

**(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE**

(11) Application No. AU 2009292694 B2

(54) Title
Method and arrangement in a telecommunication system

(51) International Patent Classification(s)
H04W 16/26 (2009.01) **H04B 7/15** (2006.01)

(21) Application No: **2009292694** (22) Date of Filing: **2009.04.22**

(87) WIPO No: **WO10/033065**

(30) Priority Data

(31) Number **61/098,367** (32) Date **2008.09.19** (33) Country **US**

(43) Publication Date: **2010.03.25**
(44) Accepted Journal Date: **2014.08.07**

(71) Applicant(s)
Telefonaktiebolaget L M Ericsson (publ)

(72) Inventor(s)
Dahlman, Erik;Jading, Ylva;Parkvall, Stefan;Johansson, Niklas

(74) Agent / Attorney
Watermark Patent and Trade Marks Attorneys, Level 2 302 Burwood Road, HAWTHORN, VIC, 3122

(56) Related Art
US 2009/0252077
WO 2003/058984

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
25 March 2010 (25.03.2010)(10) International Publication Number
WO 2010/033065 A1(51) International Patent Classification:
H04W 16/26 (2009.01) *H04B 7/15* (2006.01)

(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, BR, BW, BY, BZ, CA, CH, 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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(21) International Application Number:
PCT/SE2009/050416(22) International Filing Date:
22 April 2009 (22.04.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/098,367 19 September 2008 (19.09.2008) US

(71) Applicant (for all designated States except US): TELEFONAKTIEBOLAGET L M ERICSSON (PUBL) [SE/SE]; S-164 83 Stockholm (SE).

(72) Inventors; and

(75) Inventors/Applicants (for US only): DAHLMAN, Erik [SE/SE]; Tackjärnvägen 12, S-168 68 Bromma (SE). JADING, Ylva [SE/SE]; Västmannagatan 81 B, S-113 26 Stockholm (SE). PARKVALL, Stefan [SE/SE]; Västmannagatan 53, S-113 25 Stockholm (SE). JOHANSSON, Niklas [SE/SE]; Töjnavägen 27A, S-191 34 Sollentuna (SE).

(74) Agent: HASSELGREN, Joakim; Ericsson AB, Patent Unit LTE, S-164 80 Stockholm (SE).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (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, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, 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 ARRANGEMENT IN A TELECOMMUNICATION SYSTEM

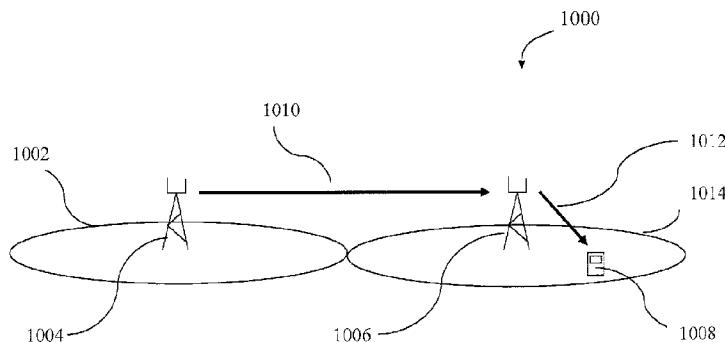


Figure 10

(57) Abstract: Method and apparatus for avoiding or reducing interference between transmissions (1010) from a donor eNB (1004) to a relay node (1006) and down link transmissions (1012) from the relay node to at least one mobile terminal (1008), where the transmissions take place in overlapping frequency bands. In the method, at least one interruption is created in a transmission from the relay node to the mobile terminal (s), and during the created interruption, a transmission from the donor eNB is received. This may result in an improved reception of the transmission from the eNB in the relay node.

Method and Arrangement in a Telecommunication System

TECHNICAL FIELD

5 The invention relates to a method and an arrangement in a telecommunication system, in particular to enable backwards compatible self-backhauling in an E-UTRAN (Evolved Universal Terrestrial Radio Access Network).

BACKGROUND

10 In certain situations it may be advantageous to extend the radio coverage of a cellular telecommunication system by using a wireless relay node, which is connected to a base station. The relay node may constitute one or more cells of its own, or may be used to extend the cells covered by the base station.

15 In e-UTRAN (Evolved Universal Terrestrial Radio Access Network), also known as LTE, self-backhauling is one of the relaying techniques which are considered to be included in the radio access network standard. The concept of self-backhauling 20 implies that a wireless base station is wirelessly connected to the remaining part of a network via another cell, sometimes called the anchor cell, here referred to as the donor cell. The donor cell is controlled by an eNB (evolved Node B), which here will be referred to as the donor eNB or donor node. The 25 donor eNB may also be called the anchor eNB. The wireless eNB will here be referred to as the relay node (RN) or relay. The relay may also be called the self-backhauled eNB or the s-eNB.

30 The use of wireless backhaul to a base station by means of, for example, a specific radio-link technology such as MiniLink, sometimes also called micro wave, has been used for many years. These specific technologies may, however, require additional transceiver equipment or specific, dedicated

frequency bands to operate in, and may also require line-of-sight conditions.

The concept of self-backhauling also implies that the link 5 between the donor eNB and the relay node, here referred to as the self-backhaul link, should be possible to operate in the same frequency spectrum, i.e. frequency-overlapped with, the radio access links that provide access for mobile terminals, also known as User Equipment(UEs), within the donor cell and 10 the UEs within the cell(s) controlled by the relay node. It is also typically assumed that the radio technology used for the self-backhaul link is basically similar to the one used within the donor cell and the cell(s) of the relay node respectively, possibly with some additional extensions to optimize for the 15 backhaul application. For example, in case the donor eNB and the relay node use the LTE radio access technology for communicating with UEs within their cell(s), the self-backhaul link should also be LTE-based, or at least based on an LTE-like radio technology. Signals which overlap in frequency 20 interfere with each other, which may obstruct reception of the signals.

SUMMARY

As it is desirable to obtain a satisfactory reception of the 25 self-backhaul link at the relay node the present invention provides a mechanism for enabling avoidance or reduction of the interference which may occur when a self-backhaul link between a donor eNB and a relay node and radio access links within the cell(s) controlled by the relay node operate in the 30 same frequency spectrum. These objects are met by a method and apparatus according to the attached independent claims.

According to one aspect, a method is provided in a relay node in a wireless communication system for avoiding or reducing

interference between transmissions from a donor eNB to the relay node and downlink transmissions from the relay node to at least one mobile terminal connected to the relay node. In the method, at least one interruption is created in said 5 transmission from the relay node to the mobile terminal(s), and a transmission is received from the donor eNB during said at least one created interruption.

According to another aspect, a relay node is provided in a 10 wireless communication system, and adapted to avoid or reduce interference between transmissions from a donor eNB to the relay node and downlink transmissions from the relay node to at least one mobile terminal connected to the relay node. The relay node comprises an interference avoiding unit, which is 15 adapted to create at least one interruption in the transmission from the relay node to the mobile terminal(s). The relay node further comprises a receiving unit, which is adapted to receive a transmission from the donor eNB during the interruption(s).

20 According to yet another aspect, a donor eNB connected to a relay node, such as the one described earlier in a wireless communication system, is adapted to avoid or reduce interference between transmissions from the donor eNB to the 25 relay node and downlink transmissions from the relay node to at least one mobile terminal connected to the relay node. The donor eNB comprises a time-shifting unit which is adapted to shift subframes destined for the relay node one or more OFDM symbol durations in time relative to the relay node downlink 30 subframes. The donor eNB further comprises a transmitting unit, which is adapted to transmit the time-shifted subframes or other subframes to the relay node.

According to yet another aspect, an arrangement is provided and adapted to avoid or reduce interference in a wireless communication system. The arrangement comprises an eNB controlling a donor cell, and a relay node. When at least one 5 mobile terminal connected to the relay node, the relay node is configured to create at least one interruption in a transmission to the mobile terminal(s), and to receive a transmission from the eNB controlling the donor cell during the interruption(s).

10

In the different aspects above, the transmissions from the donor eNB to the relay node and the downlink transmissions from the relay node to the mobile terminal(s) take place in overlapping frequency bands, which is one reason why these 15 transmissions can interfere with each other.

Various embodiments are possible for the method, nodes and arrangement described above. In one exemplary embodiment, the transmission interruption is created by using a downlink 20 transmission subframe format that is known to legacy mobile terminals. When the format is known to legacy users, the embodiment is backwards compatible and may be used by both legacy users and other users, which is an advantage since it may take some time before all users have changed their legacy 25 equipment to a new or upgraded version after a system upgrade.

In another embodiment, the interruption could be created by using a downlink transmission subframe format, in which the subframe contents are limited to reference symbols and control 30 signalling, which are allocated in less than 3 OFDM symbols of the subframe. The interruption could also be created by using the MBSFN-subframe format, which is also known to legacy mobile terminals, therefore not requiring modification of the legacy mobile terminals.

In one embodiment, the subframes of the transmission from the donor eNB to the relay node are time-shifted one or more OFDM symbol durations relative to the downlink subframes. This 5 embodiment can enable avoidance or reduction of interference between the first part of the subframes of the radio access link and selected parts of the subframes of self-backhaul link. The number of OFDM symbol durations of the time shift may for example be selected based on the duration of a control 10 region used in the subframes within the cells of the relay node. Thereby, the first part of the subframes of the self-backhaul link will basically not be subject to interference from the first part of the subframes of the radio access link, which may improve the performance. However, some other part, 15 e.g. the last part, of the subframes of the self-backhaul link will be subject to interference instead.

Further, in one embodiment, a last part of at least one subframe of the transmission from the donor eNB to the relay 20 node could be left unused for transmission. This embodiment can enable further avoidance or reduction of interference between the self-backhaul link and the radio access links. The time length of the unused part may for example depend on the number of OFDM symbol durations of a time shift of the 25 subframe.

For any of the embodiments, the number of created downlink transmission interruptions can vary from several interruptions per radio frame to less than one interruption per radio frame. 30

In one embodiment, it is the relay node that decides at which point in time the interruptions should be created and that informs the concerned mobile terminals of during which time interval an interruption will be created in the downlink

transmission. If necessary, the relay node also informs the donor eNB of during which time interval an interruption will be created in the downlink transmission. It may not be necessary to inform the eNB if the relay node knows or is able 5 to predict when the donor eNB will transmit on the self-backhaul link.

In another embodiment, it is the donor eNB that decides at which point in time the interruptions should be created and 10 informs the relay node about when the relay node should create interruptions. In that case, the relay node informs the concerned mobile terminals of during which time interval an interruption will be created in the downlink transmission.

15 The different features of the exemplary embodiments above may be combined in different ways according to need, requirements or preference.

BRIEF DESCRIPTION OF THE DRAWINGS

20 The invention will now be explained in more detail by means of exemplary embodiments and with reference to the accompanying drawings, in which:

25 -Figure 1 is a schematic view illustrating a self-backhaul link being subject to interference.

-Figure 2 is a flow chart illustrating an embodiment of procedure steps in a relay node for avoiding or reducing interference.

30 -Figures 3-4 illustrate different subframe structures, which can be used in the described embodiments.

-Figures 5-7 illustrate embodiments of inter-link relations when using embodiments of the described procedure for avoiding or reducing interference.

-Figures 8-9 are block diagrams illustrating embodiments of a relay node and a donor eNB.

-Figure 10 is a schematic view illustrating an arrangement according to one embodiment.

5

DETAILED DESCRIPTION

The invention can be used to avoid or reduce interference between transmissions over a self-backhauling link and transmissions between one of the nodes connected to the self-
10 backhaul link and the UEs served by the cell(s) controlled by said node.

The invention is particularly useful where the transmissions, at least partly, take place in the same frequency spectrum and where it is desired that the communication is backwards
15 compatible for legacy UEs, i.e. UEs communicating according to an earlier version of a transmission standard or protocol or the like. The present invention may also be used to avoid or reduce interference in other, similar situations.

20 It may be desirable for network operators to use the same or overlapping frequency bands for the self-backhaul link and for the communication within the cells of the donor and/or the relay node, for several reasons. One of the reasons is that the need for access to any additional frequency bands,
25 dedicated to the backhaul link, is set aside. Acquiring additional frequencies may not be possible or may be expensive. Further, the need for additional frequency-specific or link-specific equipment, dedicated for communication over the backhaul link, is reduced. Further, the use of self-
30 backhauling may also enable non line-of-sight transmission, which may be useful in many situations.

The invention addresses the problem of the interference which would most likely occur when overlapping frequency bands are

used for the self-backhaul link and for the relay-to-UE transmissions within the cell(s) controlled by the relay node respectively. This problem is illustrated in figure 1 as follows:

5 A donor eNB 104 transmits to a relay node 106 on a self-backhaul link 110 at the same time as the relay transmits to a UE 108 within one of its own cells. The relay node then "overhears" its own transmission 112 to the UE, which "overheard" transmission 112 then interferes 116 with the
10 incoming transmission from the donor cell. This results in that the relay node may not be able to detect the incoming transmission from the donor cell properly, and thereby may fail to secure important information.

15 The above described interference can, however, be avoided by inserting transmission interruptions in the downlink transmission 112 from the relay node 106 to the UE 108. These interruptions can be regarded as "holes" or "gaps" of a certain duration in the transmission, during which "holes" or
20 "gaps" the relay may receive incoming transmissions on the self-backhaul link 110 without severe interference from the downlink transmissions 112 within the cell(s) controlled by the relay. This can also be described as time multiplexing between the self-backhaul link and the access link in the
25 cell(s) of the relay node.

Transmission interruptions can be implemented in different ways. However, it is highly desirable to make the implementation backwards compatible for legacy UEs, i.e. fully
30 aligned with downlink transmission schemes as defined in earlier versions of a transmission protocol, as for example in Release 8 of the 3GPP-specifications for the LTE standard, where the interference problem described above did not occur, since no self-backhaul links were considered in that version.

Backwards compatibility enables legacy UEs to act according to a previous version of the transmission protocol, and still be able to communicate with UEs and nodes which act according to a more recent, considerably changed version of the 5 transmission protocol, e.g. Release 10 of the 3GPP-specifications for the LTE standard. In a backwards compatible system, the legacy UEs do not necessarily have to "be aware" of the new version or be upgraded or adapted to the new version, which is an advantage.

10

Therefore, the interruptions in the downlink should preferably be created in a way which is backwards compatible for legacy UEs. The challenge with this is that the legacy UEs expect a certain format in the downlink transmissions, which should not 15 be diverged from. Changing the expected format would require changes to be made in the earlier version of the transmission protocol, which is troublesome and undesirable.

An ordinary LTE Release 8 subframe is illustrated in figure 20 3a. This is the subframe format which is normally expected by the legacy UEs. An LTE-subframe has a duration of 1 ms, which typically equals the duration of 14 OFDM symbols (Orthogonal Frequency Division Multiplexing). Typically, the first 1-3 OFDM symbols of the subframe are used for control information. 25 Further, in these ordinary unicast subframes there are several mandatory reference symbols, e.g. evenly distributed over the frequency-time-grid. These reference symbols may be used by a receiving unit, e.g. for estimating the channels over which the transmitted symbols propagate.

30

In one embodiment, the interruptions in the relay downlink transmission are created by the use of MBSFN-subframes (Multicast/Broadcast Single Frequency Network). Certain downlink subframes are then defined as being MBSFN-subframes.

The MBSFN-subframes are known to legacy UEs, e.g. Release 8, but are known to be used in a very different situation, i.e. for MBSFN-transmissions.

5 An MBSFN-subframe is illustrated in figure 3b and figure 4. Typically, the first two OFDM-symbols of an MBSFN-subframe are defined to comprise reference symbols and control information. These two first symbols constitute the [cell specific] control region, or unicast region. The contents of the remaining part
10 of the MBSFN-subframe are not specified. This means that it is possible to leave out the distributed reference symbols, which are mandatory in ordinary LTE-downlink-subframes. Thereby, a major part 406 of the MBSFN-subframe may be left empty, i.e. left unused for transmission. This empty part 406 of the
15 MBSFN-subframe may be regarded as a transmission interruption or a "hole" or "gap" in the transmission for a certain time interval. This interruption or pause in the downlink transmission gives the relay an opportunity to receive a transmission from the donor eNB during the corresponding time
20 interval, without suffering from interference from the downlink.

The unicast region 404, comprises reference symbols in the first OFDM-symbol of the subframe in the case of 2-antenna-
25 port transmission, and in the first and second OFDM-symbol of the subframe in the case of 4-antenna-port transmission. In addition to containing the reference symbols, this region is also completely or partly used for L1/L2 control signalling, i.e. HARQ (Hybrid Automatic Repeat reQuest) acknowledgements
30 and scheduling grants. If not told otherwise, the legacy UEs will ignore all but the unicast region of the MBSFN-subframes.

The number of downlink subframes that are defined as MBSFN-subframes can vary from several subframes per frame to less

than one subframe per frame, e.g. one subframe every fourth frame. The number of MBSFN-subframes may for example vary in accordance with the amount of communication on the self-backhauling link. In general, one frame or radio frame 5 comprises 10 subframes.

In one embodiment, the relay node decides which subframes that are suitable to be defined as MBSFN-subframes. The relay node then communicates to the donor eNB and the concerned UEs at 10 which point in time the MBSFN-subframes will be transmitted on the downlink. Thereby, the donor eNB "knows" during which time interval it is advantageous/suitable to transmit to the relay on the self-backhaul link.

15 In another embodiment of the present invention, the donor eNB decides when to transmit to the relay node on the self-backhaul link and which subframes that should be defined as MBSFN-subframes in the relay node. The donor eNB then communicates to the relay node at which point in time to 20 transmit MBSFN-subframes on the downlink, and the relay node informs the UEs about the MBSFN-subframes. The relay then "knows" during which time interval or at which point in time to expect transmissions on the self-backhauling link, since the donor eNB transmits on the self-backhauling link during 25 the time interval corresponding to the relay downlink transmission of the MBSFN-subframes.

In another embodiment, the occurrences of transmissions from the donor eNB on the self-backhaul link are known or 30 predictable to the relay node. For example, they may be scheduled in a certain way, which is known to the relay node or can be predicted by the relay node. The relay node may then adapt to the transmissions from the donor eNB by inserting MBSFN-subframes in the downlink when an incoming transmission

on the self-backhaul link is expected. The relay node also informs the UEs of at which point in time to expect MBSFN-subframes. In this embodiment, the donor eNB may be unaware of the insertion of MBSFN-subframes.

5

In cases when both the self-backhaul link and the RN-to-UE links are LTE-based and have the same subframe structure, the control region of the relay downlink transmissions 508 will severely interfere with the corresponding part 506 of the 10 self-backhaul transmission as illustrated in figure 5. This could be a problem, especially when the corresponding part of the self-backhaul transmission is considered to be particularly important. To avoid or reduce this interference between the first parts of the subframes, the self-backhaul 15 link can be staggered in time, i.e. time-shifted, as outlined in figure 6. If the length of the control region 608 in the subframes transmitted on the relay downlink is one OFDM-symbol, the staggering 604 should be at least one OFDM-symbol duration. Similarly, if the length of the control region 608 20 in the subframes transmitted on the relay node downlink is two OFDM-symbols, the staggering 604 should be at least two OFDM-symbol durations.

25 The use of staggering will avoid or reduce the interference problem in the first part of the subframes on the self-backhaul link, but it will move the interference to another part of the subframe. For example, the last part 606 of a subframe on the self-backhauling link may be severely interfered by a subsequent subframe transmission within the 30 cell(s) of the relay.

The above described interference can be avoided in another possible embodiment, illustrated in figure 7. When the interference from the relay downlink occurs in the last part

of the subframes of the self-backhaul link, the subframe length may be shortened on the self-backhaul link in order to avoid or reduce the interference. In other words, the length of the subframes may depend on the amount of staggering 704, 5 which in turn may depend on e.g. the length of the unicast region 708 in the subframes of the relay downlink. Thus, the donor eNB refrains from transmitting on the self-backhaul link during said last part 706 of a regular subframe duration, as illustrated in figure 7.

10

Alternatively, the donor eNB transmits also during the last part of the subframe on the self-backhaul link and it is assumed that the channel coding applied to the self-backhaul link will be sufficient to overcome the interference.

15

Figures 5-7 show a plurality of consecutive MBSFN-subframes and "self-backhaul-subframes", which are partially subject to interference. However, the creation of interruptions in the downlink and the transmission on the self-backhauling link is 20 not limited to this scenario, as stated earlier. The number of downlink subframes which comprise an interruption can vary from several subframes per frame to less than one subframe per frame. The number of subframes received from the donor eNB on the self-backhaul link may vary in a corresponding way.

25

Figure 8 illustrates a relay node 800 in a wireless communication system according to one embodiment. The relay node 800 is adapted to avoiding or reducing interference between transmissions 808 from a donor eNB to the relay node 30 and downlink transmissions 806 from the relay node 800 to at least one mobile terminal (not shown) connected to the relay node. The relay node 800 comprises an interference avoiding unit 802, which is adapted to create at least one interruption in the transmission 806 from the relay node 800 to the mobile

terminal(s). The relay node 800 further comprises a receiving unit 804, which is adapted to receive a transmission 808 from the donor eNB during the interruption(s).

5 Figure 9 illustrates a donor eNB 900, which is connected to a relay node (not shown) in a wireless communication system according to one embodiment. The donor eNB 900 is adapted to avoid or reduce interference between transmissions 906 from the donor eNB to the relay node and downlink transmissions 10 (not shown) from the relay node to at least one mobile terminal (not shown) connected to the relay node. The donor eNB comprises a time-shifting unit 902, which is adapted to shift subframes destined for the relay node one or more OFDM symbol durations in time relative to the relay node downlink 15 subframes. The donor eNB 900 further comprises a transmitting unit 904, which is adapted to transmit the time-shifted subframes or other subframes to the relay node.

It should be noted that figures 8 and 9 merely illustrate 20 various functional units in the relay node 800 and the eNB 900 in a logical sense. However, the skilled person is free to implement these functions in practice using any suitable software and hardware means. Thus, the invention is generally not limited to the shown structure of the relay node 800 and 25 the eNB 900.

Figure 10 illustrates an arrangement 1000 according to one embodiment. The arrangement 1000 is adapted to avoiding or reducing interference in a wireless communication system. The 30 arrangement comprises an eNB 1004 controlling a donor cell 1002, and a relay node 1006. When at least one mobile terminal 1008 is connected to the relay node, the relay node is configured to create at least one interruption in a transmission 1012 to the mobile terminal(s) 1008, and to

receive a transmission 1010 from the eNB 1004 controlling the donor cell 1002 during the created interruption(s).

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Method in a relay node in a wireless communication system, for avoiding or reducing interference between transmissions from a donor evolved Node B, donor eNB, to the relay node and downlink transmissions from the relay node to at least one mobile terminal connected to the relay node, the method including the following steps:

5 -creating at least one interruption in said downlink transmissions from the relay node to the at least one mobile terminal;

10 -receiving transmissions from the donor eNB during said at least one interruption,

wherein said transmissions take place in overlapping frequency bands, and wherein said at least one interruption is created by using a Multicast/Broadcast Single Frequency Network-subframe format, MBSFN-subframe format.

15 2. The method according to claim 1, wherein said at least one interruption is created by using the MBSFN-subframe format known to legacy mobile terminals i.e. backwards compatibility enabled mobile terminals.

3. The method according to claim 1 or claim 2, wherein said at least one interruption is created by using the MBSFN-subframe format, in which the 20 subframe contents are limited to reference symbols and control signalling, which are allocated in less than 3 OFDM symbols of the subframe.

4. The method according to any one of the claims 1-3, wherein the subframes of the transmission from the donor eNB to the relay node are time-shifted one or more OFDM symbol durations relative to the downlink subframes.

25 5. The method according to claim 4, wherein the number of OFDM symbol durations of the time shift is selected based on the duration of a control region used in subframes within the cells of the relay node.

6. The method according to claim 4 or 5, wherein a last part of at least one subframe of the transmission from the donor eNB to the relay node is left unused for transmission.
7. The method according to claim 6, wherein the time length of the unused part depends on the number of OFDM symbol durations of the time shift of the subframe.
8. The method according to any one of the claims 1-7, wherein the number of said downlink interruptions can vary from several interruptions per radio frame to less than one interruption per radio frame
9. The method according to any one of the claims 1-8, wherein the relay node decides at which point in time the interruptions should be created and, wherein the relay node informs the concerned mobile terminals and, if necessary, the donor eNB of during which time interval an interruption will be created in the downlink transmission.
10. The method according to any one of the claims 1-8, wherein the relay node is informed by the donor eNB of at which point in time the interruptions should be created and, wherein the relay node informs the concerned mobile terminals of during which time interval an interruption will be created in the downlink transmission.
11. Relay node in a wireless communication system, said relay node adapted to avoiding or reducing interference between transmissions from a donor evolved Node B, donor eNB, to the relay node and downlink transmissions from the relay node to at least one mobile terminal connected to the relay node, said relay node including:
 - an interference avoiding unit adapted to create at least one interruption in said downlink transmissions from the relay node to the at least one mobile terminal;
 - a receiving unit adapted to receive transmissions from the donor eNB during said at least one interruption,

wherein said transmissions take place in overlapping frequency bands, and wherein said at least one interruption is created by using a Multicast/Broadcast Single Frequency Network-subframe format, MBSFN-subframe format.

- 5 12. The relay node according to claim 11, wherein the interference avoiding unit is further adapted to create said at least one interruption by using the MBSFN-subframe format known to legacy mobile terminals i.e. backwards compatibility enabled mobile terminals.
- 10 13. The relay node according to claim 11 or claim 12, wherein the interference avoiding unit is further adapted to create said at least one interruption by using the MBSFN-subframe format, in which the subframe contents are limited to reference symbols and control signalling, which are allocated in less than 3 OFDM symbols of the subframe.
- 15 14. The relay node according to any one of the claims 11-13, wherein the receiving unit is further adapted to receive subframes of the transmission from the donor eNB to the relay node, which are time-shifted one or more OFDM symbol durations relative to the downlink subframes.
- 20 15. The relay node according to claim 14, wherein the receiving unit is further adapted to receive subframes in which the number of OFDM symbol durations of the time shift is selected based on the duration of a control region used in subframes within the cells of the relay node.
- 25 16. The relay node according to claim 14 or 15, wherein the receiving unit is further adapted to receive subframes in which a lastpart of at least one subframe of the transmission from the donor eNB to the relay eNB is left unused for transmission.
17. The relay node according to claim 16, wherein the receiving unit is further adapted to receive subframes in which the time length of the unused part

depends on the number of OFDM symbol durations of the time shift of the subframe.

18. The relay node according to any one of the claims 11-17, wherein the interference avoiding unit is further adapted to being able to vary the number of

5 said downlink interruptions from several interruptions per radio frame to less than one interruption per radio frame.

19. The relay node according to any one of the claims 11-18, wherein the relay node is adapted to decide at which point in time the interruptions should be created and, wherein the relay node is further adapted to inform the concerned

10 mobile terminals and, if necessary, the donor eNB of during which time interval an interruption will be created in the downlink transmission.

20. The relay node according to any one of the claims 11-18, wherein the relay node is adapted to be informed by the donor eNB of at which point in time the interruptions should be created and, wherein the relay node is further adapted

15 to inform the concerned mobile terminals of during which time interval an interruption will be created in the downlink transmission

21. Donor evolved Node B, donor eNB connected to a relay node as the one described in claim 11 in a wireless communication system, said donor eNB adapted to avoid or reduce interference between transmissions from the donor

20 eNB to the relay node and downlink transmissions from the relay node to at least one mobile terminal connected to the relay node, said donor eNB including:

-a time-shifting unit adapted to shift subframes destined for the relay node one or more OFDM symbol durations in time relative to the relay node downlink subframes,

25 -a transmitting unit adapted to transmit said time-shifted subframes or other subframes to the relay node.

22. The donor eNB according to claim 21, wherein the time- shifting unit is further adapted to select the number of OFDM symbol durations of the time shift

based on the duration of a control region used in subframes within the cells of the relay node.

23. The donor eNB according to claim 21 or claim 22, further including:

-a transmit duration shortening unit adapted to leave a last part of at least

5 one subframe of the transmission from the donor eNB to the relay node unused for transmission.

24. The donor eNB according to claim 23, wherein the transmit duration shortening unit is further adapted to make the time length of the unused part depend on the number of OFDM symbol durations of the time shift of the
10 subframe.

25. The donor eNB according to claim 21-24, wherein the transmitting unit is further adapted to being able to vary the number of subframes sent to the relay station from several per radio frame to less than one subframe per radio frame.

26. The donor eNB according to claim 21-25, wherein the donor eNB is
15 adapted to being informed by the relay node of during which time interval an interruption will be created in the relay node downlink transmission.

27. The donor eNB according to claim 21-25, wherein the donor eNB is adapted to decide at which point in time the relay node downlink interruptions should be created and, wherein the donor eNB is further adapted to inform the
20 relay node of when to create the interruptions in said downlink transmission.

28. Arrangement adapted to avoid or reduce interference in a wireless communication system including:

-an evolved Node B, eNB, controlling a donor cell, and

-a relay node,

25 wherein when at least one mobile terminal is connected to the relay node, the relay node is configured to:

-create at least one interruption in a transmission to the mobile terminal(s);

-receive a transmission from the eNB controlling the donor cell during said at least one interruption,

wherein said transmissions take place in overlapping frequency bands, and wherein said at least one interruption is created by using a

5 Multicast/Broadcast Single Frequency Network-subframe format, MBSFN-subframe format.

TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)

WATERMARK PATENT AND TRADE MARKS ATTORNEYS

P34254AU00

1/7

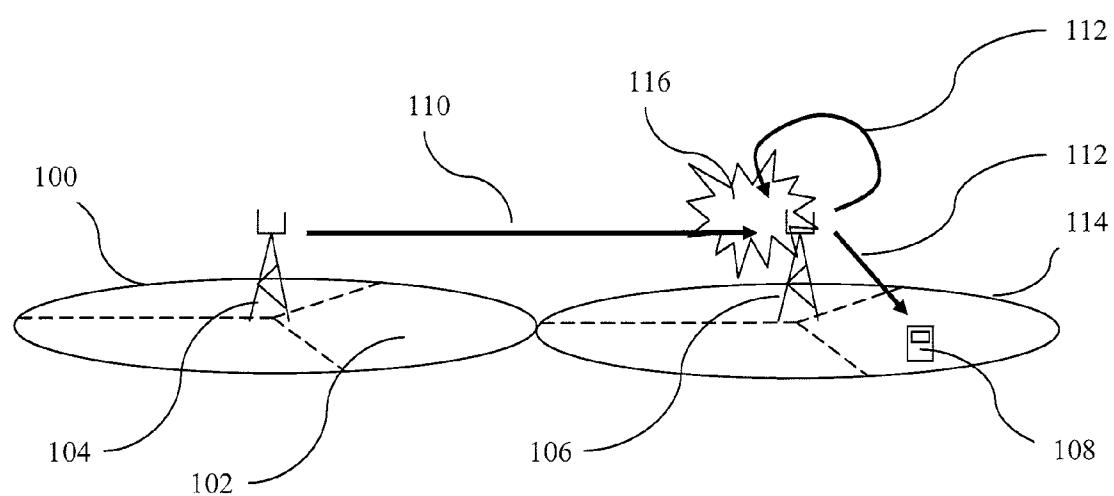


Figure 1

2/7

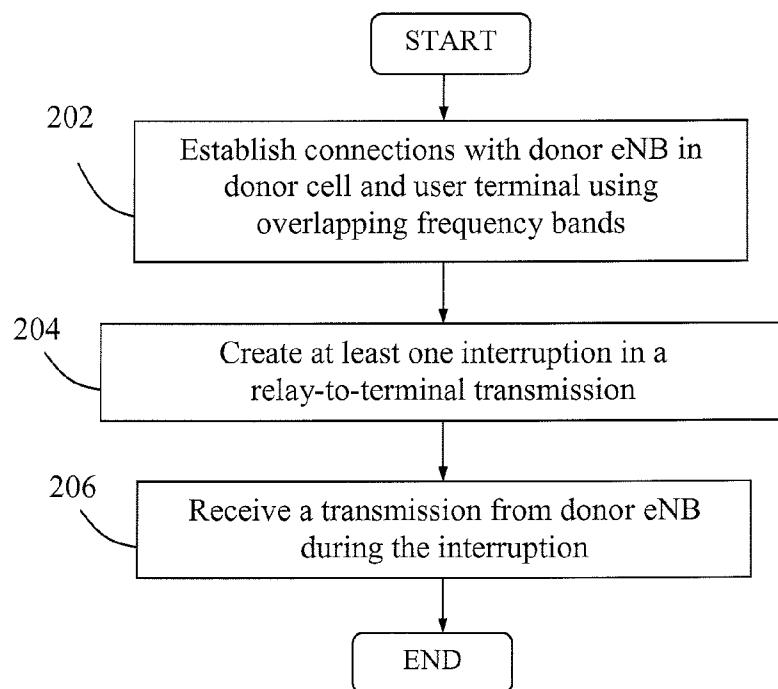


Figure 2

3/7

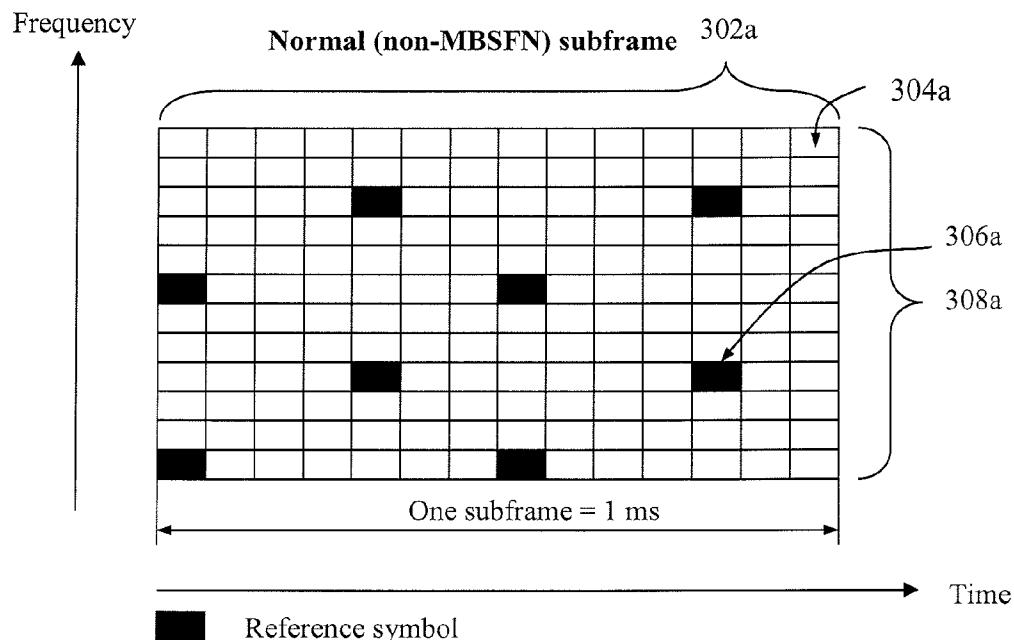


Figure 3a

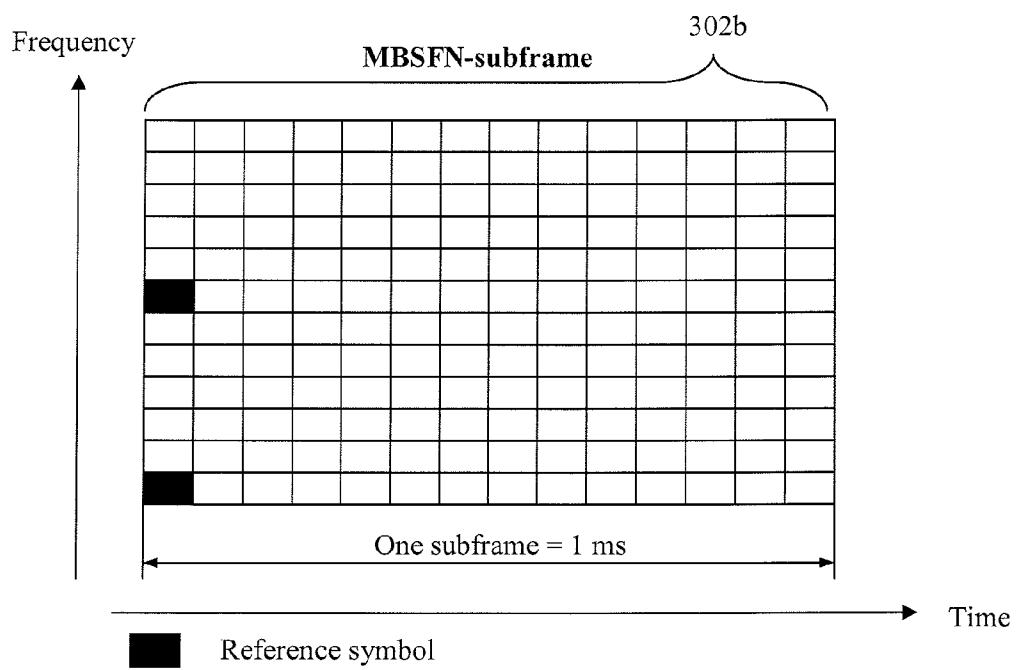


Figure 3b

4/7

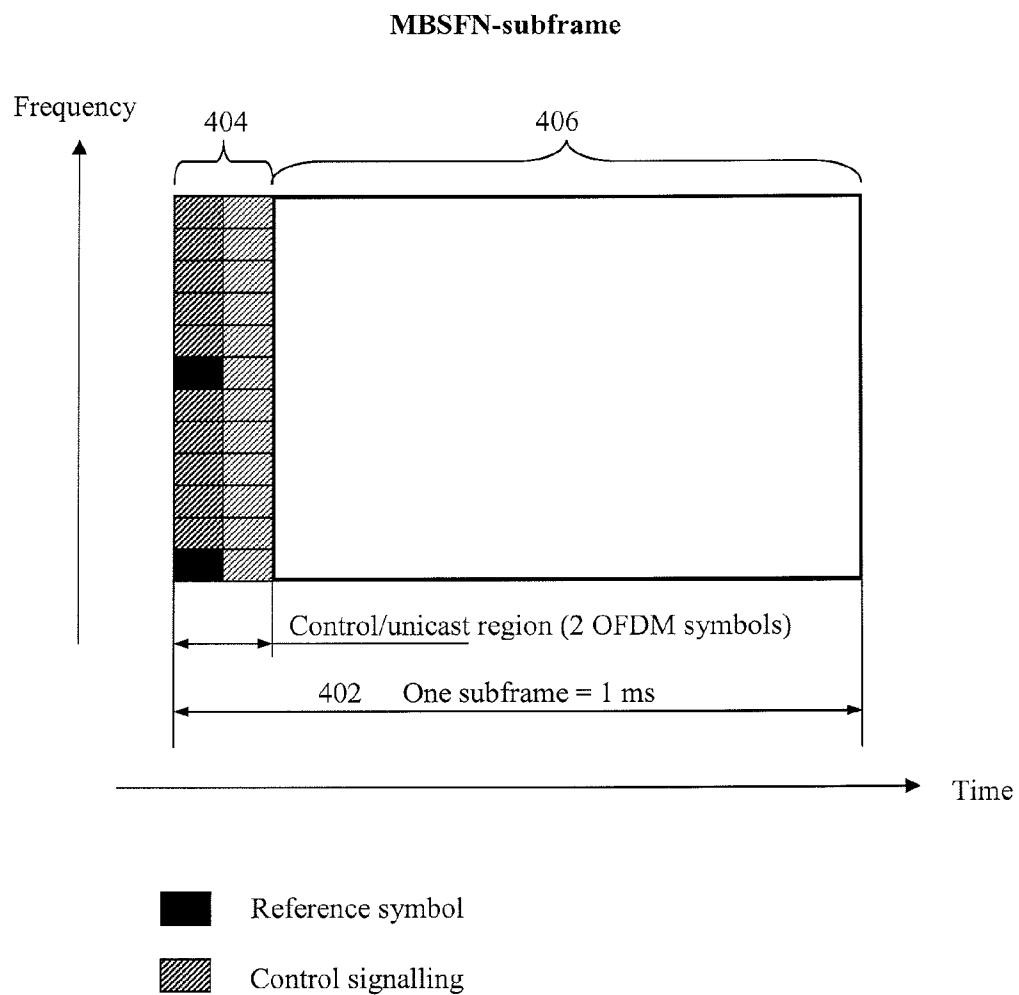


Figure 4

5/7

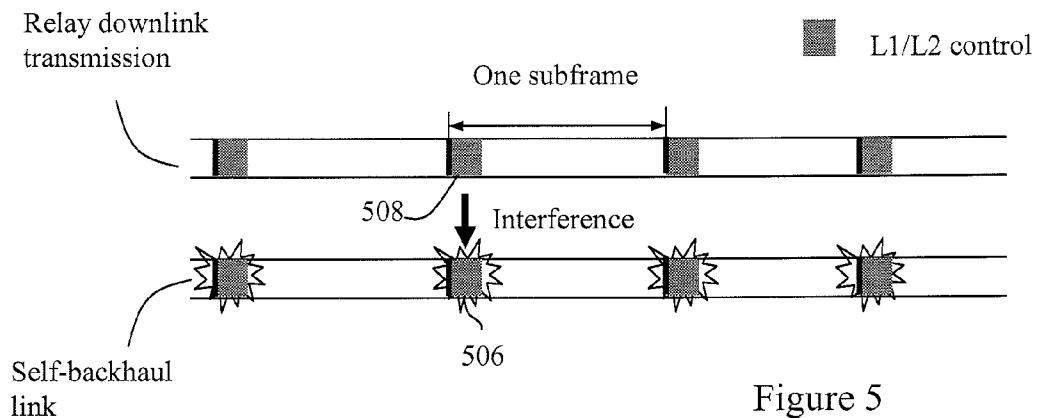


Figure 5

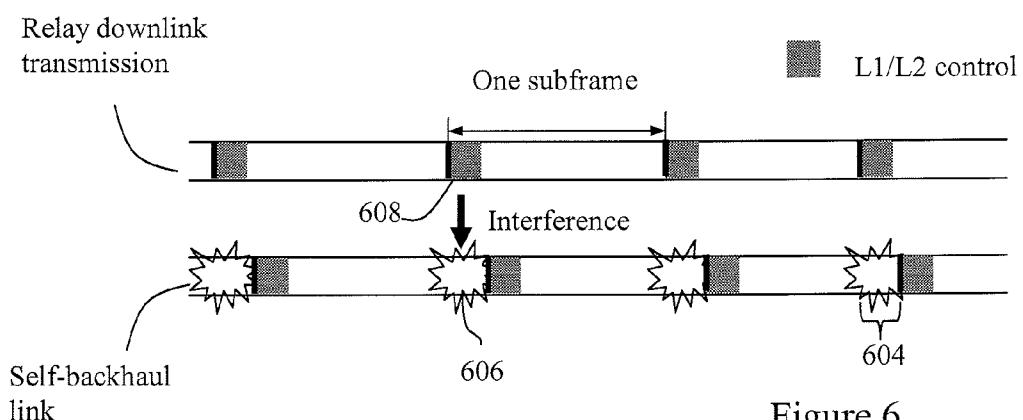


Figure 6

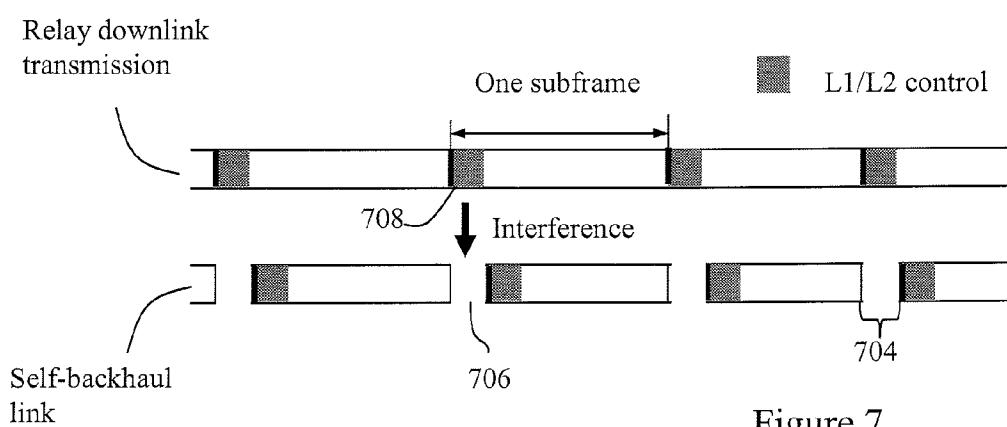


Figure 7

6/7

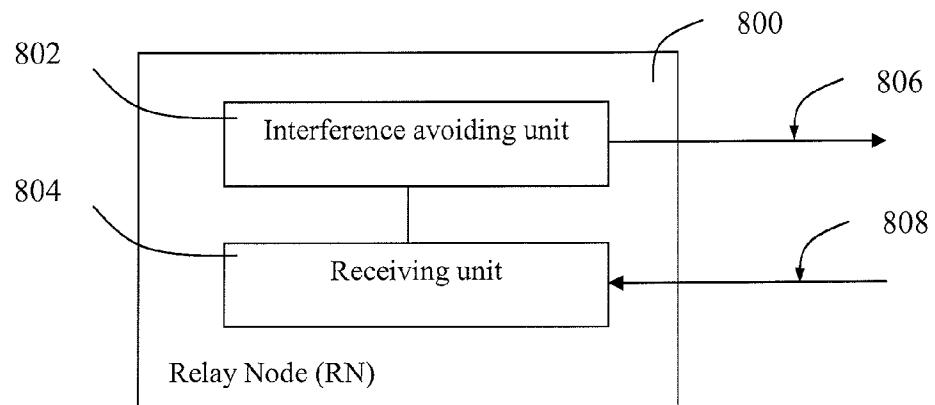


Figure 8

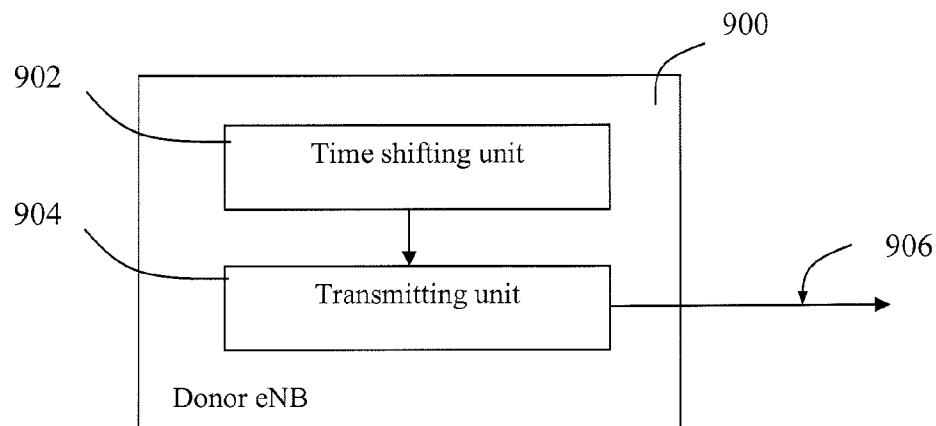


Figure 9

7/7

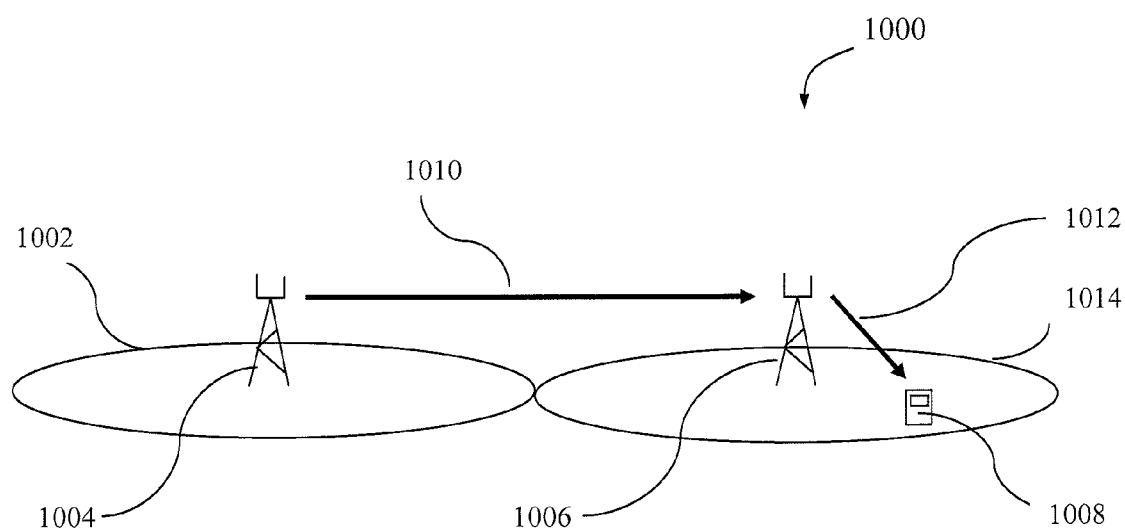


Figure 10