、当該指向性アンテナにより形成される放射角thetaの３次元ビーム）は、領域７９に到達する。このように、ビームが鋭くなると、電波の到達領域が狭くなり、電波のエネルギーが狭い領域に集中する。一例として、球状の領域７８に到達する電波を放射する無指向性アンテナのアンテナゲインが１である場合に、放射角thetaの３次元ビームを形成する指向性アンテナのアンテナゲインＧ

は以下のように表される。

[0049] [数3]

$$G = \frac{2}{(1-\cos\theta)}$$

[0050] なお、指向性アンテナのアンテナ素子数が増えると、指向性アンテナによってより鋭いビームを形成することが可能になる。即ち、指向性アンテナのアンテナ素子数が増えると、指向性アンテナのゲインのピークが向上する。以下、この点について、図５を参照して具体例を説明する。

[0051] 図５は、アンテナ素子数とアンテナゲインのピークとの関係の例を説明するための説明図である。図５を参照すると、アンテナ素子数に対するアンテナゲインを示すグラフが示されている。このように、アンテナ素子数が増加すると、アンテナゲインのピークが向上する。

[0052] （ビームフォーミングに関する課題）

上述したように、一般的なビームフォーミングでは、基地局が有するアンテナ素子の数の増加に伴い、ビームフォーミングに関連する負荷も増大し得る。例えば、重み係数のセットを算出するための処理が増大する。即ち、端末装置又は基地局の処理の観点での負荷が増大する。また、例えば、重み係数の推奨セットの通知のためにより多くの無線リソースが必要になり、その結果オーバーヘッドが増大する。即ち、無線リソースの観点での負荷が増大する。

[0053] また、上述したように、上記負荷の増大を抑えるために、個別のビームにセルＩＤを割り当てることにより、ビームに対応する通信領域（即ち、ビームが届く領域）を仮想的なセルとして扱うことも、考えられる。この場合に、例えば、基地局が個別の３次元ビームのためのＣＲＳを当該個別の３次元ビームにより送信することが考えられる。さらに、例えば、基地局が上記個別の３次元ビームのための同期信号（例えば、ＰＳＳ及びＳＳＳ）又はシス

テム情報（例えば、ＭＩＢ及びＳＩＢ）などを当該個別の３次元ビームにより送信することも考えられる。

[0054] ・ＣＲＳ間での干渉

しかし、セルごとに送信されるＣＲＳについてのリソース割当てパターン（即ち、リソースブロック内におけるＣＲＳへのリソースエレメントの割当てのパターン）の数は限られているので、ＣＲＳ間での干渉が発生し得る。一例として、ビームにより送信されるＣＲＳと隣接セルで送信されるＣＲＳとの干渉が生じ得る。

[0055] より具体的には、例えば、ＣＲＳの信号系列として、５０４種類の信号系列（即ち、５０４種類のセルＩＤに対応する信号系列）が用意されている。一方、ＣＲＳについてのリソース割当てパターン（即ち、周波数方向へのシフトのパターン）として、６種類の割当てパターンしか用意されていない。ＣＲＳについてのリソース割当てパターンが基地局間で重複しないようにセルＩＤを決定し、ＣＲＳ間での干渉を回避することは容易である。しかし、多数のビームに別々のセルＩＤを割り当てると、いずれかのビームと隣接セルとの間でＣＲＳについてのリソース割当てパターンが同一になり得る。そのため、ＣＲＳ間での干渉が生じる可能性がある。以下、図６及び図７を参照して、ＣＲＳについてのリソース割当てパターンの具体例を説明する。

[0056] 図６は、ＣＲＳについてのリソース割当てパターンの第１の例を説明するための説明図である。図６を参照すると、サブフレーム８１内で時間方向に並ぶ２つのリソースブロック８３が示されている。各リソースブロック８３は、時間方向において、１スロット（即ち、７ＯＦＤＭシンボル）の幅を有する。また、各リソースブロック８３は、周波数方向において１２サブキャリアの幅８５を有する。時間方向において１ＯＦＤＭの幅を有し、周波数方向において１サブキャリアの幅を有する無線リソースは、リソースエレメントと呼ばれる。各リソースブロック８３に含まれるいくつかのリソースエレメントが、ＣＲＳに割り当てられ、ＣＲＳは、割り当てられたリソースエレメントで送信される。具体的には、各リソースブロック内の１番目のＯＦＤ

Ｍシンボルに対応するリソースエレメントのうちの、６サブキャリアの間隔を有する２つのリソースエレメントが、ＣＲＳに割り当てられる。また、リソースブロック内の３番目のＯＦＤＭシンボルに対応するリソースエレメントのうちの、６サブキャリアの間隔を有する２つのリソースエレメントも、ＣＲＳに割り当てられる。この例では、ＣＲＳは、リソースエレメント８７Ａ～８７Ｆで送信される。

[0057] 図７は、ＣＲＳについてのリソース割当てパターンの第２の例を説明するための説明図である。図７を参照すると、図６と同様に、２つのリソースブロック８３が示されている。この例では、ＣＲＳは、リソースエレメント８７１～８７Ｐで送信される。図７の例では、図６の例と比べて、ＣＲＳに割り当てられるリソースエレメントは、周波数方向において１サブキャリア分だけシフトされている。このような周波数方向におけるシフトとして６種類のシフトがあるので、ＣＲＳについてのリソース割当てパターンとして６種類のリソース割当てパターンがある。

[0058] 以上のように、ＣＲＳについてのリソース割当てパターンは限られているので、ＣＲＳ間での干渉が発生し得る。

[0059] ・無指向性エリアのための送信電力の減少

また、基地局の送信電力は所定の最大送信電力を超えてはならないので、無指向性エリアでの信号の送信に加えて個別の３次元ビームによる信号（例えば、ＣＲＳ、同期信号、システム情報など）の送信も行われると、無指向性エリアのための送信電力が減少し得る。これは、ユーザの通信容量の減少、スループットの低下、又はセルの縮小などにつながり得る。

[0060] 一例として、３次元ビームによる信号の送信に起因して、無指向性エリアにおいてダウンリンクで送信されるデータ信号の送信電力が減少する。その結果、ユーザの通信容量が減少し、スループットが低下し得る。

[0061] 別の例として、３次元ビームによる信号の送信に起因して、無指向性エリアにおいてＣＲＳの送信電力が減少する。そのため、ＣＲＳの受信強度が所定の受信強度を超える領域が縮小し、無指向性エリアが縮小し得る。その結

果、ユーザの通信容量が減少し、スループットが低下し得る。以下、この点について図８及び図９を参照して具体例を説明する。

[0062] 図８は、３次元ビームにより信号が送信されない場合のセルを説明するための説明図である。図８を参照すると、互いに隣接する基地局９１Ａ及び基地局９１Ｂが示されている。また、基地局９１Ａのセル９３Ａ及び基地局９１Ｂのセル９３Ｂも示されている。セル９３Ａ及びセル９３Ｂは、無指向性エリアである。さらに、セル９３Ａ内に位置する端末装置９５Ａ～９５Ｃ、及び、セル９３Ｂ内に位置する端末装置９５Ｄ～９５Ｈが、示されている。端末装置９５Ｄ～９５Ｈは、セル９３Ｂ内に位置する高層ビル９７内に位置する。この例では、基地局９１Ａは、３次元ビームにより信号を送信していない。

[0063] 図９は、３次元ビームにより信号が送信される場合のセルを説明するための説明図である。図９を参照すると、図８と同様に、基地局９１Ａ及び基地局９１Ｂ、並びに、端末装置９５Ａ～９５Ｈが、示されている。この例では、基地局９１Ａは、３次元ビーム９９により信号（例えば、ＣＲＳ、同期信号など）を送信する。そして、上記３次元ビームによる上記信号の送信に起因する送信電力の増加に伴い、例えば、無指向性エリアにおけるＣＲＳの送信電力が減少する。そのため、図９の例では、図８の例と比べて、無指向性エリアであるセル９３Ａは小さく、端末装置９５Ｃは、セル９３Ａ内に位置せず、通信できない。その結果、例えば、ユーザの通信容量が減少し、スループットが低下する。

[0064] 以上のように、無指向性エリアのための送信電力が減少し得る。そして、これは、例えばユーザの通信容量の減少、スループットの低下、又はセルの縮小などにつながり得る。

[0065] そこで、本開示の実施形態は、例えば、ビームフォーミングに関連する負荷を軽減しつつ干渉の増加を抑えることを可能にする。また、本開示の実施形態は、例えば、ビームフォーミングに関連する負荷を軽減しつつ無指向性エリアのための送信電力の減少を抑制する。

[0066] ＜＜２．通信システムの概略的な構成＞＞

続いて、図１０～図１２を参照して、本開示の実施形態に係る通信システム１の概略的な構成を説明する。図１０は、本開示の実施形態に係る通信システム１の概略的な構成の一例を示す説明図である。図１０を参照すると、通信システム１は、基地局１００及び端末装置２００を含む。通信システム１は、例えば、ＬＴＥ、ＬＴＥ－Ａｄｖａｎｃｅｄ、又はこれらに準ずる通信方式に従ったシステムである。

[0067] 基地局１０●は、端末装置２００との無線通信を行う。

[0068] ・無指向性エリアでの無線通信

基地局１００は、セル１０内に位置する端末装置２００との無線通信を行う。セル１０は、ビームフォーミングを伴わない電波に対応する通信領域（即ち、無指向性エリア）である。

[0069] 例えば、基地局１００は、無指向性アンテナを備え、無指向性の電波により信号を送信する。基地局１００は、例えば、無指向性の電波によりＣＲＳ（Cell-Specific Reference Signal）を送信する。また、基地局１００は、例えば、無指向性の電波により、その他の制御信号（例えば、同期信号、及びシステム情報など）及びデータ信号を送信する。

[0070] なお、基地局１００は、無指向性アンテナの代わりに、セクタアンテナを備え、無指向性ビームの代わりに、ビームフォーミングを伴わないセクタビームにより信号を送信してもよい。また、基地局１００は、無指向性アンテナ及びセクタアンテナの代わりに、指向性アンテナが有する複数のアンテナ素子の一部を用いて、ビームフォーミングを伴わない電波により信号を送信してもよい。

[0071] ・指向性エリアでの無線通信

さらに、とりわけ本開示の実施形態では、基地局１００は、３次元ビーム（即ち、３次元方向へのビーム）を形成可能な指向性アンテナを備え、３次元ビームによって信号を送信する。以下、この点について図１１を参照して具体例を説明する。

[0072] 図１１は、基地局１００により形成される３次元ビームの例を説明するための説明図である。図１１を参照すると、指向性アンテナ１０１が示されている。指向性アンテナ１０１は、３次元ビームを形成可能である。図１１に示されるように、指向性アンテナ１０１は、異なる３次元方向への複数の３次元ビーム２０を形成する。例えばこのように、指向性アンテナ１０１は高い位置に配置され、３次元ビーム２０は、いずれかの方向（下方向、上方向又は水平方向）に向かって放射される。そして、各３次元ビーム２０に対応する通信領域３０に到達する。具体的には、３次元ビーム２０Ａが形成され、３次元ビーム２０Ａは通信領域３０Ａに到達する。また、３次元ビーム２０Ｂが形成され、３次元ビーム２０Ｂは通信領域３０Ｂに到達する。このように、３次元ビーム２０は通信領域３０に到達する。その結果、通信領域３０内に位置する端末装置２００は、当該３次元ビーム２０により送信される信号を受信することができる。

[0073] さらに、基地局１００は、上記指向性アンテナにより形成される個別の３次元ビームにセルＩＤを割り当て、当該セルＩＤに基づいて、当該個別の３次元ビームによりＣＲＳを送信する。即ち、基地局１００は、個別の３次元ビームに対応する通信領域（サービスエリア）を仮想的なセル（以下、「仮想セル」と呼ぶ）として扱う。

[0074] 具体的には、例えば、基地局１００は、指向性アンテナにより形成される３次元ビームにセルＩＤを割り当て、当該セルＩＤに対応するリソース割当てパターンで、当該セルＩＤに対応する信号系列のＣＲＳを送信する。また、例えば、基地局１００は、端末装置２００による上記ＣＲＳについての測定結果が所定の条件を満たす場合に、上記個別の３次元ビームに対応する通信領域（サービスエリア）への端末装置２００のハンドオーバを行う。そして、基地局１００は、端末装置２００宛の信号を上記個別の３次元ビームにより送信する。このように、個別の３次元ビームに対応する通信領域（サービスエリア）は仮想的なセルとして扱われる。以下、図１２を参照して、３次元ビームによる無線通信の例を説明する。