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- (54) **Title:** IMPROVED MACRO DIVERSITY HANDOVER IN WIRELESS MULTI-HOP RELAY- NETWORKS

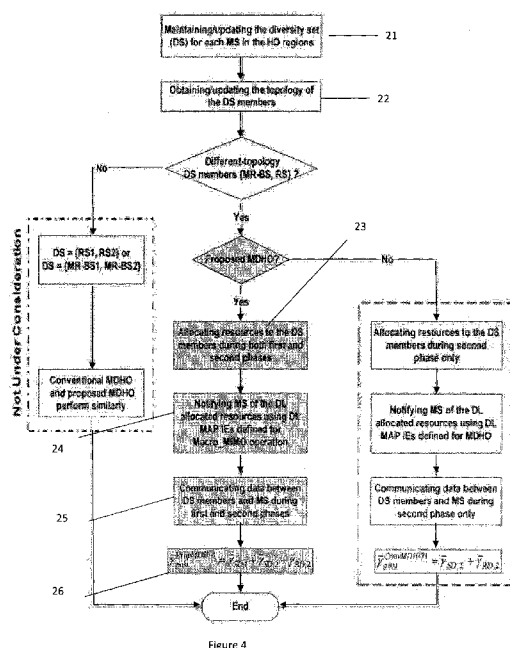


Figure 4

- (57) **Abstract:** A method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks comprising the steps of main-
taining (21) a diversity set for each mobile station (MS) (11) in the handover regions, establishing (22) the topology of the diversity set members, allocat-
ing (23) resources to the diversity set members for both first and second phases, notifying (24) the MS of the allocated resource, communicating (25) between the diversity set members and MS during both first and second phases; and combining (26) the signals received during the first and second phase from the diversity set members.



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**Improved Macro Diversity Handover in Wireless Multi-Hop Relay
Networks**

Field of Invention

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The present invention relates generally to wireless cellular networks, more particularly to a method for an improved macro diversity handover technique for multi-hop relay networks.

10 Background of the Invention

In wireless communication systems which involve mobile applications, the handover procedure has a significant impact on the system's performance. A handover process which is also
15 known as a handoff can be defined as a transfer communication services from one access station to a target access station as mobility causes dynamic variations in link quality and interference levels in cellular systems, sometimes requiring that a particular user changes its serving station. A Macro
20 Diversity Handover (MDHO) is referred to a process in which a mobile station (MS) communicates simultaneously with at least two access stations. A diversity set members is the access stations which are involved with mobile station (MS) in Macro Diversity Handover (MDHO). Due to the introduction of relay
25 station (RS) in the multi-hop relay (MR) network infrastructure, the diversity set members can be a multi-hop

relay base station (MR-BS) and RS, two different RSs or two different MR-BSs.

In the conventional Macro Diversity Handover (MDHO), only the simultaneous transmissions of the diversity set members are received by the mobile station (MS) despite the topology of the diversity set members. Whenever the diversity set members are MR-BS and RS, the signal transmitted by the MR-BS during the first phase is not exploited by the MS even though the MS is idle in this phase. Hence, the topology of the diversity set members is not fully exploited. This causes low diversity gain, low received signal strength and high bit error rate (BER), which result in low performance of the MS in the handover regions.

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Therefore the present invention provides an efficient macro diversity handover (MDHO) technique for multi-hop wireless relay networks to overcome the above-mentioned drawbacks. In the present efficient MDHO technique, the MS received the signal transmitted by the MR-BS during the first phase in addition to the simultaneous transmissions of the MR-BS and RS occur during the second phase whenever the MR-BS and RS are included into the diversity set of the MS. The present technique also performs similarly as the conventional MDHO whenever two RSs or two MR-BSs are the diversity set members of the MS. Thus, the topology of the diversity set members is

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fully exploited. This will then increase the diversity gain and the received signal strength and decreases the BER, which are important in enhancing the performance of the MS in the handover regions.

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Other objects of this invention will become apparent on the reading of this entire disclosure.

Summary of the Invention

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In the present invention, a method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks, the method comprising the steps of maintaining a diversity set for each mobile station (MS) in the handover regions, in which
15 each diversity set includes at least two different-topology access stations that can communicate with the associated mobile station (MS), establishing the topology of the diversity set members, allocating resources to the diversity set members for both first and second phases, notifying the
20 mobile station (MS) of the allocated resources, communicating between the diversity set members and MS during both first and second phases, and combining the signals received during the first and second phase from the diversity set members.

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Brief Description of the Drawings

Other objects, features, and advantages of the invention will be apparent from the following description when read with
5 reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

Figure 1a shows a schematic diagram of the improved MDHO
10 system of the present invention with the diversity set members are MR-BS1 and 2-hop RS1;

Figure 1b shows a schematic diagram of the improved MDHO
system of the present invention with the diversity set members
15 are MR-BS1 and n-hop RS1;

Figure 2 illustrates a schematic diagram of the MDHO scenarios in multi-hop relay networks of the present invention;

20 Figure 3 is a schematic diagram of a conventional MDHO with the diversity set members are MR-BS1 and RS1; and

Figure 4 depicts a flowchart of a method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks of
25 the present invention.

Detailed Description of the Preferred Embodiments

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those of ordinary skill in the art that the invention may be practiced without these specific details. In other instances, well-known methods, procedures and/or components have not been described in detail so as not to obscure the invention. Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

The macro diversity handover (MDHO) is the process in which the MS communicates simultaneously with at least two access stations as shown in Figure 1. The access station can be a MR-BS or RS and this access stations list is called a diversity set and is maintained by the MS and MR-BS for each MS in the handover regions. In the uplink (UL), MDHO is accomplished by having at least two access stations receiving the same protocol data unit (PDU) from the MS such that the selection diversity of the received PDU is performed among the access stations. In the downlink (DL), MDHO is accomplished by having at least two access stations transmitting the same MAC/PHY PDU to the MS such that diversity combining can be performed.

In the present invention, the improved macro diversity handover (MDHO) system for multi-hop relay networks can be applied to two hop wireless relay networks in which the diversity set size is two and can easily be extended to the scenarios involving more than two hop relay stations and/or diversity set size of more than two. Figure 1 shows an improved topology-aware MDHO (10) of the present invention in two scenarios, namely where the diversity set members are multi-hop relay base station (MR-BS1) (12) and two hop relay station (2 hop RS1) (13) shown in Figure 1a and where the diversity set members are multi-hop relay base station (MR-BS1) (12) and n-hop relay stations (n-hop RS) shown in Figure 1b.

In the present improved MDHO system (10), the mobile station (MS) (11) listens to both the transmission of the MR-BS1 (12) occurs during the first phase and the simultaneous transmissions of the MR-BS1 (12) and RS1 (13) occur during the second phase as shown in Figure 1a. While for n-hop relay networks, the transmission sequences during the n phases are shown in Figure 1b. Therefore, the topology of the diversity set members is fully exploited and the performance of the MDHO is improved.

The general handover method performs network topology advertisement which is followed by allocating scanning

intervals to the MSs. The MDHO capability can be enabled or disabled in the REG-REQ/RSP message exchange. With MDHO enabled, the MS performs the stages which include the MDHO decision and initiation, diversity set selection or updates, anchor station selection or update and MDHO execution and termination.

The MR-BS and RS supporting MDHO shall broadcast downlink channel descriptor (DCD) message that includes the H_Add Threshold and H_Delete Threshold. These thresholds are used by the MDHO capable MS to determine if the MOB_MSHO-REQ message should be sent. If the long-term carrier to interference and noise ratio (CINR) of the neighbor MR-BS or RS is higher than H_ADD Threshold, then the MS sends the MOB_MSHO-REQ message to request adding this neighbor station to the diversity set. If the long-term CINR of the access MR-BS or RS, currently in the diversity set, is less than H_Delete Threshold, then the MS sends MOB_MSHO-REQ message to request dropping this access station from the diversity set.

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As shown in Figure 2, due to the introduction of RS in the MR network infrastructure, different intra-cell and inter-cell MDHO scenarios can occur. There are two main cases that differ from each other in the topology of the access stations constituting the diversity set of the MS. In the first case, where two different-topology access stations are the diversity

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set members of the MS, for instance MR-BS and RS which we named this as different-topology case. The RS is controlled by either the same MR-BS in the diversity set in case of intra-cell MDHO as in scenario 1 shown in Figure 2, or another MR-BS
5 in case of inter-cell MDHO as in scenarios 2.

Whereas, the second case corresponds to the MDHO scenarios in which the diversity set members of the MS are two similar-topology access stations, for instance two RSs or two MR-BSs,
10 and we named this as similar-topology case. The two RSs in the diversity set are controlled by either the same MR-BS in case of intra cell MDHO as in scenario 3 as shown in Figure 2, or different MR-BRs in case of inter-cell MDHO as in scenario 4.

15 Simultaneous transmissions of the diversity set members during the second phase of the intra-cell MDHO scenarios increase the number of co-channel interference sources compared to the inter-cell MDHO scenarios or the scenarios in which either RS or MR-BS transmits in the interference-limited environment. On
20 the other hand, during the first phase, interference only comes from MR-BSs which might be lower than that for the second phase.

The improved MDHO system of the present invention in
25 different-topology case will be further described herein.

Figure 3 shows a conventional MDHO (10') when the diversity set members are MR-BS1 (12') and RS1 (13') where the MS (11') listens only to the simultaneous transmissions of the MR-BS1 (12') and RS1 (13') during the second phase. In the different-topology case of the conventional MDHO, the transmission sequences of the diversity set members during the two phases will be described now. Only RS1 (13') listens to the transmission of MR-BS1 (12') during the first phase, whereas during the second phase, both MR-BS1 (12') and RS1 (13') transmit synchronously to the MS (11') by using the same radio resource. The MS combines the signals received from MR-BS1 and RS1 using, for example, maximal-ratio combining (MRC) at the end of the two phases.

Thus, at a given sub-carrier, the average post processing DL CINR obtained at the MS after MRC can be derived as:

$$\bar{\gamma}_{post}^{ConvMDHO1} = \bar{\gamma}_{SD,2} + \bar{\gamma}_{RD,2}$$

where $\bar{\gamma}_{SD,2}$ and $\bar{\gamma}_{RD,2}$ denote the average CINR of the MR-BS1→MS link and RS1→MS link, respectively.

With this result, it shows the signal transmitted by MR-BS1 in the first phase is not exploited by the MS even though the MS is idle in this phase. As a result, the topology of the diversity set members is not fully exploited. This causes low

diversity gain, low received signal strength and high bit error rate (BER), which result in low performance of the MS in the handover regions.

5 Whereas the improved MDHO system in the different-topology case of the present invention, the transmission sequences of the diversity set members during the two phases as shown in Figure 1a will now be described. Both MS (11) and RS1 (13) receive and buffer the transmission of the MR-BS1 (12) during
10 the first phase. Then in the second phase, both MR-BS1 (12) and RS1 (13) transmit synchronously to the MS (11) by using the same radio resource. At the end of the two phases, the MS (11) combines the signals received during the first phase and second phase using MRC, for example.

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Hence, at a given sub-carrier, the average post processing DL CINR achieved at the MS (11) and MRC can be derived as:

$$\bar{\gamma}_{post}^{PropMDHO} = \bar{\gamma}_{SD,1} + \bar{\gamma}_{SD,2} + \bar{\gamma}_{RD,2}$$

20 Where $\bar{\gamma}_{SD,i}$ and $\bar{\gamma}_{RD,i}$ are the average CINR of the MR-BS1 $\rightarrow$ MS link and RS1 $\rightarrow$ MS link, respectively, during phase i .

With this result, it shows that the MS received both the transmission of the MR-BS occurs during the first phase and
25 the simultaneous transmissions of the MR-BS and RS take phase

during the second phase. Thus, the topology of the diversity set members is fully exploited. This increases the diversity gain and the received signal strength while decreases the BER, which results in enhancing the performance of the MS in the
5 handover regions.

Figure 4 shows a process flowchart of the improved MDHO of the present invention over the conventional MDHO. The diversity set is first maintained or updated (21) by the MS and MR-BS
10 for each MS in the handover regions as described previously. The present system is mainly operated on MR-BSs and thus, all the MR-BSs and RSs should aware of their topology and all RSs directly or indirectly communicate with the MR-BSs that they are associated to. It should be noted that the indirect
15 communication between RS and MR-BS is the communication through another RS in case of more than two-hop RS. Specific management signaling needs to be exchanged in order to allow the MR-BS to learn about the topology of its corresponding RSs. The topology information may be exchanged within the RS
20 network entry procedures using RNG-REQ/RSP messages. In addition, the MR-BS might also obtain or update (22) the topology information of its associated RSs, directly or indirectly, through wireless relay links using the MR_NBR-INFO MAC management message. However, for MR-BS to MR-BS
25 communication, the topology information (22) is obtained via

the backbone network. Note that all the topology information will be gathered before any communication to the MSs.

The implementation and operation of the above-mentioned topology setup are highly dependent upon the RS deployment scenarios, i.e. fixed relay, normadic relay or mobile relay. For a fixed relay deployment, the MR-BS can easily pre-set the topology information. For normadic relay, on the other hand, the topology information setup should follow the location changes of the RSs. For mobile relay, the MR-BS needs to update the topology information with the transmission.

After maintaining or updating the diversity set members (21) and obtaining or updating their related topology information (22), the MR-BS allocates (23) the radio resources to the diversity set members and MS during the two phases accordingly so that the topology of the diversity set members is fully exploited. The MR-BS is allocated with resources during both first and second phases while the RS is allocated with resources during the second phase only. The resources allocated to both MR-BS and RS during second phase are identical. The resource allocated to the MR-BS during first phase may be different from the resources allocated during the second phase with the same size. Therefore, the diversity set members use these allocated resources to communicate the same data with the MS (11) during both first and second phases.

In orthogonal frequency division multiple access (OFDMA)-based multi-hop relay system, multiple users transmit or receive simultaneously on the different sub-carriers per OFDM symbol. The OFDM symbols are allocated by time division multiple access (TDMA) method in the time domain, and the sub-carriers within OFDM symbols are divided by OFDMA method in the frequency domain into subsets of the sub-carriers, wherein each subset is called a sub-channel. Each sub-channel may comprise the sub-carriers from a number of OFDM symbols. These sub-channels are the base resource allocation unit. The sub-channel may spread over the entire bandwidth to provide frequency diversity and average the inter-cell interference. A zone is defined as a number of OFDMA symbols, in the UL or the DL, that use the same sub-channel definition, for instance, permutation. The zone may be comprised of contiguous OFDM symbols. The UL and DL sub-frame may contain more than one permutation zone. A MDHO zone is defined for use in the handover area with same sub-channel permutation between all diversity set members. The MDHO zone may be defined by the OFDMA downlink STC_Zone_IE by setting IDcell=0.

The MR-BS uses DL-MAP information elements (IEs) defined for Macro_MIMO operation to notify (24) the MS of the allocated resources during both first and second phases. Each MS can determine when, i.e OFDMA symbol and where, i.e. sub-channel, it should receive from the MR-BS during both first and second

phase and when and where it should receive from the RS during the second phase based on a schedule received from the MR-BS. The present invention is similar to the standard procedure for MDHO and multiple-input multiple-output (MIMO) which is denoted as Macro_MIMO operation. Thus, the MR-BS uses the Macro_MIMO_DL_Basic_IE() and MIMO_in_another_BS_IE() information elements defined for Macro-MIMO operation to notify the MS of the allocated resources.

10 When using Macro_MIMO in the MDHO mode, a packet index is transmitted and all these regions with the same packet index shall be combined at the MS. Then the MS demodulates signal in the same procedure as in non-MDHO mode if it does not receive MIMO_in_another_BS_IE() or Macro_MIMO_DL_Basic_IE(). The same
15 data are transmitted (25) from multiple access stations in the same data region. MS may perform RF or diversity combining (26). The MIMO_in_another_BS_IE() shows that data is transmitted (25) to the MS through other access station at the same frame. This IE shall be right after the IE defining the
20 same data or data regions received in the current MR-BS. MS may perform RF or diversity combining (26).

When the MS received Macro_MIMO_DL_Basic_IE(), it demodulates the signal in the same procedure as in the non-MDHO mode and
25 then it performs soft combining for those data regions with the same packet index. Therefore, this system benefits from

combination of RF, diversity combining and soft data combining. As can be understood from the foregoing description, the present invention can be implemented without any requirements of modifications on MS (11).

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As will be readily apparent to those skilled in the art, the present invention may easily be produced in other specific forms without departing from its essential characteristics. The present embodiments is, therefore, to be considered as
10 merely illustrative and not restrictive, the scope of the invention being indicated by the claims rather than the foregoing description, and all changes which come within therefore intended to be embraced therein.

Claims

1. A method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks, said method comprising the
5 steps of:

maintaining (21) a diversity set for each mobile station (MS) (11) in the handover regions, in which each diversity set includes at least two different-topology access stations that can communicate with the associated mobile station (MS) (11);

10 establishing (22) the topology of said diversity set members; allocating (23) resources to said diversity set members for both first and second phases;

notifying (24) said mobile station (MS) (11) of the allocated resources;

15 communicating (25) between said diversity set members and MS during both first and second phases; and

combining (26) the signals received during said first and second phase from said diversity set members.

20 2. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 1, wherein said diversity set members are multi-hop relay base station (MR-BS) (12) and at least one 2-hop relay station (RS) (13).

3. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 2, wherein said MR-BS (12) is allocated resources during both first and second phases, in which the resource during the first phase is different from the resource allocated to the second phase with the same size.

4. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 2, wherein said RS (13) is allocated resources during second phase, in which said resources are identical to the resources allocated to the MR-BS during second phase.

5. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 1, wherein said method further comprising the step of exchanging management signaling between said MR-BS (12) and its corresponding RSs (13) to obtain the topology information.

6. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 1, wherein said mobile station (MS) (11) is notified by MR-BS (12) using the IEs defined for MDHO and multiple-input multiple-output (MIMO), denoted as Macro_MIMO operation.

7. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 1, wherein said step of communicating further comprising the step of transmitting data in the first data region by said MR-BS, and transmitting data simultaneously by said MR-BS and RS in the second data region of same size which including the step of soft combining the first and second data regions signals to achieve diversity combining and soft combining gain.

8. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 1, wherein said diversity set members are multi-hop relay base station (MR-BS) and n-hop relay station (RS), in which said resource allocated to the MR-BS during the 1st, 2nd, ..., and nth-1 phases are different from the identical resources allocated to the MR-BS and RS during the nth phase with the same size.

9. The method for an improved macro diversity handover (MDHO) for multi-hop relay (MR) networks as claimed in claim 8, wherein said MR-BS transmits data in the 1st, 2nd, ..., and nth-1 data regions, and MR-BS and RS simultaneously transmit data in the nth data region of same size, further comprising the step of soft combining all data regions signals to achieve diversity combining and soft combining gain.

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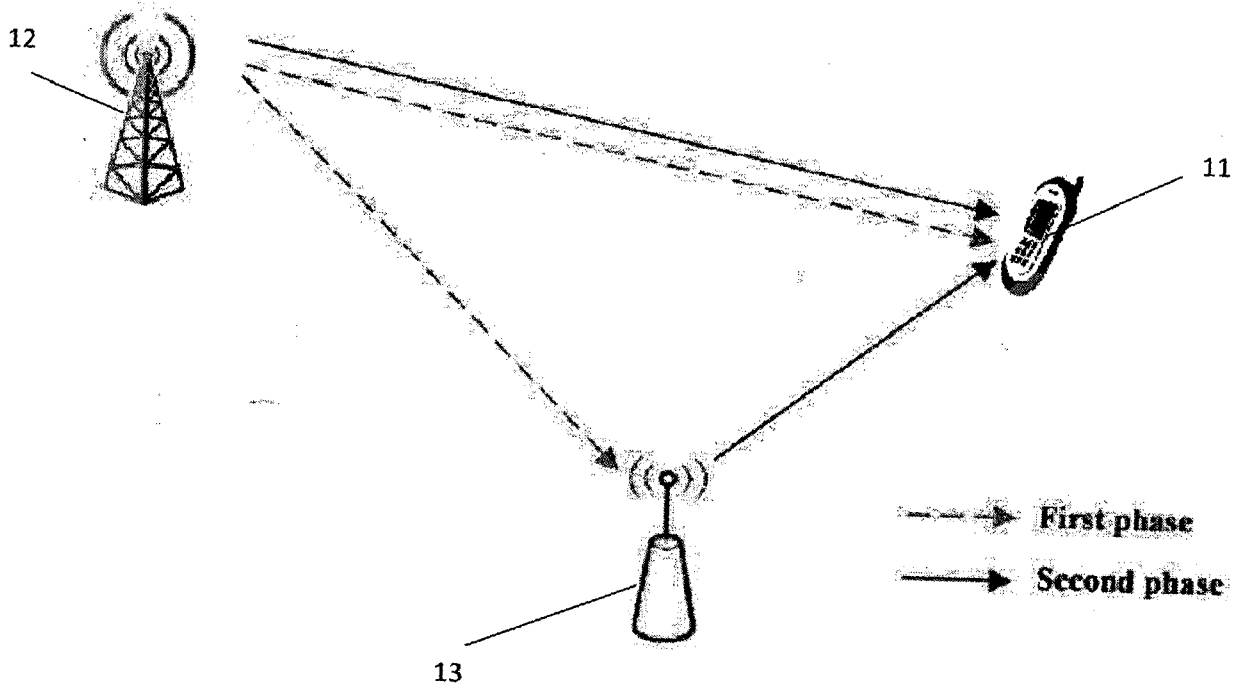


Figure 1a

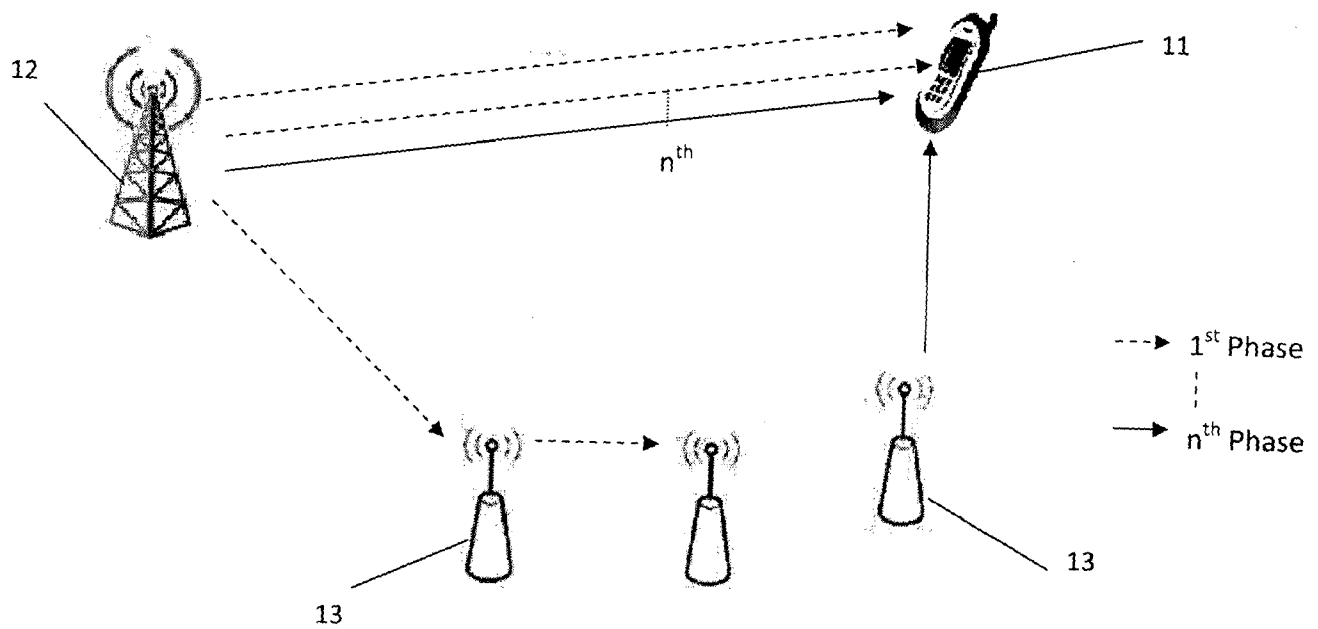


Figure 1b

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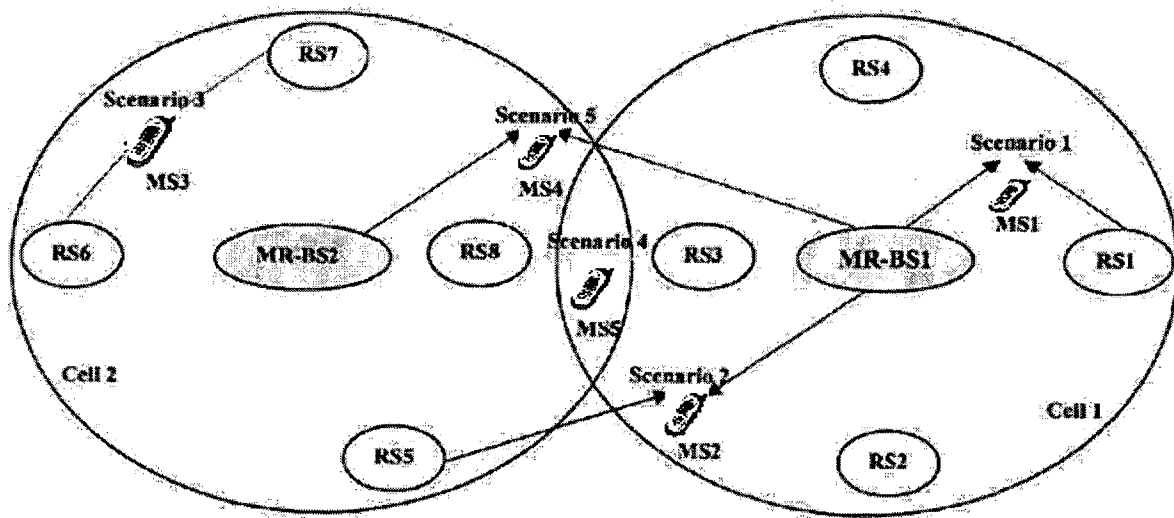
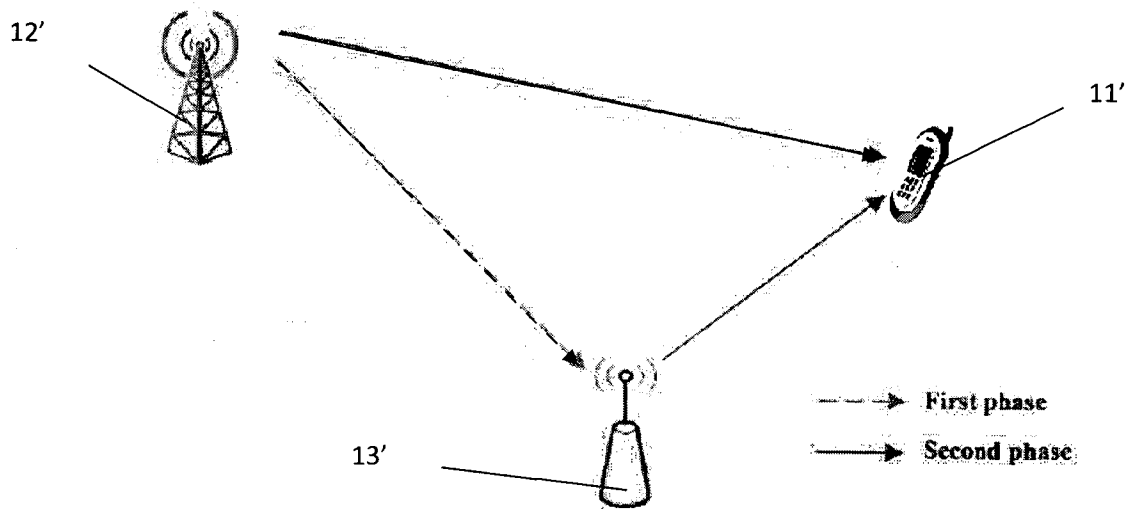


Figure 2



Prior Art

Figure 3

SUBSTITUTE SHEET

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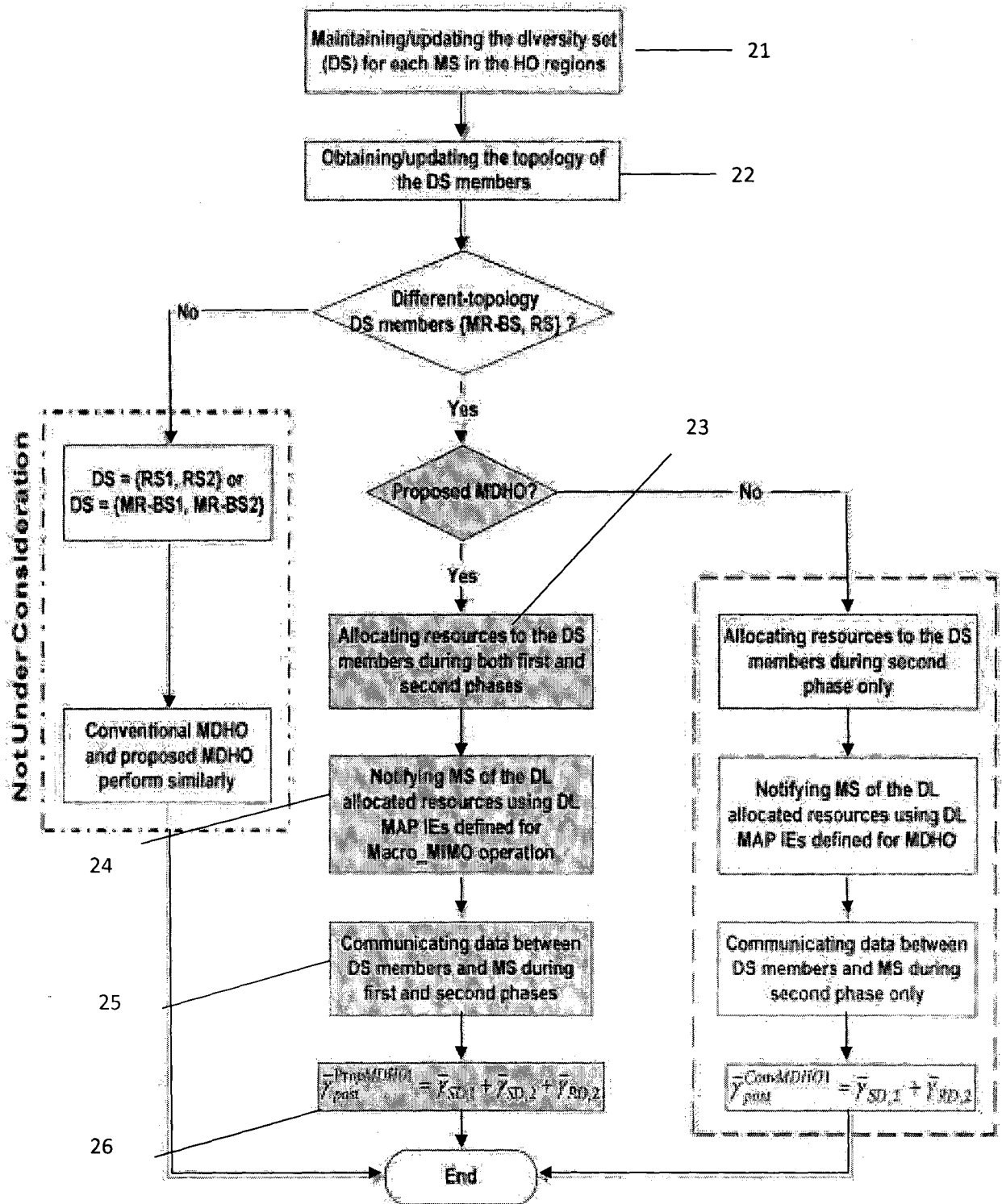


Figure 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/MY2012/000089

A. CLASSIFICATION OF SUBJECT MATTER

H04W 36/00 (2009.01) H04W 28/00 (2009.01)

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)

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)

EPODOC, WPI, www.freepatentsonline.com: wireless, handoff, handover, macro diversity, MDHO, multi-hop relay, add, combine and similar terms.Google Scholar (<http://scholar.google.com.au/>): MDHO, relay, phases.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

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"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
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INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/MY2012/000089
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SULTAN, J., et al., "Topology-aware macro diversity handover technique for IEEE 802.16j multi-hop cellular networks", IET Communications, 2011 (published: 25 March 2011), Vol. 5, Issue 5, pages 700 - 708. Abstract, sections 1, 2, 2.4, 2.4.1.	1 - 9