



- (51) **International Patent Classification:**
H04B 7/04 (2006.01) *H04L 5/14* (2006.01)
H04W 36/08 (2009.01)
- (21) **International Application Number:** PCT/FI2015/050144
- (22) **International Filing Date:** 6 March 2015 (06.03.2015)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (71) **Applicant:** NOKIA TECHNOLOGIES OY [FI/FI];
Karaportti 3, FI-02610 Espoo (FI).
- (72) **Inventor:** HALLIVUORI, Juha; Nirvankatu 70, FI-33820
Tampere (FI).
- (74) **Agents:** NOKIA TECHNOLOGIES OY et al.; Ari
Aarnio, IPR Department, Karakaari 7, FI-02610 Espoo
(FI).
- (81) **Designated States** (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

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

- (54) **Title:** METHOD AND APPARATUS FOR BASE STATION DIVERSITY DUPLEXING

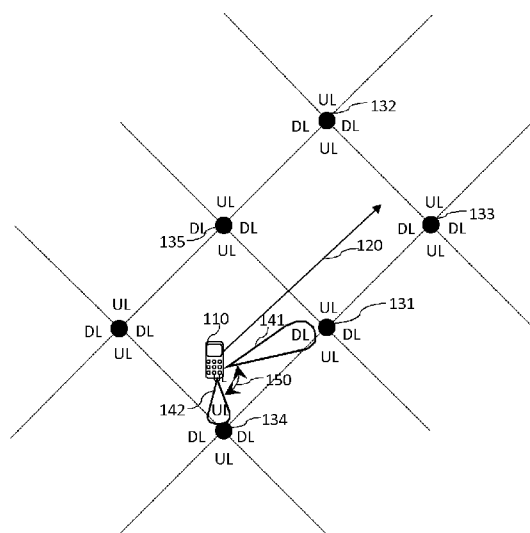


Figure 1

- (57) **Abstract:** In accordance with an example embodiment of the present invention, a first beam (141) is formed towards a first base station (131) for receiving a first signal on a frequency channel from the base station and a second beam (142) is formed towards a second base station (134) different from the first base station for transmitting a second signal on the frequency channel towards the second base station at least in part simultaneously with the receiving.



METHOD AND APPARATUS FOR BASE STATION DIVERSITY DUPLEXING

5 TECHNICAL FIELD

The present application relates generally to mobile wireless communications. More particularly, it relates to employing base station diversity to establish and maintain full duplex communication on a transmission channel.

10

BACKGROUND

Typical cellular and local area networks operate either in Frequency Division Duplexing (FDD) or in Time Division Duplexing mode (TDD), wherein communication between user equipments (UEs) occurs through the network. In FDD operation, a frequency band is dedicated for uplink (UL) transmissions, where the UE transmits and a base station (BS) of the network receives; another, non-overlapping frequency band is dedicated for downlink (DL) transmission, where the BS transmits and the UE receives. In full-duplex FDD, a UE transmits on the UL frequency band simultaneously with receiving on the DL frequency band. In half-duplex FDD, transmission on the UL frequency band and reception on the DL frequency band occur only at non-overlapping time instances. In TDD operation, all communication occurs on the same frequency band and the same channel within the frequency band, but the UL and DL transmissions occur only at non-overlapping time instances. Handover or reselection of the UE is typically based on link qualities between the UE and respective target base stations.

25

SUMMARY

Various aspects of examples of the invention are set out in the claims.

30 According to a first aspect of the present invention, there is disclosed a method for forming a first beam towards a first base station for receiving a first signal on a frequency channel from the base station and forming a second beam towards a second base station different from the first base station for transmitting a second signal on the frequency channel towards the second base station at least in part simultaneously with the receiving.

35

According to a second aspect of the present invention, there is disclosed an apparatus comprising at least one first antenna element for forming a first beam towards a first base station for receiving a first signal on a frequency channel from the base station, at least one second antenna element for

forming a second beam towards a second base station different from the first base station for transmitting a second signal on the frequency channel towards the second base station at least in part simultaneously with the receiving.

5 According to a third aspect of the present invention, there is disclosed a base station comprising at least one first antenna element for forming a first beam towards a mobile station for receiving a first signal on a frequency channel from the mobile station, at least one wired interface for transmitting a second signal towards the mobile station through a second base station different from the first base station on the frequency channel at least in part simultaneously with the
10 receiving.

According to a third aspect of the present invention, there is disclosed a first base station comprising at least one first antenna element for forming a first beam towards a mobile station for receiving a first signal on a frequency channel from the mobile station, the first base station
15 comprising at least one first interface for transmitting a second signal towards the mobile station through a second base station different from the first base station, the second base station comprising at least one second antenna element for forming a second beam towards a mobile station for transmitting a third signal corresponding to the second signal on the frequency channel to the mobile station at least in part simultaneously with the receiving.

20

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of example embodiments of the present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings
25 in which:

- FIGURE 1 depicts a system in accordance with embodiments of the present invention;
FIGURE 2 depicts another system in accordance with embodiments of the present invention;
FIGURE 3 depicts example scenarios for handover or reselection in accordance with embodiments of the present invention;
30 FIGURE 4 depicts additional example scenarios for handover or reselection in accordance with embodiments of the present invention;
FIGURE 5 depicts yet another system in accordance with embodiments of the invention;
FIGURE 6 depicts a flow diagram for a UE in accordance with embodiments of the present invention;
35 FIGURE 7 depicts a flow diagram for a BS in accordance with embodiments of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

An example embodiment of the present invention and its potential advantages are understood by referring to FIGURES 1 through 7 of the drawings.

5

FIGURE 1 depicts a system in which a UE (110) is present with the coverage area of a network comprising BSs (131-135) in accordance with embodiments of the invention. The UE (110) in general attempts to synchronize to and receive system information from the network for which it may form a first beam (141) using a frequency channel towards a DL signal of any of the BSs in the network, for example BS 131. The UE may form a second beam (142) using the same frequency channel towards any other of the BSs providing an UL, for example BS 134. As a result, the UE may then both receive from BS 131 through the first beam and transmit to BS 142 through the second beam substantially simultaneously using the same frequency channel, thereby employing base station diversity.

15

In a typical network, multiple BSs are available to provide an UL to the UE. In accordance with some embodiments of the invention, the UE determines a relative spatial relationship (151) between the UE, the BS (131) presently providing the DL signal to the UE and at least one of the BSs (134, 135) available to provide the UL to the UE. Based at least in part on the relative spatial relationship, the UE may select one of the available BSs to provide the uplink, for example BS 134. The selection may select a BS based on the relative spatial relationship providing an angular threshold of least about 50 degrees or may select a BS based on the relative spatial relationship providing an allowable angular range of about 50 to about 150 degrees.

20

The angular threshold may be measured as the difference between an angle of arrival of the main lobe of the DL and the angle of departure of the main lobe of the UL. The selection of a BS to provide the UL may be biased towards selecting a BS for which the difference is large. For example, it may apply one or more thresholds to the difference, such as selecting a BS for which the difference is at least about 50 degrees or selecting a BS for which the difference is between about 50 to about 150 degrees.

30

In an alternative embodiment, the UE may, rather than applying angular thresholds, select a BS at least according to the relative angular relationship in view of a shape of the first beam and potential beams towards the candidate BSs. For example, in reference to FIGURE 2, the UE may select to form beam 230 towards BS 260 to provide the UL rather than form a beam 220 towards BS 240, due to the higher sensitivity of DL beam 210 in the direction of UL beam 220 compared to UL beam 230.

35

In some embodiments, the UL and DL beam may be formed jointly at least in part based on at least one null of each other's beam. In the process of selecting a BS for the UL, the beam for the DL may hence be rotated in accordance with a null of a beam towards a potential UL BS to achieve an enhanced diversity between the UL and DL while the UL beam is selected in accordance with a null of the DL beam.

Referring back now to FIGURE 1, information to determine available BSs and their location relative to the UE may be determined by measurement and adaptively beamforming towards any measured DL signal. In addition, and especially for BSs providing UL without colocated DL, for which such measurement and adaptive beamforming is not possible, such information may be obtained from a database stored either in the UE or in the network.

Once the UL and DL beams are formed, their alignment with the direction of the BSs providing the UL and DL respectively may change as a result of device rotation and/or movement. To maintain the appropriate alignment, rotations of the UE may be determined from at least one of a compass and an accelerator sensor measurement, in accordance with which the DL and UL beams may be updated to maintain the alignment. Updating the DL and UL beams may involve selecting at least one of a new DL or UL base station in accordance a relative spatial angle changed as a result of rotation or movement. Movement of the device may be determined according to measurements from the accelerator sensor and generally any position determining method.

In accordance with embodiments of the present invention, a UE (110) may need to handover or reselect at least one of the UL and DL to a different BS than the ones to which the current UL and DL beams are respectively formed, for example because the UE is moving along path 120 as depicted in FIGURE 1. As a result of the movement, the pathloss between the UE and the UL or DL BS may exceed a threshold in accordance with commonly known art or may result in an undesirable relative spatial relationship between the UL BS, the DL BS and the UE, for example because the angular difference becomes smaller than a threshold. The UE may then select a new BS for the DL in accordance with a relative spatial relationship between the new BS, the current serving UL BS and the UE, select a new BS for the UL in accordance with a relative spatial relationship between the new BS, the current serving DL BS and the UE or may simultaneously select a new BS for the DL and a new BS for the UL in accordance with a relative spatial relationship between the new DL BS, the new UL BS and the UE. The DL and/or UL beams are then updated in accordance with the selection. In FIGURE 3a, as an example, a handover/reselection (312) of the UL from a BS₁ (311) to a BS₃ (313) is depicted, while the DL remains served by BS₂.

It may however occur that no suitable new BS is available either due to non-existence, inadequate linkbudget or undesirable relative spatial relationship, for example when the angular difference

between the available DL BS and the available UL BS fails to exceed a minimum threshold, resulting in insufficient spatial isolation. In such cases, the UE may according to embodiments of the present invention as a result be forced to switch from employing base station diversity to frequency division duplexing as depicted in FIGURE 3b where as an example the UL (321, 331) is moved to a different channel (323) in a full-duplex manner (323, 324) or to time division duplexing (333, 334) as for example depicted in FIGURE 3c.

As described previously, the UL and DL beams may need to be updated to compensate for device rotation and/or movement to ensure their continued alignment with the UL BS and DL BS respectively. It may however occur that the UE is rotating or moving too fast to maintain proper alignment, resulting in decreased diversity between the UL and DL. In such cases, the UE may according to embodiments of the present invention as a result be forced to switch from employing base station diversity (411, 421, 431) to half (413, 414) or full (423, 424) frequency division duplexing as depicted in FIGURE 4a and FIGURE 4b respectively where as an example the UL is moved to a different channel or to time division duplexing (433, 434) as for example depicted in FIGURE 4c. Whether the device rotation and/or movement exceeds an acceptable threshold (412, 422, 432) for the purpose of maintaining alignment may be directly determined from measurements using the aforementioned compass, accelerometer and positioning methods or may be indirectly determined from a rate of change in the relative spatial relationship between the DL BS, the UL BS and the UE.

In the above, embodiments of the invention for determining a relative spatial relation and selecting a BS for at least one of a DL or UL are described as being effected by a UE. One skilled in the art will however understand that through exchange of information with at least one BS, such determining and selecting may be made for the UE by any network device, such as a BS or a mobility management entity (MME).

In FIGURE 5, a UE (520) is shown with its serving UL BS (532) and its serving DL (BS), the UE forming beams (542, 541) towards the UL BS and DL BS respectively, the DL and UL BS selected in accordance with the relative spatial relationship (550) between the UL BS, the DL BS and the UE. The UL BS employs at least one antenna element (571) for forming a beam (561) on a frequency channel towards the UE for receiving transmissions from the UE, whereas the DL BS employs at least one antenna element (572) for forming a beam (562) on the frequency channel towards the UE for transmitting towards the UE. In some embodiments, the UL BS transmits information through an interface (580), for example a (wired) X2 interface, to the DL BS for the DL BS to transmit to the UE. Such information may for example information for controlling the UL transmissions at the UE to the UL BS or user data to be transmitted to the UE. In other embodiments, the DL BS transmits information regarding its transmissions to the UL BS for the

purpose of managing interference from beam 562 into beam 561. Additionally, the UL BS may transmit information regarding its scheduled receptions, such as for example information relating to the position of UEs from which it is scheduled to receive transmissions at a certain time, for the purpose of managing interference from beam 562 into beam 561. Information exchanged over interface 580 hence may comprise both user data for the UE, information for controlling the UL and DL transmissions and receptions at the UE and information for coordination between the UL BS and DL BS.

The UL BS (532) may determine the DL BS from information received from the UE. The UL BS may also determine a relative spatial relationship between itself, the UE and candidate DL BSs for the UE. For example, the UL BS may retrieve position information of itself, the UE and candidate DL BSs and compute an angular difference at the UE between the UE's UL beam (542), directed towards the eNBs UL beam (562) formed by the at least one antenna element 572, and any beam 541 the UE may form towards the DL beam (561) formed by at least one antenna element (571) of respective candidate DL BSs (531). At least in part based on the relative spatial relationship, the UL BS may select a DL BS to serve the UE and instruct the DL BS initiate transmission to the UE. Such instruction may comprise information related to the position or direction relative to the DL BS of the UE, such that the DL BS may form beam 561 at least based on this information. Once a DL BS is serving the UE, the DL BS in its turn in similar fashion determine a new UL BS for the UE. It is also within the scope of the present invention that a serving UL BS may determine a new UL BS for the UE to handover/reselect to in this manner and that a serving DL BS may determine a new DL BS for the UE to handover/reselect to in this manner. As not all information received from the UL BS is to be transmitted to the UE and the signal format of information over the interface 580 is in general different than the signal format of the DL link between the DL BS and the UL, the DL BS will in general which information of the information received from the UL BS, and in what signaling format, to transmit to the UE.

FIGURE 6 depicts a flow diagram of methods according to various embodiments of the invention. At 610, a first beam is formed by a UE towards a DL BS for receiving a first signal on a frequency channel from the DL BS. At 620, a relative spatial relationship is determined between the UE, the DL BS at at least one candidate UL BS different from the DL BS. At 630, a UL BS is selected at least in part based on the determined relative spatial relationship. At 640, a second beam is formed towards the selected UL BS. At 650 the UE transmits to the UL BS and receives from the DL BS substantially simultaneously on the same channel, thereby exploiting the diversity achieved by the selection of the DL BS at least based on the determined relative spatial relationship.

At 660, the UE determines a need to handover or reselect from the UL BS to a new UL BS, where the need may for example be determined based on signaling from the DL BS, a measured link

quality or a relative spatial relationship between the UE, the DL BS and the UL BS. At 670, the UE determines for at least one new candidate UL BS a relative spatial relationships between the UE, the DL BS and the new candidate UL BS. Based on the determined relative spatial relationship, may select a new UL BS from the at least one new candidate UL BSs.

5

If the relative spatial relationship between the UE, the DL BS and the selected new UL BS is satisfactory, for example an angular difference being above a minimum threshold or falling within an acceptable range, then the UE may proceed with base station diversity using the selected new UL BS by transmitting to the selected new UL BS and receiving from the DL BS substantially simultaneously on the same channel (671). If it is not satisfactory, the UE may for example switch from operating according to base station diversity to operating according to full duplex frequency division duplexing by transmitting to any UL BS and receiving from the DL BS on different channels (672). As an alternative, the UE may for example switch to operating according to a time division duplexing by receiving from the DL BS on the channel and transmitter either to the UL BS or the selected new UL BS on the channel not simultaneously with the receiving (673). That is, if base station diversity cannot be maintained with the currently serving UL BS and with a selected new UL BS, the UE may switch to operating according to TDD either with the currently serving UL BS or the selected new UL BS.

10

15

20

25

At 680, a rate of rotation or movement of the UE is determined. At least in dependence on the rate exceeding a threshold, the UE may for example switch from operating according to base station diversity to operating according to full duplex frequency division duplexing by transmitting to any UL BS and receiving from the DL BS on different channels (681). Alternatively, the UE may for example switch to operating according to a time division duplexing by receiving from the DL BS on the channel and transmitter to the UL BS on the channel not simultaneously (682).

FIGURE 7 depicts a flow diagram of methods according to various embodiments of the invention. At 710, a UL beam is formed towards a UE. In some embodiments, a selection (740) of a DL BS may be received from the UE. In other embodiments, a relative spatial relationship between the UE, a UL BS providing the UL beam and at least one candidate DL BS may be determined (720). For example, the angular difference at the UE between the UEs beam towards the UL BS and towards the candidate DL BS may be determined. In some embodiments, the location of the UE may be received through the UL beam for this purpose, or it may be determined by a network using any positioning method.

30

35

Once the relative spatial relationship has been determined, a DL BS may be selected from the at least one candidate DL BSs based on the relative spatial relationship. The selected DL BS may then be prompted to form a beam towards the UE, for which it may receive the location of the UE

to assist in forming the beam. Once the DL beam has been formed, the UL BS providing the UL beam may then receive from the UE substantially simultaneously with the transmission of the DL BS using the DL beam, exploiting the base station diversity achieved through the relative spatial relationship.

5

Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect of one or more of the example embodiments disclosed herein is that an apparatus according to the invention ensures an adequate spatial separation between the UL and DL, relieving the need for complex interference cancellation between UL and DL or other separation methods such as antenna phasing, pulse interleaving or code spreading.

10

Embodiments of the present invention may be implemented in software, hardware or a combination thereof. The software and/or hardware may reside on chips comprising for example dedicated circuits or DSPs. In an example embodiment, the software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a “computer-readable medium” may be any non-transitory media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer. A computer-readable medium may comprise a computer-readable storage medium that may be any non-transitory media or means that can contain or store the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer.

15

20

While embodiments of the invention are described in terms of user equipment and base stations, one skilled in the art will appreciate that the invention is not limited to such devices and may be practiced using other devices using any air interface, such as for example any WLAN client using a network of WLAN access points or a wireless sensor using a network of sensor receptors.

25

Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

30

It is also noted herein that while the above describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

35

WHAT IS CLAIMED IS

1. An apparatus comprising:
at least one first antenna element for forming a first beam towards a first base station
5 for receiving a first signal on a frequency channel from the base station;
at least one second antenna element for forming a second beam towards a second
base station different from the first base station for transmitting a second signal on the
frequency channel towards the second base station at least in part simultaneously with the
receiving.
10
2. The apparatus of claim 1 further comprising at least one processor and at least one memory
including computer program code, the at least one memory and the computer program
code are configured, with the at least one processor, to cause the apparatus at least to
15 determine a relative spatial relationship between the second base station, the first
base station and the apparatus; and
select the second base station at least in part in dependence of the relative spatial
relationship.
3. The apparatus of claim 2 wherein the relative spatial relationship comprises a difference of
20 an angle of arrival at the apparatus of the first signal received from the first base station
and the angle of departure of the second signal from the apparatus towards the second base
station.
4. The apparatus of claim 3, the at least one memory and the computer program code are
25 configured, with the at least one processor, to cause the apparatus at least to select the
second base station biased towards the difference being large.
5. The apparatus of claim 3, the at least one memory and the computer program code are
30 configured, with the at least one processor, to cause the apparatus at least to select the
second base station based on the difference exceeding 50 degrees.
6. The apparatus of claim 2, wherein the relative spatial relationship is determined at least in
part according to measurements by the apparatus.
- 35 7. The apparatus of claim 2, wherein the relative spatial relationship is determined at least in
part according to position information of the first and second base station obtained from a
database.

8. The apparatus of claim 1, wherein the at least one first antenna element and the at least one second antenna element form the first and second beam at least in part based on at least one null of each other's beam.
- 5 9. The apparatus of claim 1, wherein at least one of the first and second beams are adjusted according to at least one of a compass and an accelerator sensor measurement.
10. The apparatus of claim 1 further comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to
10 determine a second relative spatial relationship between a third base station, the first base station and the apparatus; and
switch in dependence of the second relative spatial relationship from transmitting the second signal on the frequency channel towards the second base station at least in part
15 simultaneously with the receiving to:
transmitting the second signal on the frequency channel towards the third base station at least in part simultaneously with the receiving; and at least one of
transmitting the second signal on a different frequency channel towards the third base station at least in part simultaneously with the receiving; and
20 transmitting the second signal on the same different frequency channel towards the second base station not simultaneously with the receiving.
11. The apparatus of claim 1 further comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to
25 determine a rate of rotation of the apparatus; and
switch in dependence of the rate of rotation from transmitting the second signal on the frequency channel towards the second base station at least in part simultaneously with the receiving to: transmitting and receiving the first and second signal to the first or second
30 base station according to a full frequency division duplexing or a half frequency division duplexing or a time division duplexing.
12. A base station comprising:
at least one first antenna element for forming a first beam towards a mobile station
35 for receiving a first signal on a frequency channel from the mobile station;
at least one wired interface for transmitting a second signal towards the mobile station through a second base station different from the first base station on the frequency channel at least in part simultaneously with the receiving.

13. The base station of claim 10, further comprising at least one processor and at least one memory including computer program code, the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to

determine a relative spatial relationship between the second base station, the base station and the mobile station; and

select the second base station at least in part in dependence of the relative spatial relationship.

14. The base station of claim 11 wherein the relative spatial relationship comprises a difference of an angle of departure at the mobile of the first signal transmitted towards the first base station and the angle of arrival at the mobile station of a third signal associated with the second signal from the second base station.

15. The apparatus of claim 12, the at least one memory and the computer program code are configured, with the at least one processor, to cause the base station at least to select the second base station biased towards the difference being large.

16. The apparatus of claim 12, the at least one memory and the computer program code are configured, with the at least one processor, to cause the base station at least to select the second base station based on the difference exceeding 50 degrees.

17. The apparatus of claim 12, wherein the relative spatial relationship is determined at least in part according to measurements received from the mobile station.

18. The apparatus of claim 12, wherein the relative spatial relationship is determined at least in part according to position information of the first and second base station obtained from a database.

19. An apparatus comprising:

a first base station comprising at least one first antenna element for forming a first beam towards a mobile station for receiving a first signal on a frequency channel from the mobile station;

the first base station comprising at least one first interface for transmitting a second signal towards the mobile station through a second base station different from the first base station;

the second base station comprising at least one second antenna element for forming a second beam towards a mobile station for transmitting a third signal corresponding to the second signal on the frequency channel to the mobile station at least in part simultaneously with the receiving.

5

20. The apparatus of claim 17, the second base station further comprising

at least one second interface for receiving the second signal from the first base station; and

10

at least one processor and at least one memory including computer program code, the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus at least to determine the third signal from the second signal.

21. The apparatus of claim 17, further comprising:

15

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

determine a relative spatial relationship between the first or second base station, a third base station and the mobile station; and

20

select to handover the mobile station from the first or second base station to the third base station at least in part in dependence of the relative spatial relationship.

22. The base station of claim 19 wherein the relative spatial relationship comprises a difference of an angle of departure at the mobile of the first signal transmitted towards the first base station and the angle of arrival at the mobile station of a fourth signal from the third base station.

25

23. The apparatus of claim 20, the at least one memory and the computer program code are configured, with the at least one processor, to cause the base station at least to select the third base station biased towards the difference being large.

30

24. The apparatus of claim 20, the at least one memory and the computer program code are configured, with the at least one processor, to cause the base station at least to select the third base station based on the difference exceeding 50 degrees.

35

25. The apparatus of claim 19, wherein the relative spatial relationship is determined at least in part according to measurements received from the mobile station.

26. The apparatus of claim 20, wherein the relative spatial relationship is determined at least in part according to position information of the third base station and the first or second base station obtained from a database.

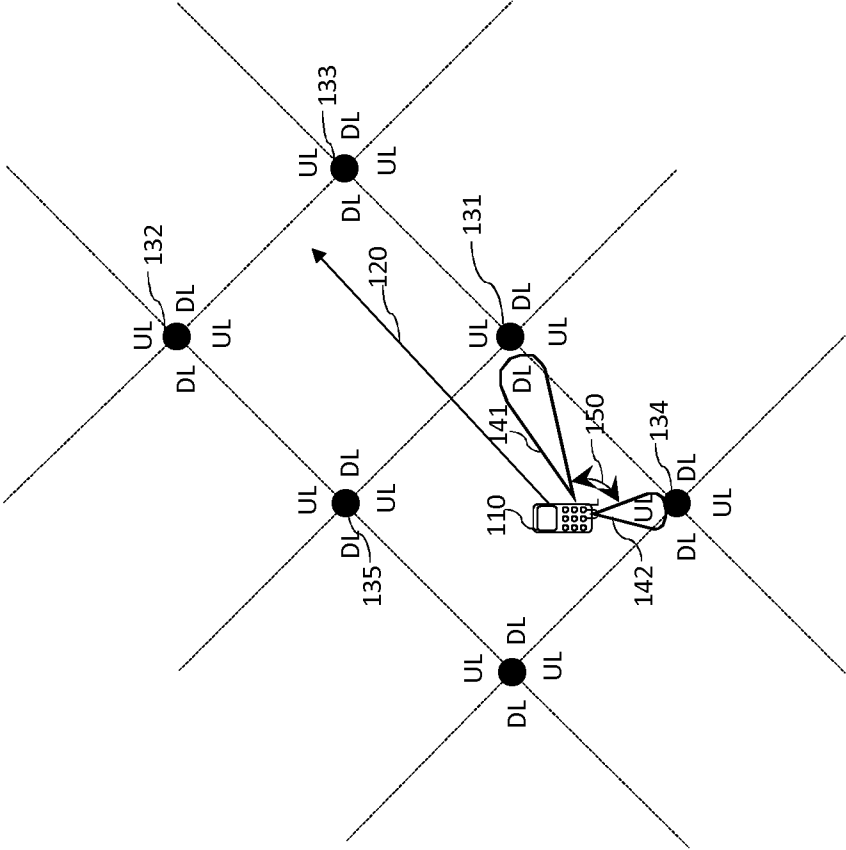


Figure 1

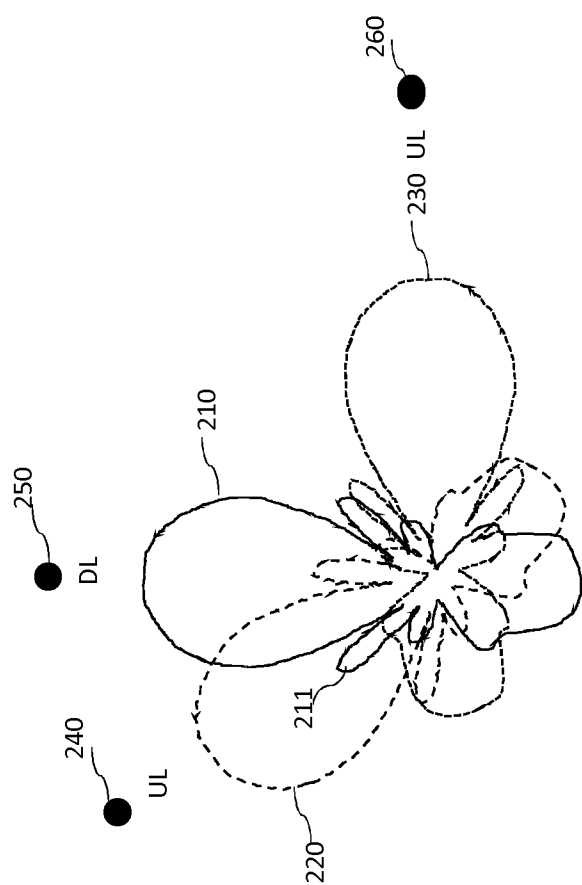


Figure 2

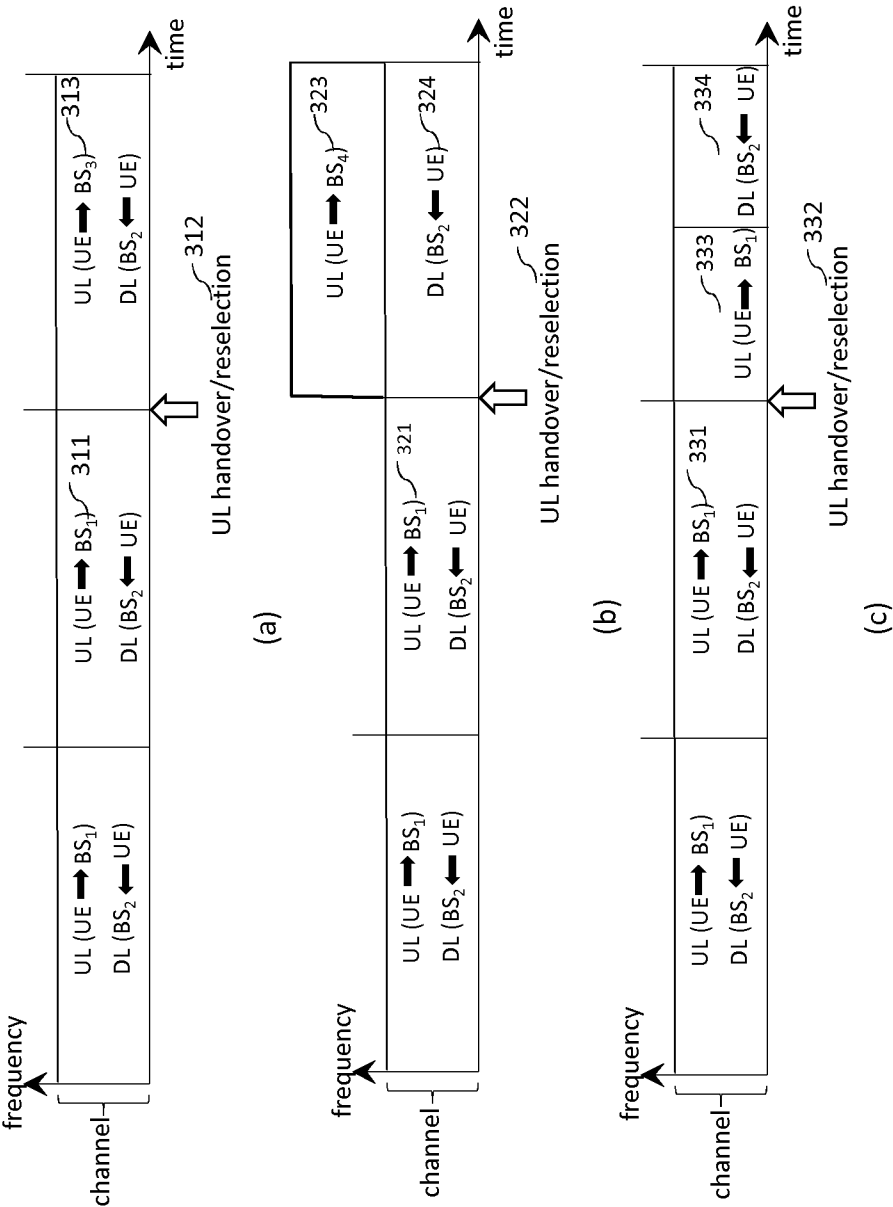


Figure 3

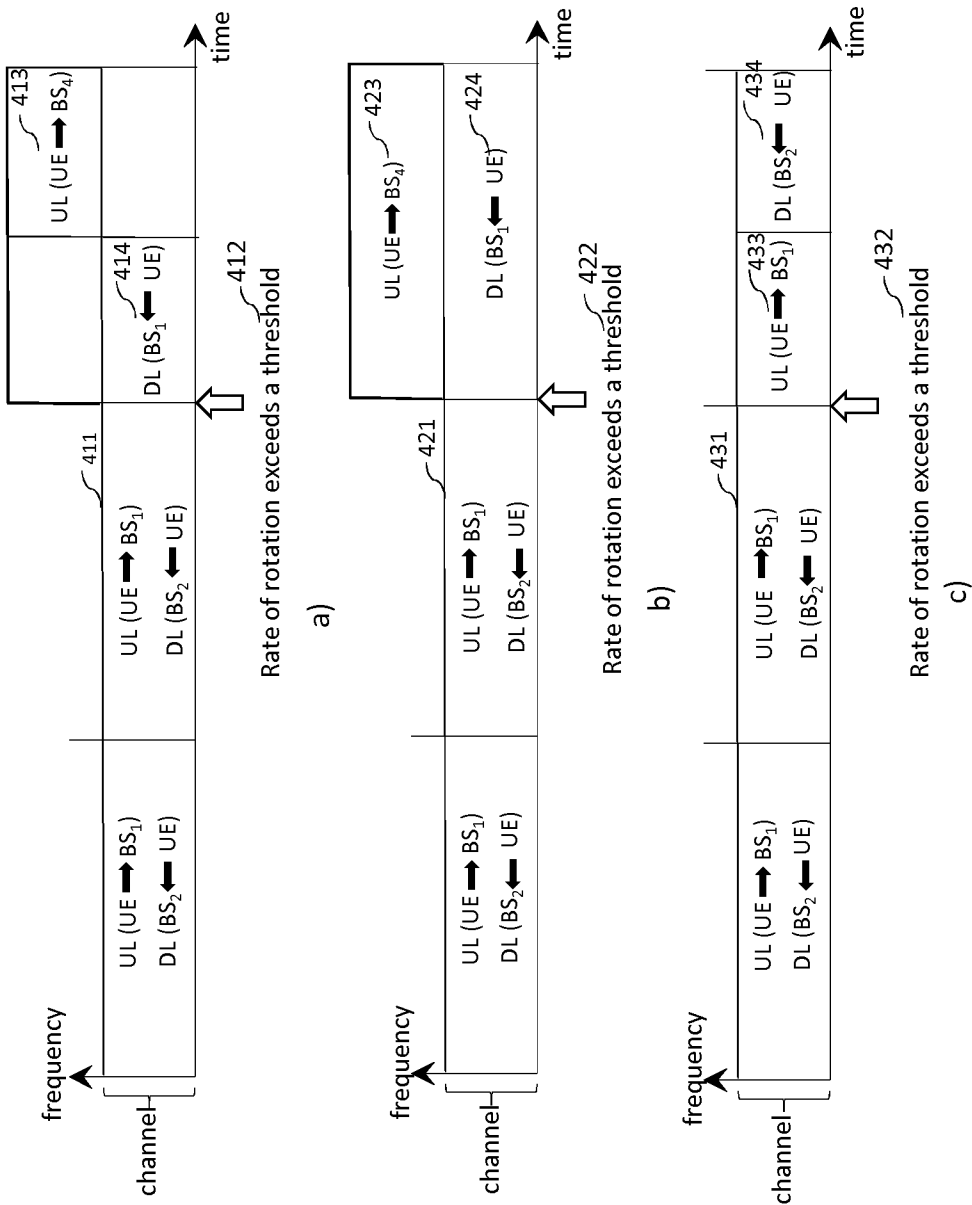


Figure 4

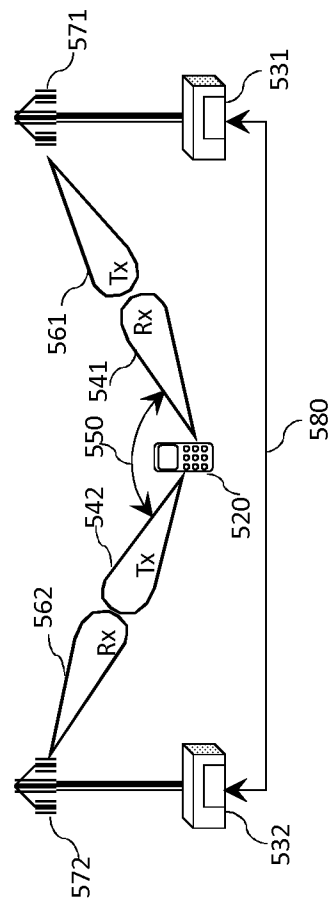


Figure 5

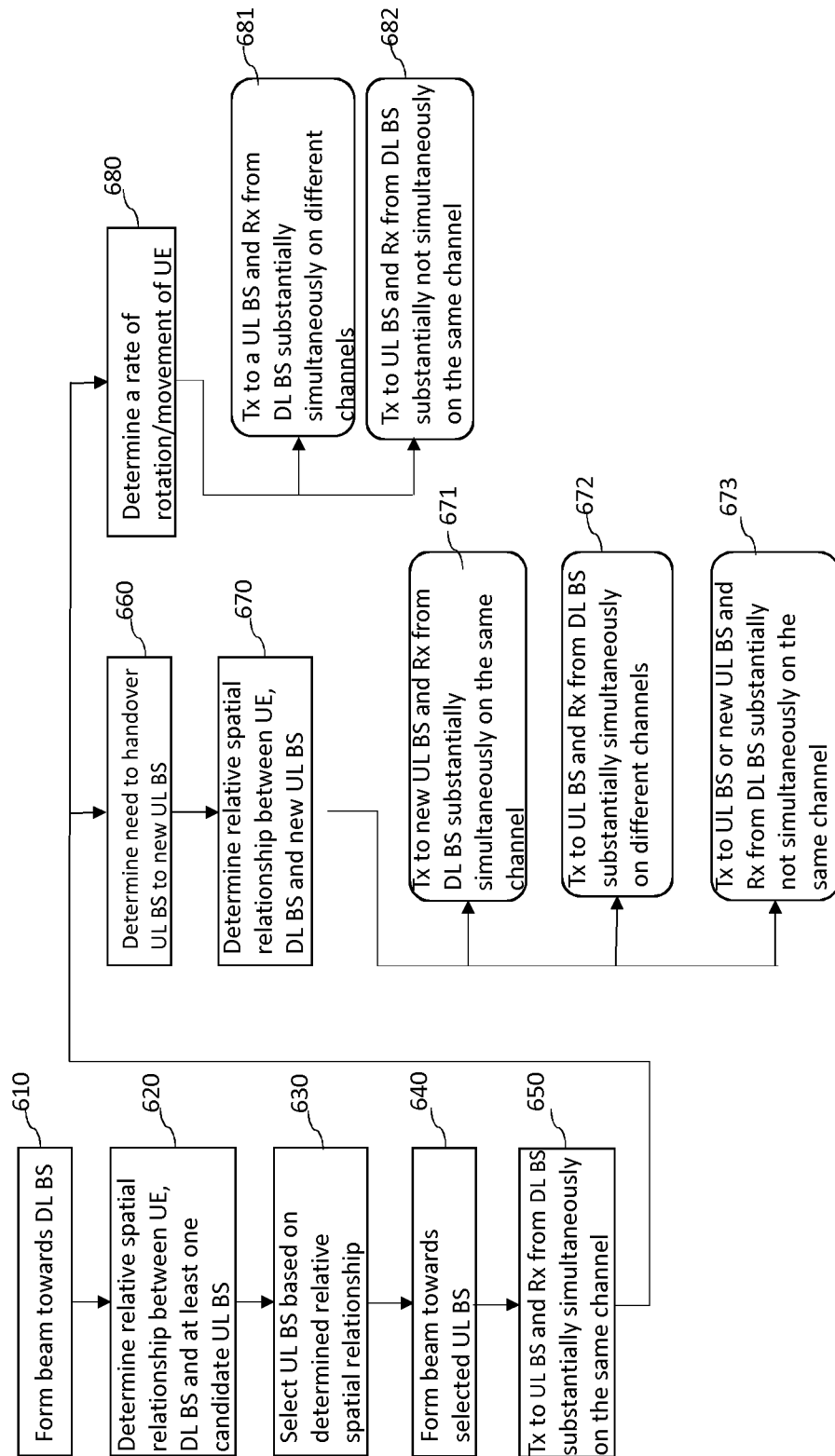


Figure 6

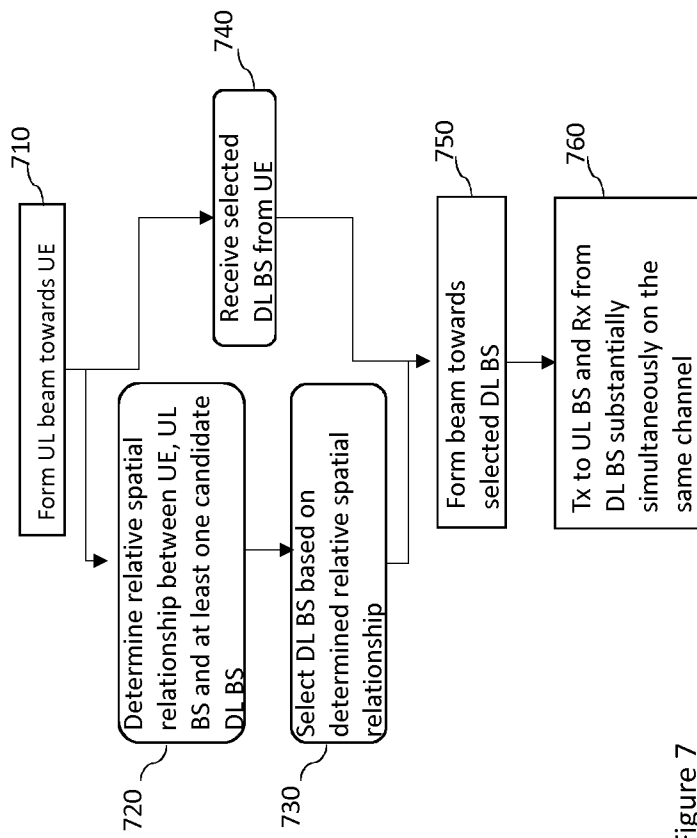


Figure 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2015/050144

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: H04B, H04W, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

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

EPO-Internal & translations from Thomson Reuters and IPPH/SIPO, WPI, XP3GPP, XPAIP, XPESP, XPESP2, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPOAC, XPRD, XPTK, COMPD, INSPEC, TDB, NPL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015049626 A1 (CHEN WANSHI [US] et al.) 19 February 2015 (19.02.2015) paragraphs [0004] and [0005]	1-26
A	US 2005277419 A1 (TAKANO NAHOKO [JP] et al.) 15 December 2005 (15.12.2005) claim 1; figure 1	1-26
A	US 2011159881 A1 (SHIN WON JAE [KR] et al.) 30 June 2011 (30.06.2011) paragraphs [0006], [0007] and [0010]	1-26
A	US 2014148182 A1 (JEONG SU-RYONG [KR] et al.) 29 May 2014 (29.05.2014) paragraphs [0034] - [0036]	1-26

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search
19 August 2015 (19.08.2015)Date of mailing of the international search report
01 September 2015 (01.09.2015)Name and mailing address of the ISA/FI
Finnish Patent and Registration Office
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328Authorized officer
Pasi Helminen
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on Patent Family Members

International application No.
PCT/FI2015/050144

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
US 2015049626 A1	19/02/2015	WO 2015023647 A1	19/02/2015
.....			
US 2005277419 A1	15/12/2005	US 8228866 B2	24/07/2012
		AU 2003236363 A1	13/10/2003
		CN 1647567 A	27/07/2005
		CN 100407848 C	30/07/2008
		CN 1968540 A	23/05/2007
		CN 101312598 A	26/11/2008
		CN 101312598 B	24/07/2013
		JP 2004007030 A	08/01/2004
		JP 4423836 B2	03/03/2010
		JP 2010051034 A	04/03/2010
		JP 4858601 B2	18/01/2012
		JP 2009065693 A	26/03/2009
		JP 4893724 B2	07/03/2012
		JP 2009071865 A	02/04/2009
		JP 4968244 B2	04/07/2012
		KR 20040093749 A	08/11/2004
		KR 100786909 B1	17/12/2007
		WO 03084274 A1	09/10/2003
.....			
US 2011159881 A1	30/06/2011	US 8416738 B2	09/04/2013
		KR 20110075182 A	06/07/2011
.....			
US 2014148182 A1	29/05/2014	KR 20140067275 A	05/06/2014
		WO 2014081271 A1	30/05/2014
.....			

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2015/050144

CLASSIFICATION OF SUBJECT MATTER

IPC
H04B 7/04 (2006.01)
H04W 36/08 (2009.01)
H04L 5/14 (2006.01)