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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 October 2013 (03.10.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/143084 A1

(51) International Patent Classification:
H04W 36/32 (2009.01)

(21) International Application Number:
PCT/CN2012/073181

(22) International Filing Date:
28 March 2012 (28.03.2012)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **NEC (CHINA) CO., LTD.** [CN/CN]; 20/F, Shining Tower, No. 35, Xueyuan Road, Haidian District, Beijing 100191 (CN).

(72) **Inventors; and**

(75) **Inventors/Applicants** *(for US only)*: **YI, Su** [CN/CN]; 11F, Bldg. A, Innovation Plaza, Tsinghua Science Park, Haidian District, Beijing 100084 (CN). **LEI, Ming** [CN/CN]; 11F, Bldg. A, Innovation Plaza, Tsinghua Science Park, Haidian District, Beijing 100084 (CN). **Huang, Qing** [CN/CN]; Beijing Jiaotong University, No. 3 Shang Yuan Cun, Haidian District, Beijing 100044 (CN). **ZHOU, Jianmei** [CN/CN]; Beijing Jiaotong University, No. 3 Shang Yuan Cun, Haidian District, Beijing 100044 (CN).

(74) **Agent**: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

(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, 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, 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, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, 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, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR HANDOVER

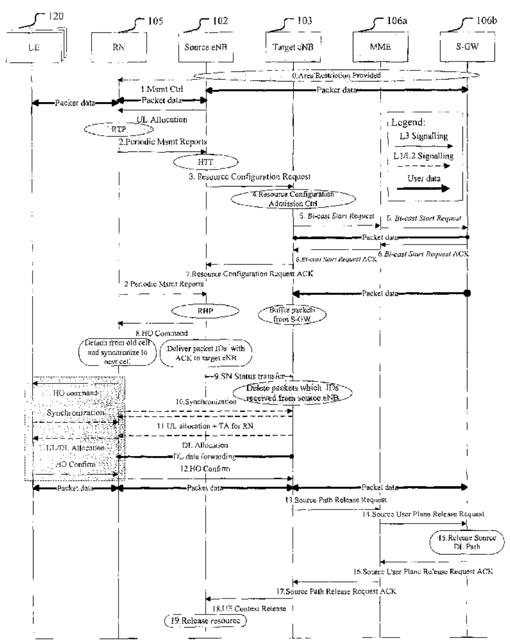


FIG. 2

(57) Abstract: A fast handover method is provided. At a source eNB, the method may comprise: receiving a measurement report sent periodically from a mobile node, wherein the sending of the measurement report is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location and velocity information of the mobile node besides the conventional measurement information; performing handover preparation; and executing handover to a target eNB no later than the mobile node arriving at a Reference Handover Point (RHP), With particular embodiments of the present invention, the measurement results may be reported in time by defining a RTP and the handover may be executed timely by defining a RHP. Moreover, by defining a HTT, the handover preparation including data bi-casting may be started not too early, such that the consumption of network resources may be minimized. Thus, the handover time may be reduced and the handover success probability may be improved.

WO 2013/143084 A1

Published:

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

METHOD AND APPARATUS FOR HANDOVER

FIELD OF THE INVENTION

[0001] Embodiments of the present invention generally relates to a handover procedure in a communication system, and more particularly to a method, a system, an apparatus, an eNodeB, a mobile node, and a computer program for fast handover in high speed mobile environment.

BACKGROUND OF THE INVENTION

[0002] This section introduces aspects that may help facilitate a better understanding of the invention(s). Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] The abbreviations and terms appearing in the description and drawings are defined as below.

3GPP	Third Generation Partnership Project
DL	Downlink
eNB	eNodeB, Base Station in EUTRAN
E-UTRAN	Evolved UTRAN
HTT	Handover Time Threshold
IE	Information Element
LTE-A	Long Term Evolution-Advanced
QoS	Quality of Service
RN	Relay Node
RTP	Reference Trigger Point where the measure process must start
RHP	Reference Handover Point where the handover execution process must start
ST	Speed Threshold
UE	User Equipment
UL	Uplink

[0004] As a fast and convenient public transportation system, high-speed railways have been developed rapidly recent years and more and more people choose to travel by high-speed trains. In the long time travelling, various mobile wireless services not only voice and short messages but also various multimedia services such as web browsing, email, videophone, online gaming, Video-On-Demand (VOD) and video conference and so on should be provided to passengers aboard the high-speed trains.

[0005] Generally, these multimedia services with a high data rate are characterized with high level of Quality of Service (QoS) and low latency requirements, which can currently only be offered by broadband access technologies in normal mobility. If deployed in a high speed mobile environment, the performance of these technologies will decrease seriously. There is a technological gap regarding radio access techniques which could offer high transmission data rates and low latency to support real time applications in high mobility environments.

[0006] In order to provide high data rates, the cell radius of broadband access systems will shrink so does the overlapping of two adjacent radio cells because of high carrier frequency deployed. At high speed scenarios, the sojourn time in handover area will drastically decrease. So a fast handover scheme is required which can maintain a shorter handover execution time.

[0007] Mobile relaying in a cellular network (e.g., a mobile relay installed on trains) can help provisioning of high data rate coverage in high-speed railway environments, reducing the influence of penetration loss, reducing the handover overhead, prolonging the battery lifetime for user equipment and generally enhancing cell capacity and effective throughput.

[0008] Third Generation Partnership Project (3GPP) has proposed 3GPP LTE to meet the huge demand of wireless services. LTE is expected to provide more capacity, better coverage, higher throughput, reduced latency with less network complexity and low installation cost. What's more, the International Union of Railways has decided to deploy LTE as the next wireless communication system on railways.

SUMMARY OF THE INVENTION

[0009] Therefore, it would be desirable in the art to provide a fast handover scheme in high-speed mobile environment in LTE-A to improve the performance of handover, which is one of the main challenges in high speed train communications.

[0010] To better address one or more of the above concerns, in a first aspect of the invention, a method for handover at a source eNB is provided. The method may comprise:

receiving a measurement report sent periodically from a mobile node, wherein the sending of the measurement report is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location, velocity and signal strength information etc. of the mobile node; performing handover preparation; and executing handover to a target eNB no later than the mobile node arriving at a Reference Handover Point (RHP).

[0011] In some embodiments, performing the handover preparation comprises: in response to the time the mobile node runs to the RHP is equal to or shorter than a Handover Time Threshold (HTT), sending a resource configuration request message to the target eNB, such that the target eNB executes the resource configuration and requests data bi-casting; and receiving a resource configuration request ACK message from the target eNB; wherein the HTT is equal to P+T, wherein P is reporting period of the measurement report, and T is the time for the resource configuration and signaling for establishing the data bi-casting.

[0012] In a second aspect of the invention, a method for handover at a mobile node is provided. The method may comprise sending periodically a measurement report to a source eNB, wherein the sending is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location, velocity and signal strength information etc. of the mobile node.

[0013] In a third aspect of the invention, an apparatus for handover at a source eNB is provided. The apparatus may comprise a report receiving unit, configured to receive a measurement report sent periodically from a mobile node, wherein the sending of the measurement report is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location, velocity and signal strength information etc. of the mobile node; a handover preparation unit, configured to perform handover preparation; and handover executing unit, configured to execute handover to a target eNB no later than the mobile node arriving at a Reference Handover Point (RHP).

[0014] In a fourth aspect of the invention, an apparatus for handover at a mobile node is provided. The apparatus may comprise report sending unit, configured to send periodically a measurement report to a source eNB, wherein the sending is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location, velocity and signal strength information etc. of the mobile node.

[0015] In a fifth aspect of the invention, an apparatus is provided, which comprises at least one processor and at least one memory including computer program code. The memory and the computer program code are configured to cause the apparatus to perform embodiments of the method of the first aspect of the invention or embodiments of the method of the second aspect of the invention.

[0016] In a sixth aspect of the invention, a computer program product is provided, which, comprises at least one computer readable storage medium having a computer readable program code portion stored thereon. The computer readable program code portion comprises program code instructions for perform embodiments of the method of the first aspect of the invention or embodiments of the method of the second aspect of the invention.

[0017] Particular embodiments of the subject matter described in this specification can be implemented so as to realize one or more of the following advantages.

[0018] With particular embodiments of the techniques described in this specification, the measurement results may be reported in time by defining a RTP and the handover may be executed timely by defining a RHP. Moreover, by defining a HTT, the handover preparation including data bi-casting may be started not too early, such that the consumption of network resources may be minimized. Thus, the handover time may be reduced and the handover success probability may be improved.

[0019] Other features and advantages of the embodiments of the present invention will also be understood from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other aspects, features, and benefits of various embodiments of the invention will become more fully apparent, by way of example, from the following detailed description and the accompanying drawings, in which:

[0021] Fig. 1 illustrates an exemplary scenario where the fast handover scheme in high-speed mobile environment may be implemented according to embodiments of the present invention;

[0022] Fig. 2 illustrates an exemplary signal flow of the fast handover scheme according to embodiments of the present invention;

[0023] Fig. 3 is a schematic block diagram of an apparatus 300 that may be configured to practice the exemplary embodiments of the present invention;

[0024] Fig. 4 is a schematic block diagram of an apparatus 400 that may be configured to practice the exemplary embodiments of the present invention;

[0025] Fig. 5 illustrates a simplified block diagram of a network element 500 that is suitable for use in practicing the exemplary embodiments of the present invention;

[0026] Fig. 6 illustrates the simulation results of Handover Failure Probability with different RN velocity;

[0027] Fig. 7 illustrates the simulation results of Handover Overall Procedure Delay with different RN velocity; and

[0028] Fig. 8 illustrates the simulation results of Handover Interruption Time.

[0029] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION OF EMBODIMENTS

[0030] Hereinafter, the principle and spirit of the present invention will be described with reference to the illustrative embodiments. It should be understood, all these embodiments are given merely for the skilled in the art to better understand and further practice the present invention, but not for limiting the scope of the present invention. For example, features illustrated or described as part of one embodiment may be used with another embodiment to yield still a further embodiment. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions should be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0031] The disclosed subject matter will now be described with reference to the attached figures. Various structures, systems and devices are schematically depicted in the drawings for purposes of explanation only and so as to not obscure the description with details that are well known to those skilled in the art. Nevertheless, the attached drawings are included to describe and explain illustrative examples of the disclosed subject matter. The words and phrases used herein should be understood and interpreted to have a meaning consistent with the understanding of those words and phrases by those skilled in the relevant art. No special definition of a term or phrase, i.e., a definition that is different from the ordinary and customary meaning as understood by those skilled in the art, is intended to be implied by consistent usage of the term or phrase herein. To the extent that a term or phrase is intended to have a special meaning, i.e., a meaning other than that understood by skilled artisans, such a special definition will be expressly set forth in the specification in a definitional manner that directly and unequivocally provides the special definition for the term or phrase.

[0032] There are several characteristics in high-speed mobile scenarios. First, in high-speed scenarios, because of imperfect channel measurement, it's very difficult to determine the correct point to trigger handover and cause more dropped and blocked handovers. On the other hand, it is easy to get the location and velocity information of the train. Second, in high-speed scenarios, the time to perform the handover is much shorter as the handover has to take place in the overlapping region of two neighboring cells. So fast handover is required to ensure the success of handover.

[0033] Normally, the handover procedure can be divided into four parts: measurement, handover preparation, handover execution and handover completion.

[0034] In embodiments of the present invention, several reference points in location are set to help determining the proper point to trigger handover. Specifically, a Reference Trigger Point (RTP) is set to trigger periodic sending of the measurement report; a Reference Handover Point (RHP) is set to trigger the execution of the handover. Moreover, a Handover Time Threshold (HTT) is set to determine the start of handover preparation. Optionally, a Speed Threshold (ST) is set to determine whether the embodiments of the present invention should be applied. For example, the ST may be set as 40m/s or 60m/s. Other values may also be used.

[0035] Hereinafter, details of various embodiments of the invention will be described with reference to the accompanying drawings.

[0036] Fig. 1 illustrates an exemplary scenario where the fast handover scheme in high-speed mobile environment may be implemented according to embodiments of the present invention.

[0037] As illustrated in Fig. 1, three eNBs 101, 102, and 103 are disposed along the railway through which a high-speed train 104 goes. A Relay Node (RN) 105 is attached to the high-speed train 104, which may be referred as a mobile relay node. The eNBs 101, 102, and 103 may communicate with each other via X2 interface 108, and communicate with a Mobile Management Entity/Serving-Gateway (MME/S-GW) 106 via S1 interface 107. The eNBs 101, 102, and 103 may also communicate with the RN 105 via Un interface 109. There may be multiple UEs (not shown) held by passengers in the high-speed train 104. The UEs may communicate with the eNBs 101, 102, or 103 via the RN 105.

[0038] The skilled in the art should appreciate that the mobile Relay Node 105 may be other mobile nodes, such as a UE, a mobile femtocell, a mobile AP, etc. For the purposes of illustration and simplification, in the following description, the mobile Relay Node 105 is taken as an example to explain the embodiments of the present invention.

[0039] In the environment shown in Fig.1, the communication network is deployed with linear coverage pattern, i.e., each cell only has two neighbor cells, a forward cell and a backward cell. Such arrangement can reduce the number of eNBs under measurement to 1/6 of original number so as to expedite the measurement of the handover. However, the skilled in the art should appreciate that embodiments of the present invention may also be applied in the conventional cellular network arrangement.

[0040] Fig. 1 illustrates the scenario where the train 104 is driving from a cell served by the eNB 102 (i.e., the source eNB) towards a cell served by the eNB 103 (i.e., the target eNB), the train direction being indicated by the arrow 110. Fig. 1 also shows the reference points as introduced in embodiments of the present invention, i.e., Reference Trigger Point (RTP) 111 and Reference Handover Point (RHP) 113.

[0041] When the train 104 arrives at the RTP 111 or satisfies other event-triggered reporting criteria before arriving at the RTP 111, i.e., no later than the train 104 arriving at the RTP 111, the relay node 105 attached to the train 104 would begin to report the measurement result periodically. In addition to the original measurement items of the source and target eNBs, the measurement report should include position coordinate (X, Y) (m) and the velocity V of the relay node 105 besides the conventional measurement information.

[0042] The source eNB 102 receives the measurement report periodically and extracts the position and velocity information from the measurement report. If the time the train 104 or the relay node 105 runs to the RHP 113 is equal to or shorter than the Handover Time Threshold (HTT), and optionally if V > Speed Threshold (ST), then the source eNB 102 would perform handover preparation.

[0043] The handover preparation can include resource configuration procedure at the target eNB 103 and the establishment of data bi-casting.

[0044] When the train 104 arrives at the RHP 113 or satisfies other handover conditions before the train 104 arrives at the RHP 113, i.e., no later than the train 104 arriving at the RHP 113, the source eNB 102 would begin to execute handover.

[0045] The RTP 111 is a statistical average value of the position where the measurement process should start, which means the latest position where the measurement report must be triggered. The RHP 113 is a statistical average value of the position where the handover execution process should start, which means the latest position where the handover execution must start. The HTT is the earliest time for starting handover preparation and data bi-casting. Assuming measurement reporting period is P, handover preparation time and signaling overhead for establishing data bi-casting is T, then HTT is P+T.

[0046] According to the proposed handover scheme, the measurement results may be reported in time by defining RTP 111 and the handover may be executed timely by defining RHP 113. Moreover, by defining HTT, the handover preparation including data bi-casting may be started not too early, such that the consumption of network resources may be minimized.

[0047] Fig. 2 illustrates an exemplary signal flow of the fast handover scheme according to embodiments of the present invention. Fig. 2 has shown the signal flow between UE 120, Relay Node (RN) 105, Source eNB 102, Target eNB 103, MME 106a and S-GW 106b in order to effect a fast handover.

[0048] As shown in Fig. 2, at step 0, the MME/S-GW 106 provides area restriction information to the source eNB 102. Then, at step 1, the source eNB 102 configures the measurement procedure of the relay node (RN) 105 according to the area restriction information. For example, the configuration may be implemented by *Measurement Configuration* IE (Information Element) in *RRCConnectionReconfiguration* message. The Measurement Configuration may include measurement objects, reporting configurations (including measurement trigger by Event or Period, measurement report contents, etc.), measurement identities, measurement gaps, etc. The event-triggered period measurement report criteria may be, for example A3 as defined in LTE. Event A3 is that neighbor cell becomes better than an offset relative to the serving cell.

[0049] If the train 104 and therefore the attached RN 105 arrives at the RTP or satisfy other event-triggered reporting criteria (such as A3 described in LTE), then at step 2, the RN 105 will send measurement report to the source eNB 102 periodically. The measurement report may include measurement result such as a reference signal received quality (RSRQ), a reference signal received power (RSRP), etc. In addition to the original measurement items of the source and target eNBs, the measurement report should further include position coordinate (X, Y) (m) and the velocity V of the relay node 105.

[0050] In embodiments of the present invention, both the conventional event-triggered reporting criteria and the RTP can trigger the measurement report. Namely, if the RN 105 has not arrived at the RTP but certain event-triggered reporting criteria (such as A3) is satisfied, the measurement result report will start in advance and the location will be recorded.

[0051] Then, the source eNB 102 will receive the measurement report from the RN 105 periodically. The source eNB 102 extracts position and velocity information from the measurement report. At step 3, When a HTT is satisfied (and optionally the train speed is higher than ST), the source eNB 102 will send "Resource Configuration Request Message" to the target eNB 103, such that the target eNB 103 can execute the resource configuration and requests data bi-casting. Otherwise, the source eNB 102 will wait for the next measurement report. The HTT is satisfied means that, the time the RN 105 runs to the RHP is equal to or shorter than the HTT, wherein the HTT equals to P+T, P is the reporting period of the measurement report, and T is the handover preparation time and signaling time for establishing the data bi-casting. The skilled in the art would understand that, the time the RN 105 runs to the RHP may be calculated based on the position and velocity information extracted from the measurement report and other known information (e.g., the position of RHP). The calculation is very simple, and thus the detailed description is omitted herein.

[0052] The Resource Configuration Request Message sent to the target eNB 103 may contain the resource that the RN 105 needs, position and velocity information, UE context information etc.

[0053] Then, at step 4, after receiving the Resource Configuration Request Message from the source eNB 102, the target eNB 103 will prepare for the incoming handover and configure needed resource in advance.

[0054] After completing the resource configuration procedure, at step 5, the target eNB will send "Bi-cast Start Request Message" to the S-GW 106b through the MME 106a. Then the S-GW 106b will bi-cast the data packet to both the source eNB 102 and the target eNB 103 through S1 interface at the same time.

[0055] Then at step 6, the S-GW 106b sends a "Bi-cast Start Request ACK Message" containing the first bi-cast packet ID to the target eNB 103 through the MME 106a to inform that the packets bi-cast has started.

[0056] It can be seen that the measurement report (i.e., the position and velocity information of the RN 105) helps to decide the starting time of the resource configuration in the target eNB 103, and the data bi-casting is requested immediately after the resource configuration of the target eNB 103 is completed. Because the S-GW 106b starts bi-casting downlink data to both the source eNB 102 and the target eNB 103 right after the channel of the target eNB 103 is activated and before the handover execution process starts, it can reduce handover interruption time with the minimal consumption of network resources compared to the conventional bi-casting scheme in LTE system.

[0057] Then at step 7, after receiving the "Bi-cast Start Request ACK Message", the target eNB 103 will respond a "Resource Configuration Request ACK Message" to the source eNB 102. This message is a RRC message which contains the "MobilityControlInfo" that the

RN 105 needs to handover and other access parameters, for example, C-RNTI, target eNB security algorithm identifiers, dedicated RACH preamble and etc. Besides, the first bi-cast packet ID is also contained.

[0058] The source eNB 102 will deal with other measurement items at the same time. When the RN 105 arrives at the RHP or satisfies other handover conditions and the source eNB 102 has received the "Resource Configuration Request ACK Message" from the target eNB 103, at step 8, the source eNB 102 sends a "Handover (HO) Command Message" to the RN 105 directly. This message contains the same information as the "Resource Configuration Request ACK Message".

[0059] Similar to the measurement report, both the conventional handover criteria and the RHP can start the handover execution. Namely, if the RN 105 has not arrived at the RHP but certain handover criteria are satisfied, then the handover will start in advance and the location of handover is recorded. Otherwise, the handover procedure will be executed when the RN 105 arrives at the RHP.

[0060] Further, the source eNB 102 sends the buffered packets which have not sent to the target eNB by bi-cast through the X2 interface. The S-GW 106b would send the packet ID that has bi-casted to the source eNB so that the source eNB 102 can forward fewer packets.

[0061] Then, at step 9, the source eNB 102 sends a "SN Status Transfer Message" to the target eNB 103 to convey uplink PDCP SN receiver status and downlink PDCP SN transmitter status. The source eNB 102 sends the packet IDs to the target eNB 103 through X2 interface when it receives the ACK from the RN 105 and the target eNB 103 will delete the relevant packets, i.e, the packets whose IDs are received from the source eNB 102. The target eNB 103 will send remaining packets to the RN 105 once the RN 105 accesses to the target eNB 103.

[0062] Upon the reception of the HO message, the RN 105 will detach from the source eNB 102 and synchronize to the target eNB 103.

[0063] At step 10, the RN 105 performs synchronization to the target eNB and accesses to the target eNB via RACH. The target eNB responds with UL allocation and timing advance (TA) for the RN 105 (step 11).

[0064] After the RN 105 has successfully accessed to the target eNB 103, at step 12, the RN 105 will send a "Handover (HO) Confirm Message" to the target eNB 103. From now on, the RN 105 has established normal communication link with the target eNB 103 and then the data packets stored in the target eNB 103 starts to transmit.

[0065] To complete the handover, at step 13, the target eNB 103 sends a "Source

Path Release Request Message" to the MME 106a to inform that the RN 105 has changed cell. Then, at step 14, the MME 106a sends a "Source User Plane Release Request Message" to the S-GW 106b. Upon receiving the request, at step 15, the S-GW 106b releases the downlink data path of the source eNB 102, and at step 16, the S-GW 106b sends a "Source User Plane Release Request ACK Message" to the MME 106a. Then, at step 17, the MME 106a confirms the "Source Path Release Request Message" with a "Source Path Release Request ACK Message" to the target eNB 103.

[0066] After receiving the "Source Path Release Request ACK Message" from the MME 106a, at step 18, the target eNB 103 sends a "UE Context Release Message" to the source eNB 102 to inform success of handover and trigger the release of resources of the source eNB 102.

[0067] Upon the reception of the "UE Context Release Message", at step 19, the source eNB 102 releases radio and C-plane related resources associated to the UE context. Thus, the handover is completed.

[0068] As seen from the above description with reference to Fig. 2, to minimize the consumption of network, a proper time to start bi-casting is needed. According to embodiments of the present invention, this time is calculated based on the position and velocity of the RN 105. That is, each time the source eNB 102 receives the report from the RN 105, it will calculate the time t that the RN arrives at the RHP and compare this time t with the HTT. If t<HTT, then the handover preparation and data bi-casting may start.

[0069] Specifically, when resource configuration of the target eNB 103 has completed, the target eNB 103 will request data packets bi-casting from the S-GW 106b. Once the RN 105 access to the target eNB 103, it can receive packets from the target eNB immediately.

[0070] Because the HTT is defined based on the handover preparation time and signaling overhead in time domain for establishing data bi-casting, the bi-casting start time is right after the time the resource configuration of the target eNB 103 is completed, so it is much closer to the handover execution time and it will decrease the handover interruption time and ensure seamless handover. Besides, the bi-casting time is minimized so that the consumption of network resources is decreased.

[0071] Although the above description has given detail explanation of the embodiments of the present invention with reference to the signal flow as shown in Fig. 2, the skilled in the art should appreciate that the information related to the handover may be implemented with other messages, and the invention has no limitation in this regard.

[0072] The skilled in the art could understand that, the reference points RTP and RHP are both obtained based on vast statistic data of the fast handover. Thus, in some embodiments, the RTP and RHP may be updated based on the measurement report so as to ensure the accuracy of those reference points.

[0073] Each time the RN 105 runs across the cell, the point where the RN 105 satisfies the event-triggered reporting criteria and the point where the handover condition based on radio signal measurement is satisfied are recoded, no matter the point is front or behind the reference points. These two points may be referred as the measured trigger point and measured handover point.

[0074] Of course, if the point where handover condition is satisfied is behind the RHP, the acquisition of this point needs the help of the target eNB 103. That is, the measurement will not stop after handover to the target eNB 103. Then the RN 105 will send the report to the target eNB 103, and the target eNB 103 evaluates the ideal handover point based on the report information.

[0075] Several update schemes have been proposed to update the reference points as introduced according to embodiments of the present invention. For example, the RTP and RHP may be updated according to at least one of the following schemes.

[0076] Scheme 1:

$$RP_n = \{1 - \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})\} \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}$$

[0077] Scheme 2:

$$RP_n = \frac{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}}{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})}$$

[0078] Scheme 3:

$$RP_n = \{1 - (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)}\} \cdot RP_{n-1} + (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)} \cdot RP_{(measure,n)}$$

In the above formulas, RP represents either one of the RTP and RHP; the value of RP is the distance to the source eNB; $RP_{(measure,n)}$ is the latest measurement reference point based on the measurement of the mobile RN; RP_n is the updated reference point; RP_{n-1} is the old reference point; X_o is equal to 0; and σ and K are coefficient factors.

[0079] In addition, the RTP must be at least $(P+T)\cdot V_{\max}$ far from the RHP ahead, which means $RTP_{(n,adjust)} = \min(RTP_n, RHP_n-(P+T)\cdot V_{\max})$, where V_{max} represents the maximum velocity of high-speed trains.

[0080] The initial RP may be set according to various criteria. For example, the initial RHP may be based on the actual measurement when the network is established. Alternatively, the initial RHP may be set as the center point of two neighbor eNBs or based on certain engineering test. In one embodiment, the initial RHP is set to $RHP_{(measure,1)}$ and certain handover criteria are satisfied, e.g., the following formula (1) is satisfied.

$$RSRP_{n,target} \geq RSRP_{n,serving} + Hysteresis \qquad (1)$$

Wherein the RSRP represents Reference Signal Received Power as measured at the RN.

[0081] The initial RTP may be set as $(P+T)\cdot V_{\max}$ far from the RHP ahead, where V_{max} represents the maximum velocity of high-speed trains. Alternatively, the initial RTP may be set as $RTP_{(measure,1)}$ when the first train runs across and certain event-triggered reporting criteria are satisfied.

[0082] Fig. 3 is a schematic block diagram of an apparatus 300 that may be configured to practice the exemplary embodiments of the present invention. The apparatus 300 may be incorporated into the source eNB 102 and be configured to perform methods of the exemplary embodiments of the present invention.

[0083] As shown in Fig. 3, the apparatus 300 may comprise a report receiving unit 301, a handover preparation unit 302, and a handover executing unit 303.

[0084] The report receiving unit 301 may be configured to receive a measurement report sent periodically from a mobile relay node, wherein the sending of the measurement report is triggered no later than the mobile relay node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location, velocity and signal strength information etc. of the mobile relay node. The handover preparation unit 302 may be configured to perform handover preparation. The handover executing unit 303 is configured to execute handover to a target eNB no later than the mobile relay node arriving at a Reference Handover Point (RHP).

[0085] In some embodiments, the handover preparation unit 302 may be configured to: in response to the time the mobile relay node runs to the RHP is equal to or shorter than a handover Time Threshold (HTT), send a resource configuration request message to the target eNB, such that the target eNB executes the resource configuration and requests data bi-casting; and receive a resource configuration request ACK message from the target eNB, wherein the HTT is equal to P+T, wherein P is reporting period of the measurement report, and T is the time for the resource configuration and signaling for establishing the data bi-casting. In further embodiments, the resource configuration request ACK message may includes the first bi-casted packet ID.

[0086] In further embodiments, the sending of the resource configuration request message is further in response to the speed of the mobile relay node being higher than a Speed Threshold (ST).

[0087] In some embodiments, the data bi-casting is requested almost immediately after the resource configuration of the target eNB is completed.

[0088] In some embodiments, the RTP and RHP may be updated bases on the measurement report. For example, the RTP and RHP may be updated according to the schemes 1-3 as described previously.

[0089] Fig. 4 is a schematic block diagram of an apparatus 400 that may be configured to practice the exemplary embodiments of the present invention. The apparatus 400 may be incorporated into the relay node RN 105 and be configured to perform methods of the exemplary embodiments of the present invention.

[0090] As shown in Fig. 4 the apparatus 400 may comprise a report sending unit 401, a receiving unit 402, and an accessing unit 403.

[0091] The report sending unit 401 may be configured to send periodically a measurement report to a source eNB, wherein the sending is triggered no later than the mobile relay node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location and velocity information of the mobile relay node.

[0092] The receiving unit 402 may be configured to receive a handover command from the source eNB. The handover command may include an ID of the first packet being bi-casted. The accessing unit 403 is configured to access to a target eNB.

[0093] In some embodiments, the RTP may be updated bases on the measurement report. For example, the RTP may be updated according to the schemes 1-3 as described previously.

[0094] Fig. 5 illustrates a simplified block diagram of a network element 500 that is suitable for use in practicing the exemplary embodiments of the present invention. As shown in Fig. 5, the network element 500 includes a data processor (DP) 503, a memory (MEM) 504 coupled to the DP 503, and a communication interface 505 coupled to the DP 503. The MEM 504 stores a program (PROG) 506. The communication interface 505 may represent any interface that is necessary for communication with other network elements, such as X2 interface for bidirectional communications between eNBs, S1 interface for communication between the MME/S-GW and the eNB, or Un interface for communication between the eNB and the RN.

[0095] In some embodiments, the program (PROG) 506 may be configured, together with the DP 503, to cause the network element 500 to act as the source eNB 102 and operate in accordance with the exemplary embodiments of the invention. In other embodiments, the program (PROG) 506 may be configured, together with the DP 503, to cause the network element 500 to act as the mobile relay node RN 105 and operate in accordance with the exemplary embodiments of the invention.

[0096] The embodiments of the present invention may be implemented by computer software executable by the DP 503 of the network element 500, or by hardware, or by a combination of software and hardware.

[0097] Simulations have been executed to evaluate the performance of the handover mechanism according to embodiments of the present invention. System level simulations within a typical urban propagation environment have been performed. The network topography is assumed as a linear coverage along the railway. Each eNodeB only has two neighbor eNodeBs adjacently. Table I summarizes the general environment simulation parameters and the main handover and mobility related parameters are assumed in table II.

TABLE I : Environment parameters

Parameter	**Assumption/Explanation**
Network topography	**Linear coverage along the railway, two neighbor eNodeBs adjacently**
Inter-Site Distance(ISD)	**2000meters**
Distance between eNodeB and Railways	**10m**
eNodeB Antenna Height	**30m**
RN Antenna Height	**5m**
Carrier Frequency	**2GHz**
System Bandwidth	**10MHz**
eNodeB Tx Power	**46dBm**
eNodeB Antenna Gain	**14dBi**
Propagation Model	**Path Loss(dB) = 128.1 + 37.6 * log10**

	(R in km), where R is distance from eNodeB to RN
Shadowing Standard Deviation	**8dB**
Shadowing Correlation distance	**50m**
Shadowing Correlation b/w sectors	**0.99**
Small-scale Fading	**Rice Fading, K=20**
RN Antenna Gain	**5dBi**
Thermal Noise Level	**-174dBm/Hz**

TABLE II : Handover and mobility related parameters

Parameter	Assumption/Explanation
Layer 3 Filter Coefficient	**4**
Layer 3 Filter sampling period	**200ms**
Hysteresis	**2, 3 dB**
Time to Trigger(TTT)	**64ms**
Speed State Scale Factors	**sf-Medium: 0.75, 1.0; sf-High: 0.25, 0.5.**
Back-haul Delay	**Truncated-exponential with mean 20ms, (min, max) of (10, 100)ms**
Radio Synchronization	**1ms**
RACH Waiting	**2ms**
Preamble	**1ms**
eNodeB Processing and Grant	**7ms**
UE/RN Processing Delay	**2ms**
Packets Delay	**5ms**
Radio Link Failure(RLF) Delay	**Truncated-exponential with mean 60ms, (min, max) of (10, 500)ms**
RLC declaration of RLF	**T310=500ms**
Speed Threshold	**60m/s**

[0098] Fig. 6 illustrates the simulation results of Handover Failure Probability with different RN velocity. Hysteresis is 3 dB in left part and 2dB in right part. Because the ST is set as 60m/s, when velocity is higher than 60m/s, then the Handover Failure Probability reduces significantly about 20-30 percentages when hysteresis is 3 dB and 5-10 percentages when hysteresis is 2 dB.

[0099] Fig. 7 illustrates the simulation results of Handover Overall Procedure Delay with different RN velocity. The handover delay hysteresis is determined by propagation and velocity of RN. When velocity is higher than 60m/s, then the T_{ho_delay} reduces significantly about 150 ms. The proposed handover procedure delay can well satisfy the handover delay hysteresis. From the simulation result in Fig. 8, it is known that the Handover Interruption Time reduced about 5ms caused by packet fluctuation delay.

[00100] Exemplary embodiments of the present invention have been described above with reference to block diagrams and flowchart illustrations of methods, apparatuses (i.e., systems). It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00101] The foregoing computer program instructions can be, for example, sub-routines and/or functions. A computer program product in one embodiment of the invention comprises at least one computer readable storage medium, on which the foregoing computer program instructions are stored. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory) or a ROM (read only memory).

[00102] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00103] It should also be noted that the above described embodiments are given for describing rather than limiting the invention, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the invention and the appended claims. The protection scope of the invention is defined by the accompanying claims. In addition, any of the reference numerals in the claims should not be interpreted as a limitation to the claims. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The indefinite article "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps.

[00104] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00105] It should also be noted that the above described embodiments are given for describing rather than limiting the invention, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art readily understand. Such modifications and variations are considered to be within the scope of the invention and the appended claims. The protection scope of the invention is defined by the accompanying claims. In addition, any of the reference numerals in the claims should not be interpreted as a limitation to the claims. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The indefinite article "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps.

What is claimed is:

1. A method for handover at a source eNB, comprising:

receiving a measurement report sent periodically from a mobile node, wherein the sending of the measurement report is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location and velocity information of the mobile node;

performing handover preparation; and

executing handover to a target eNB no later than the mobile node arriving at a Reference Handover Point (RHP).

2. The method of claim 1, wherein performing the handover preparation comprises:

in response to the time the mobile node runs to the RHP is equal to or shorter than a Handover Time Threshold (HTT), sending a resource configuration request message to the target eNB, such that the target eNB executes the resource configuration and requests data bi-casting; and

receiving a resource configuration request ACK message from the target eNB;

wherein the HTT is equal to P+T, wherein P is reporting period of the measurement report, and T is the time for the resource configuration and signaling for establishing the data bi-casting.

3. The method of claim 2, wherein the sending of the resource configuration request message is further in response to the speed of the mobile node being higher than a Speed Threshold (ST).

4. The method of claim 2, wherein the data bi-casting is requested immediately after the resource configuration of the target eNB is completed.

5. The method of claim 2, wherein the resource configuration request ACK message includes the first bi-casted packet ID.

6. The method of claim 1, wherein the RTP and RHP are updated based on the measurement report.

7. The method of claim 6, wherein the RTP and RHP are updated according to at least one of the following formulas:

$$RP_n = \{1 - \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})\} \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}$$

$$RP_n = \frac{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}}{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})}$$

$$RP_n = \{1 - (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)}\} \cdot RP_{n-1} + (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)} \cdot RP_{(measure,n)}$$

wherein RP represents either one of the RTP and RHP; the value of RP is the distance to the source eNB;

$RP_{(measure,n)}$ is the latest measurement reference point based on the measurement of the mobile node; RP_n is the updated reference point; RP_{n-1} is the old reference point; X_o is equal to 0; and σ and K are coefficient factors.

8. A method for handover at a mobile node, comprising:

sending periodically a measurement report to a source eNB, wherein the sending is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location and velocity information of the mobile node.

9. A method of claim 8, further comprising:

receiving a handover command from the source eNB; and

accessing to a target eNB.

10. The method of claim 9, wherein the handover command includes an ID of the first packet being bi-casted.

11. The method of claim 8, wherein the RTP is updated according to at least one of the following formulas:

$$RP_n = \{1 - \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})\} \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}$$

$$RP_n = \frac{\frac{1}{\sqrt{2\pi\sigma}}\exp(-\frac{X_0^2}{2\sigma^2})\cdot RP_{n-1} + \frac{1}{\sqrt{2\pi\sigma}}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})\cdot RP_{(measure,n)}}{\frac{1}{\sqrt{2\pi\sigma}}\exp(-\frac{X_0^2}{2\sigma^2}) + \frac{1}{\sqrt{2\pi\sigma}}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})}$$

$$RP_n = \{1-(1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)}\}\cdot RP_{n-1} + (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)}\cdot RP_{(measure,n)}$$

wherein RP represents the RTP; the value of RP is the distance to the source eNB; $RP_{(measure,n)}$ is the latest measurement reference point based on the measurement of the mobile node; RP_n is the updated reference point; RP_{n-1} is the old reference point; X_o is equal to 0; and σ and K are coefficient factors.

12. An apparatus for handover at a source eNB, comprising:

a report receiving unit, configured to receive a measurement report sent periodically from a mobile node, wherein the sending of the measurement report is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location and velocity information of the mobile node;

a handover preparation unit, configured to perform handover preparation; and

handover executing unit, configured to execute handover to a target eNB no later than the mobile node arriving at a Reference Handover Point (RHP).

13. The apparatus of claim 12, wherein the handover preparation unit is configured to:

in response to the time the mobile node runs to the RHP is equal to or shorter than a handover Time Threshold (HTT), send a resource configuration request message to the target eNB, such that the target eNB executes the resource configuration and requests data bi-casting; and

receive a resource configuration request ACK message from the target eNB;

wherein the HTT is equal to P+T, wherein P is reporting period of the measurement report, and T is the time for the resource configuration and signaling for establishing the data bi-casting.

14. The apparatus of claim 13, wherein the sending of the resource configuration request message is further in response to the speed of the mobile node being higher than a Speed Threshold (ST).

15. The apparatus of claim 13, wherein the data bi-casting is requested immediately after the

resource configuration of the target eNB is completed.

16. The apparatus of claim 13, wherein the resource configuration request ACK message includes the first bi-casted packet ID.

17. The apparatus of claim 13, wherein the RTP and RHP are updated based on the measurement report.

18. The apparatus of claim 17, wherein the RTP and RHP are updated according to at least one of the following formulas:

$$RP_n = \{1 - \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})\} \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}$$

$$RP_n = \frac{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}}{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})}$$

$$RP_n = \{1 - (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)}\} \cdot RP_{n-1} + (1/2)^{\left(\frac{|RP_{(measure,n)} - RP_{n-1}|}{K}\right)} \cdot RP_{(measure,n)}$$

wherein RP represents either one of the RTP and RHP; the value of RP is the distance to the source eNB;

$RP_{(measure,n)}$ is the latest measurement reference point based on the measurement of the mobile node; RP_n is the updated reference point; RP_{n-1} is the old reference point; X_o is equal to 0; and σ and K are coefficient factors.

19. An apparatus for handover at a mobile node, comprising:

report sending unit, configured to send periodically a measurement report to a source eNB, wherein the sending is triggered no later than the mobile node arriving at a Reference Triggering Point (RTP), and the measurement report comprises location and velocity information of the mobile node.

20. The apparatus of claim 19, further comprising:

receiving unit, configured to receive a handover command from the source eNB; and

accessing unit, configured to access to a target eNB.

21. The apparatus of claim 19, wherein the handover command includes an ID of the first packet being bi-casted.

22. The apparatus of claim 19, wherein the RTP is updated according to at least one of the following formulas:

$$RP_n = \{1 - \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})\} \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}$$

$$RP_n = \frac{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) \cdot RP_{n-1} + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2}) \cdot RP_{(measure,n)}}{\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{X_0^2}{2\sigma^2}) + \frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(RP_{(measure,n)} - RP_{n-1})^2}{2\sigma^2})}$$

$$RP_n = \{1 - (1/2)^{\left(\frac{\left|RP_{(measure,n)} - RP_{n-1}\right|}{K}\right)}\} \cdot RP_{n-1} + (1/2)^{\left(\frac{\left|RP_{(measure,n)} - RP_{n-1}\right|}{K}\right)} \cdot RP_{(measure,n)}$$

wherein RP represents the RTP; the value of RP is the distance to the source eNB; $RP_{(measure,n)}$ is the latest measurement reference point based on the measurement of the mobile node; RP_n is the updated reference point; RP_{n-1} is the old reference point; X_o is equal to 0; and σ and K are coefficient factors.

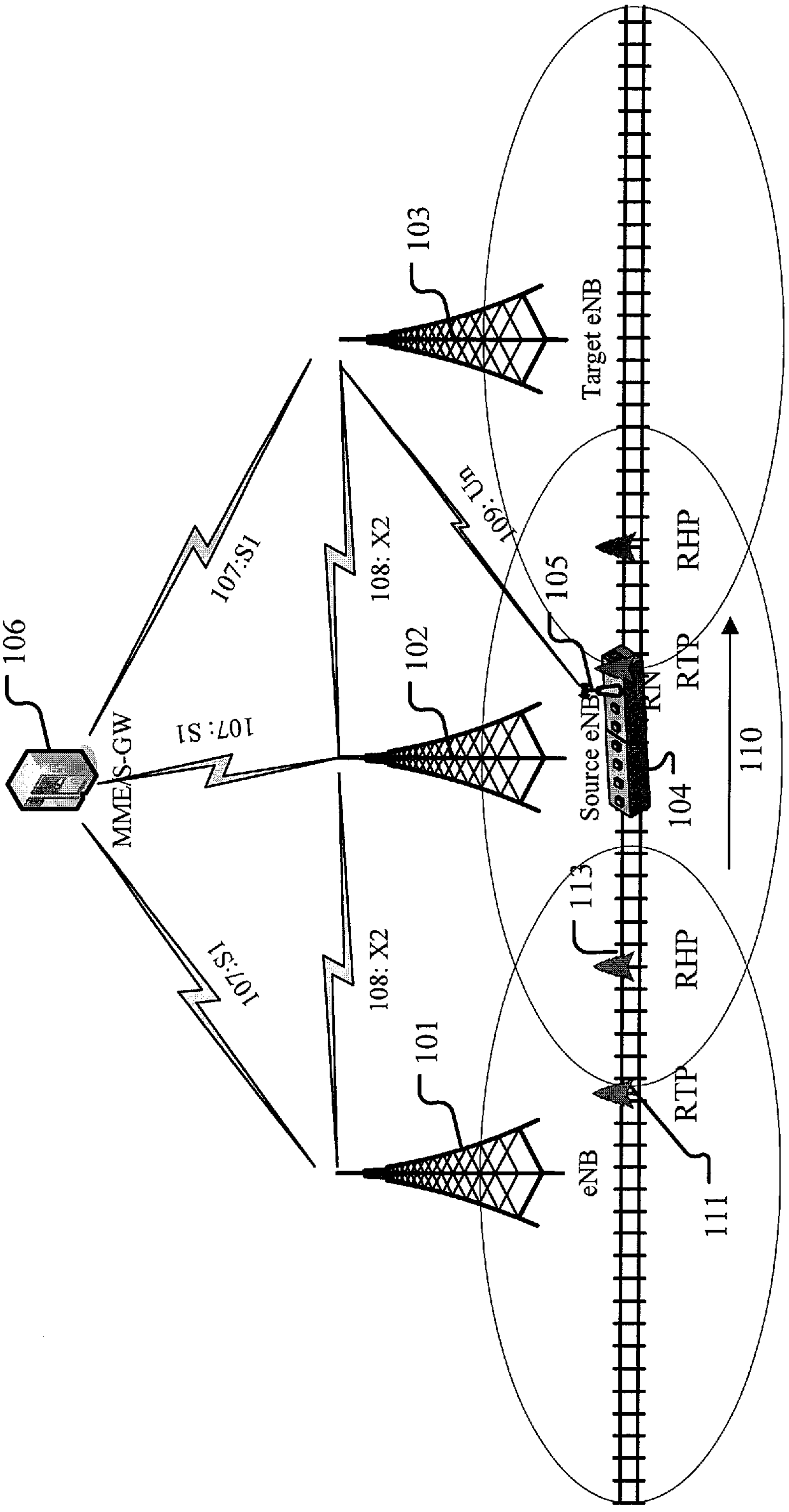

106
MME/S-GW
107:S1
107: S1
107:S1
108: X2
108: X2
109: Un
101
102
103
eNB
Source eNB
Target eNB
RN
104
105
110
111
113
RTP
RHP
RTP
RHP

Fig. 1

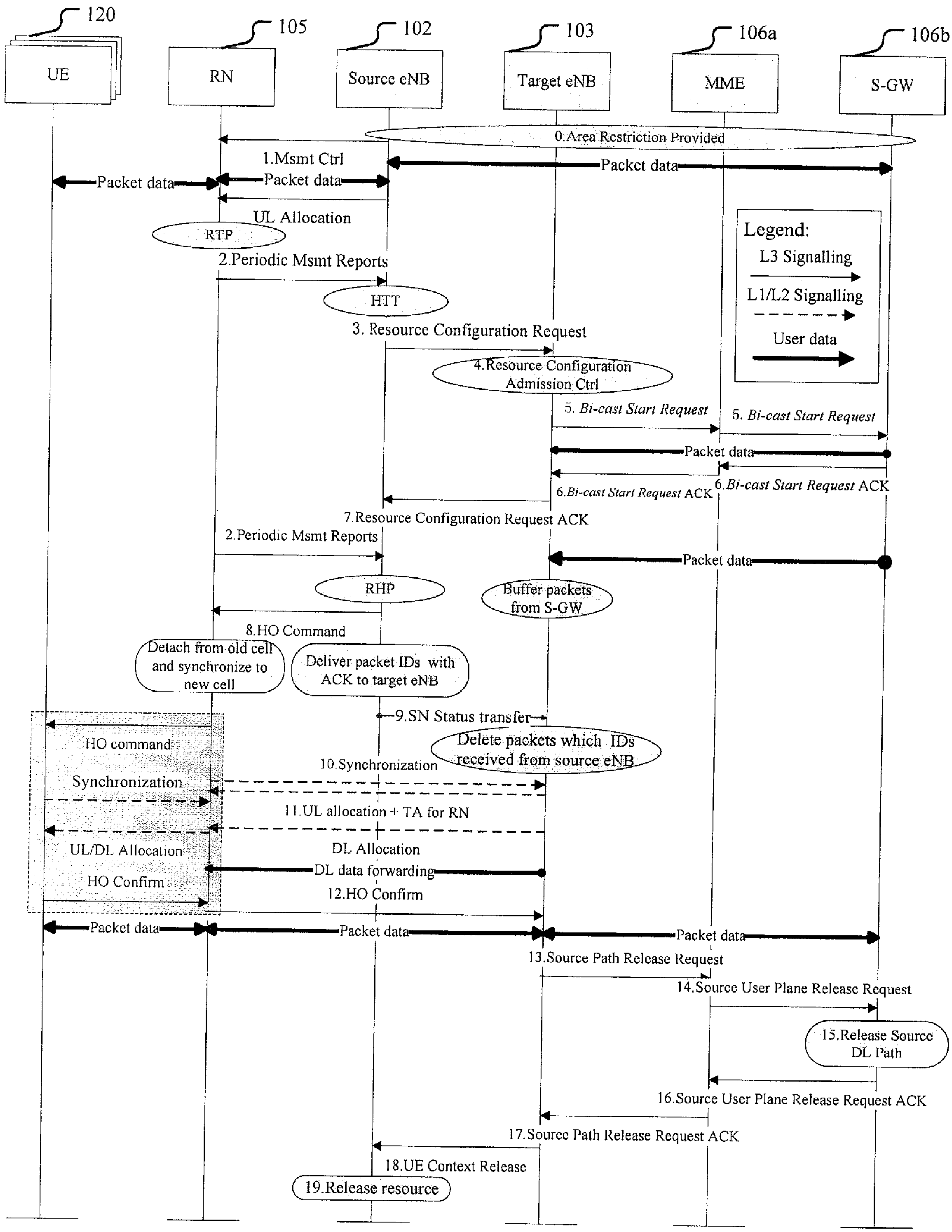

120
105
102
103
106a
106b
UE
RN
Source eNB
Target eNB
MME
S-GW
0.Area Restriction Provided
1.Msmt Ctrl
Packet data
Packet data
Packet data
UL Allocation
RTP
2.Periodic Msmt Reports
HTT
3. Resource Configuration Request
4.Resource Configuration Admission Ctrl
5. Bi-cast Start Request
5. Bi-cast Start Request
Packet data
6.Bi-cast Start Request ACK
6.Bi-cast Start Request ACK
7.Resource Configuration Request ACK
2.Periodic Msmt Reports
Packet data
RHP
Buffer packets from S-GW
8.HO Command
Detach from old cell and synchronize to new cell
Deliver packet IDs with ACK to target eNB
9.SN Status transfer
Delete packets which IDs received from source eNB
HO command
Synchronization
10.Synchronization
11.UL allocation + TA for RN
UL/DL Allocation
DL Allocation
DL data forwarding
HO Confirm
12.HO Confirm
Packet data
Packet data
Packet data
13.Source Path Release Request
14.Source User Plane Release Request
15.Release Source DL Path
16.Source User Plane Release Request ACK
17.Source Path Release Request ACK
18.UE Context Release
19.Release resource
Legend:
L3 Signalling
L1/L2 Signalling
User data

FIG. 2

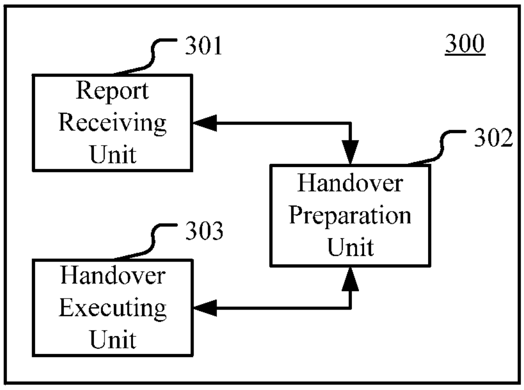


FIG. 3

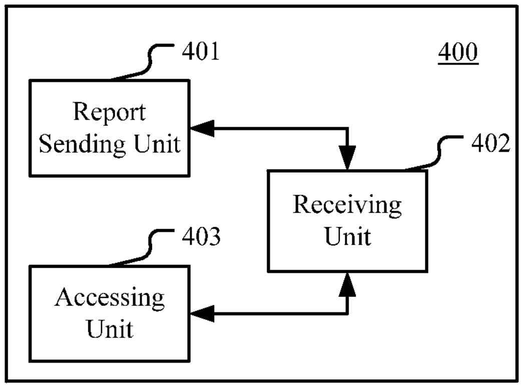


FIG. 4

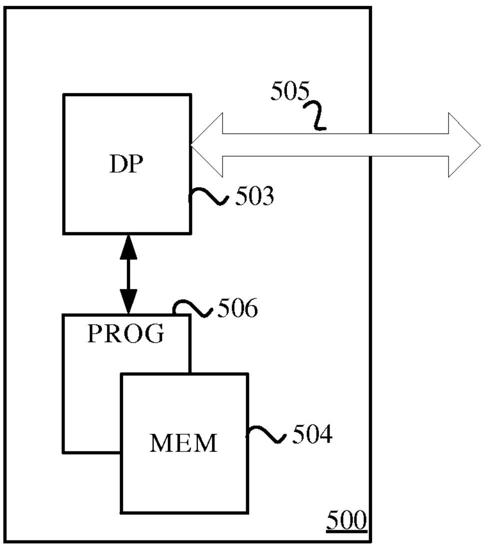


FIG. 5

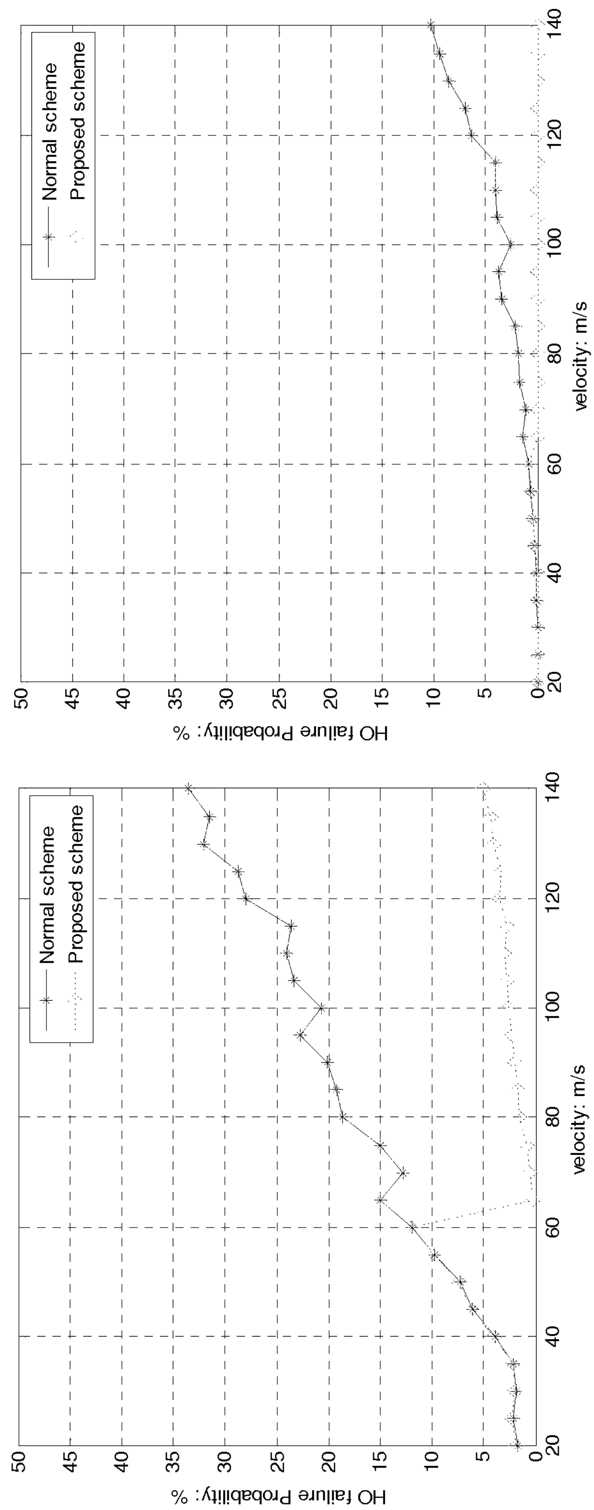
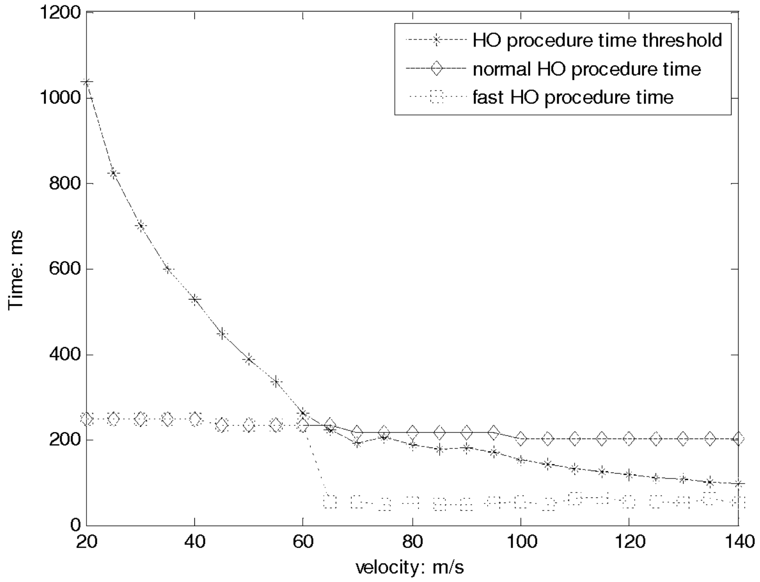
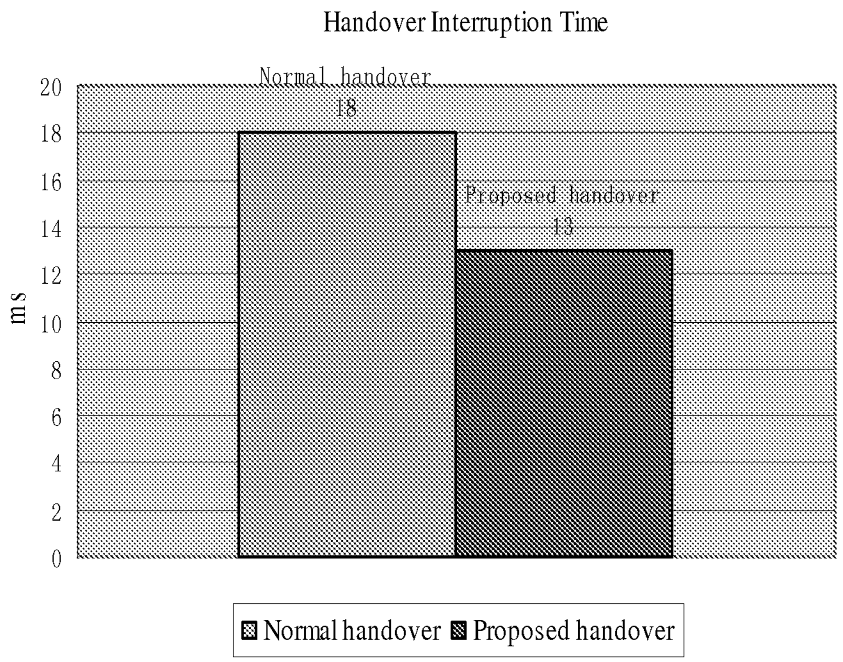

Normal scheme
Proposed scheme
HO failure Probability: %
velocity: m/s
Normal scheme
Proposed scheme
HO failure Probability: %
velocity: m/s

Fig. 6



HO procedure time threshold
normal HO procedure time
fast HO procedure time
Time: ms
velocity: m/s
0
200
400
600
800
1000
1200
20
40
60
80
100
120
140

FIG. 7



Handover Interruption Time
Normal handover
18
Proposed handover
13
ms
0
2
4
6
8
10
12
14
16
18
20
Normal handover
Proposed handover

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/073181

A. CLASSIFICATION OF SUBJECT MATTER

H04W 36/32 (2009.01) i

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: H04W, H04Q

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)

WPI, EPODOC, CNKI, CNPAT, IEEE, GOOGLE:

handoff, handover; fast, quick; location, distance, velocity, speed; measure, measurement, report; base station, eNB, NodeB, mobile, UE; high speed, train, railway

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN102300274A (BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS) 28 Dec. 2011 (28.12.2011) paragraphs 0045-0055 in the description, figures 1-6	1-6, 8-10, 12-17, 19-21
A		7, 11, 18, 22
A	US2010/0074221A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 25 Mar. 2010 (25.03.2010) the whole document	1-22
A	CN102123461A (BEIJING JIAOTONG UNIVERSITY) 13 Jul. 2011(13.07.2011) the whole document	1-22

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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

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

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

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 Dec. 2012 (14.12.2012)	**10 Jan. 2013 (10.01.2013)**

Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China
100088
Facsimile No. 86-10-62019451

Authorized officer
LIU,Yi
Telephone No. (86-10)62413335

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/073181

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN102300274A	28.12.2011	NONE	
US2010/0074221A1	25.03.2010	US8223719B2	17.07.2012
		KR20100034304A	01.04.2010
		KR100074121B1	17.10.2011
CN102123461A	13.07.2011	NONE	