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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 June 2012 (28.06.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/086321 A1

(51) International Patent Classification:
H04W 24/02 (2009.01) *H04W 24/08* (2009.01)
H04W 16/26 (2009.01)

(21) International Application Number:
PCT/JP2011/075523

(22) International Filing Date:
28 October 2011 (28.10.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1021936.8 22 December 2010 (22.12.2010) GB

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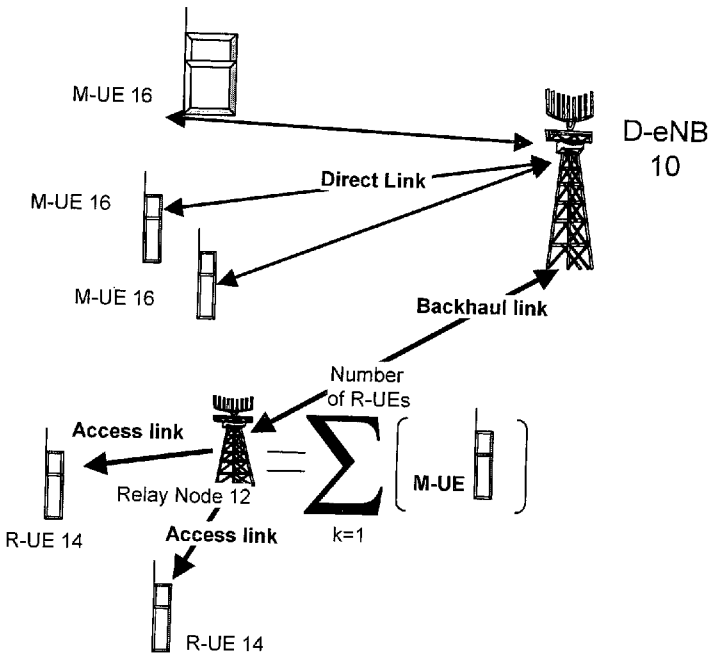
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, 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,

[Continued on next page]

(54) Title: RELAY METHOD

FIG. 2



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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).

Published:

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

(57) Abstract: A mobile communications system comprising a eNB operable to take L2 measurements, wherein said system comprises one or more relay nodes connected with the eNB, and wherein the eNB is operable to consider the one or more relay nodes in different ways, depending upon the measurements being taken.

DESCRIPTION

TITLE OF INVENTION: RELAY METHOD

TECHNICAL FIELD

The present invention relates to L2 measurements taken on the relay backhaul of a relay node (especially a Type-1 in-band relay) as applicable in the context of 3GPP Long Term Evolution (LTE)-Advanced.

BACKGROUND ART

The first release of the LTE was referred to as release-8, and provided a peak rate of 300 Mbps, a radio network delay of less than 5ms, an increase in spectrum efficiency and new architecture to reduce cost and simplify operation.

LTE-A or LTE Advanced is currently being standardized by the 3GPP as an enhancement of LTE. LTE mobile communication systems are expected to be deployed from 2010 onwards as a natural evolution of GSM and UMTS.

Being defined as 3.9G (3G+) technology, LTE does not meet the requirements for 4G, also called IMT Advanced, that has requirements such as peak data rates up to 1 Gbps.

In April 2008, 3GPP agreed to the plans for future work on Long Term Evolution (LTE). A first set of 3GPP requirements on LTE Advanced was approved in June 2008. The standard calls for a peak data rate of 1 Gbps and also targets faster switching between power states and improved performance at the cell edge.

The section below briefly discusses the network architecture of an LTE wireless communications network. Further details may be found at www.3gpp.org.

The base station - or E-UTRAN - for LTE consists of a single node, generally termed the eNodeB (eNB) that interfaces with a given mobile phone (typically termed user equipment, or user terminal). For convenience, the term UE – user equipment – will be used hereafter. The eNB hosts the physical layer (PHY), Medium Access Control layer (MAC), Radio Link Control (RLC) layer, and Packet Data Control Protocol (PDCP) layer that include the functionality of user-plane header-compression and encryption. It also offers Radio Resource Control (RRC) functionality corresponding to the control plane. The evolved RAN performs many functions including radio resource management, admission control, scheduling, enforcement of negotiated up-link QoS, cell information broadcast, ciphering/deciphering of user and

control plane data, and compression/decompression of down-link/up-link user plane packet headers.

The physical layer is often termed Layer 1. The Medium Access Control layer (MAC), Radio Link Control (RLC) layer, and Packet Data Control Protocol (PDCP) layer are collectively know as Layer 2. The Radio Resource Control is usually termed Layer 3.

Relaying is considered as an economical way of extending the coverage of a wireless communication system by improving the cell-edge throughput and system capacity. In LTE-A, relays are generally defined in two categories: type 1 and type 2. Type 1 relay nodes have their own PCI(Physical Cell ID) and are operable to transmit its common channel/signals. UEs receive scheduling information and HARQ feedback directly from the relay node. It is also possible for type 1 relay nodes to appear differently to eNBs to allow for further performance enhancement.

By contrast, type 2 relay nodes do not have a separate PCI, and are transparent to UEs.

Each relay in the network will have a link to a controlling eNB. This link is often termed the backhaul link,

and is achieved by the Un interface. Each eNB will be linked to the core network, and this link is the eNB's backhaul link. The controlling eNB is sometimes referred to as a donor eNB, or D-eNB. A D-eNB controls network traffic within a domain. Said domain may include a plurality of further nodes. Domains located geographically next to one another may be termed neighbouring domains.

A UE connected directly to a D-eNB is considered to be directly linked, or to comprise a direct link. A UE's connection to a relay node is termed an access link.

In order to support network radio link operations, radio resource management (RRM), network operations and maintenance (OAM), and self-organising networks (SON), generally measurements are taken by an eNB and are transferred over standardised interfaces. In this connection, a number of layer 2 (L2) measurement parameters are defined in TS 36.314. A copy of this documents is available at www.3gpp.org. The contents thereof are hereby incorporated by reference.

For a D-eNB, the L2 measurements have specific significance in the following areas:

i) Cell load balancing;

ii) OAM performance monitoring; and

iii) Configuration optimization

In current network architectures, some of these L2 measurements are taken by an eNB per quality of service class identifier (QCI) and/or UE. Six different types of measurement parameters have been defined, as specified in TS 36.314 – they consist of:

1. PRB usage: this is to measure the usage of time and frequency resources. This is measured to perform cell load balancing and OAM performance monitoring.

2. Received Random Access Preambles: the measured quantity in this case is the number of received Random Access preambles during a time period over all PRACHs configured in a cell. This is used for configuration optimization.

3. Number of active UEs: this measures the number of active UEs per QCI for OAM performance monitoring.

4. Packet Delay: this is to measure L2 Packet Delay for OAM performance monitoring.

5. Data Loss: this is to measure packets that are dropped due to congestion, traffic management etc for OAM performance monitoring.

6. Scheduled IP Throughput: this is to measure over Uu the IP throughput independent of traffic patterns and packet size. This measurement is performed per QCI per UE.

These measurements are executed by the L2 sub-layers, i.e. PDCP, RLC and MAC. The present invention seeks advantages in how such measurements are performed, and particularly how such measurements are taken in a network comprising a plurality of relay nodes.

The documents R2-106318: 3GPP TSG RAN WG2 meeting #72 Jacksonville, USA, Nov 15-19, 2010: 'measurements of RN' and R2-106472: 3GPP TSG RAN WG2 meeting #72 Jacksonville, USA, Nov 15-19, 2010: 'L2 measurements in D-eNB and RN disclose ways to consider L2 measurements in LTE-A networks. In both case, the D-eNB ascertains the number of direct links with UEs, and the number of access links to relay nodes. In these arrangements, each relay node is considered as a UE when the D-eNB performs L2 measurements.

SUMMARY OF INVENTION

According to the present invention there is provided a mobile telecommunications system comprising an eNB, a relay node and a plurality of UEs, wherein:

1) at least one of said UEs is directly connected with said eNB; and

2) at least one of said UEs is connected to the relay node,

wherein,

the eNB is operable to determine the total number of UEs directly connected, and the total number of UEs connected to the relay node, and use the combination of these totals to perform certain L2 measurements.

In this arrangement, the eNB is operable to ascertain the number of active UEs by summing the number of direct link UEs with the total number of UEs connected to each of the relay nodes connected with the eNB. In effect, the eNB considers the relay node, for the majority of L2 measurements, to comprise a number of directly linked UEs corresponding to the number of UEs connected to said relay. For example, if a given relay node supports six UEs, for the purposes of performing L2 measurements, the eNB considers the relay node to be equivalent to six direct linked UEs.

Furthermore, if said same eNB also supports four direct link UEs, then, for the purposes of performing L2 measurements, the eNB considers that it supports six direct link UEs (from the relay node) plus four direct link UEs, ie ten direct link UEs.

A mobile communications system comprising a eNB operable to take L2 measurements, wherein said system

comprises one or more relay nodes connected with the eNB, and wherein the eNB is operable to consider the one or more relay nodes in different ways, depending upon the measurements being taken.

In order that the present invention be more readily understood, specific embodiments thereof will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an example of a architecture of a wireless communication network.

Figure 2 is illustrates a wireless communication system in accordance with the present invention.

DESCRIPTION OF EMBODIMENTS

The present arrangement ascertains how to perform L2 measurements on the relay backhaul and determines whether new additions have to be made to TS 36.314. It is also desirable to propose methods operable to perform meaningful relay node related L2 measurements on the backhaul link that compare favourably with those taken from UEs directly linked to an eNB.

In release 10 of the 3GPP (Rel-10), and in possible future

releases some eNBs of the wireless telecommunication system will have capabilities to serve both UEs and relays nodes. Such entities are termed Donor eNBs, or D-eNBs.

Figure 1 shows a D-eNB 10 maintains a direct link with a UE 16 (termed macro-UEs and hereinafter denoted by M-UEs). The M-UE 16 is served directly via Uu interface. The D-eNB 10 is connected with a relay node 12. Accordingly, the relay node comprises a backhaul link to the D-eNB 10 via the Un interface.

The relay node is 12 operable to maintain an access link to a UE 14 (termed R-UE). This link is via the Uu interface. It will be appreciated that figure 1 is a simplified diagram, and that in practice a D-eNB 10 may support a plurality of M-UEs 16 and a plurality of relay nodes 12.

The D-eNB 10 that provides radio resources to both the M-UE 16 and the relay node. Accordingly, L2 measurements are as equally important for the relay node 12 as for M-UEs 16. As stated earlier, the L2 measurements have the following significance, namely:

i) Cell load balancing

ii) OAM performance monitoring

iii) Configuration optimization

Hence, for the purpose of performing operations (i), (ii) and (iii) above, the D-eNB 10 is required to take L2 measurements for both the relay node and the M-UEs 16.

As stated earlier, there are six primary types of measurements which have been predefined. These are 1) determining the number of active UEs; 2) PRB usage; 3) received random access preambles; 4) packet delay; 5) data loss, and 6) scheduled IP throughput. The present arrangement provides new mechanism for measuring these primary types.

Figure 2 shows an example of a simplified wireless telecommunications network comprising a D-eNB 10 and a relay node 12. In this arrangement, three M-UEs 16 are directly connected to the D-eNB. Two R-UEs 14 are connected to the relay node 12. For the purposes of making the L2 measurements, the D-eNB 10 ascertains how many M-UEs 16 are currently being served. It also ascertains the number of R-UEs being served by the relay node. The D-eNB 10 therefore takes the relay node 12 as representing two M-UEs 16 for the purpose of making type 1, 2, 4, 5 and 6 measurements.

In order for a D-eNB 10 to serve a R-UE 14 (via the relay node), not only the resources of the relay node are consumed, but also those of the controlling D-eNB 10. In addition, when considering load balancing, the resource status of the D-eNB's backhaul is an important input to the calculation of a relay node resource status. In other words, if either the access link or backhaul link resources are exhausted, a relay node 12 will not be able to serve any further R-UEs 14.

In order to apply the legacy L2 measurements as specified by TS 36.314 to relay nodes 12, it needs to be determined whether or not a relay node 12 can be treated as a M-UE 16 by a D-eNB 10 when determining L2 measurements, e.g. number of active UE, and also whether or not it acceptable for the given D-eNB 10 to regard a Un DRB of a relay node 12 as a M-UE's DRB to execute L2 measurements based on QCI.

When a measurement relates to the Received Random Access Preambles (measurement) received in connection with the configured PRACH of a cell, a Rel-10 relay node can be considered as a M-UE – however, this may not be the case with the other measurement parameters (measurement 1 & Measurements 3 to 6).

An RN 12 carries aggregated traffic and may take up a significant portion of D-eNB's 10 radio resources. This is because a Rel-10 RN 14 is in fact an eNB and is a resource-greedy node from an D-eNB point of view. As in order to the fact that just to serve an R-UE 14 via an RN 12, resources have to be allocated both on the access and backhaul links – these radio resources are owned and controlled by the D-eNB 10. For instance, suppose an R-UE 14 and an M-UE 16 generate the same amount and type of traffic belonging to the same QCI. In terms of the resource (especially radio) allocation, R-UE 14 would require twice as much as that is required by the M-UE 16 in case the same modulation and coding schemes are employed irrespective of the channel qualities. In this respect, treating an RN 12 as an M-UE 16 will lead to the creation of a wrong picture.

The interpretation of the above means that for some L2 measurement parameters a Rel-10 RN 12 can be treated as an M-UE 16 but for others an RN 12 has to be treated differently at least for future releases. In other words, for the Received Random Access Preambles, a Rel-10 RN 12 can be treated like an M-UE 16 – but as it is proposed in the present invention, in order to count the number of active UEs, an RN 12 is treated as being consisting of the same number of M-UEs 16 as the number of R-UEs 14 being served by it.

In addition to the need to re-define certain measurement parameters as specified in TS 36.314 to suit the backhaul, new measurement parameters need to be defined. For instance, in the case of mobile relays it is important that the RN 12 is capable of performing the RACH procedure whilst continuing to operate in the capacity of a relay, which is especially desirable at the time of handover in order to minimize the latency. This will require the definition of a new R-PRACH and associated new parameter to measure the Received Random Access Preambles. This measurement parameter is applicable to R-PRACH. As a result, there will exist no valid reason/ground to treat an RN 12 as an M-UE 16 in future releases.

In order to convey the correct picture, this present invention treats an RN 12 as that being consisting of the same number of M-UEs 16 as the number of R-UEs 14 being served by it. In the light of this, in order to take L2 measurements per QCI per UE, it is envisaged that each RN 12 takes L2 measurements as stipulated by TS 36.314 and passes them on to the respective D-eNB 10 for the latter to perform meaningful measurements that will compare well with those taken from M-UEs 16 directly. This is partly because due to insufficient number of DRBs being available on the

backhaul, different Uu QCI traffic types get multiplexed on to a single Un DRB. This makes it difficult to identify the true per-Uu-QCI traffic belonging to R-UEs 14 at the given D-eNB 10. This situation gets exacerbated due to the fact that S1/X2 S1/X2 (S1 is the communications interface between eNBs and the EPC (packet core network), while X2 interfaces between eNBs) terminates directly at a relay itself in certain relay architectures (especially the relay architecture being considered for Rel-10) and as a result, measuring per UE/QCI traffic pertaining to R-UEs 14 at the given D-eNB 10 is very difficult or rather impossible.

On the other hand, it is mentioned in R2-106318: 3GPP TSG RAN WG2 meeting #72 Jacksonville, USA, Nov 15-19, 2010: 'measurements of RN' that an RN 12 takes the L2 measurements and pass them on to its OAM. In the same way D-eNB 10 takes its own measurements and passes them onto its OAM. Given that the resources are owned and controlled by the D-eNB 10, these two OAM should communicate with each other in order to accomplish any meaningful optimisation/load-balancing/SON. However, minimizing information exchange between the related OAM systems should be preferred. Hence, it is better for the D-eNB 10 to take the overall measurements in its domain with a help of RNs 12 and applies its optimisation/SON/load-balancing.

This requires that an RN 12 takes L2 measurements periodically in the legacy way on its access link and passes them on to the respective D-eNB 10 for the latter to perform meaningful L2 measurements in its domain.

Some measurements taken on Uu per R-UE 14 and QCI can be a good representation of those on Un. This is because the support of R-UEs 14 on the Uu interface depends on the capability/capacity of Un. Further, given that different Uu QCIs are mapped onto Un due to DRB limitation, the Uu measurement will give the correct picture in terms of what QCIs are in-fact supported.

Accordingly, one of the objectives of the present invention is to get each RN 12 to periodically take the measurements and to send them to the D-eNB 10 and so that the D-eNB 10 can use these in its own measurements. For the D-eNB 10 to take the necessary L2 measurements especially on Un, some of the measurements need to be refined and formulated as presented in the subsequent paragraphs. As the overall resource owner, it is better for the D-eNB 10 to apply OAM, SON and optimisation especially on Un based on the measurements taken by itself and collected from the RNs 12 it serves. This will make sure that a correct picture regarding every RN being served will be sent to neighbouring base

stations for the latter to use at the time of handover and load balancing situations. Further relay's OAM may not communicate directly with the D-eNB's OAM.

Thus, legacy L2 measurements, which are per QCI and/or per UE, are easily achieved by L2 sub-layers on the Uu interface but are difficult on the Un interface.

It is therefore desirable to provide an arrangement operable to perform meaningful relay related L2 measurements on the Un interface (i.e., backhaul) that will compare well with those taken from M-UEs.

A relay node can apply the same L2 measurements as those applicable to the legacy eNB on the access link without having any problem because an RN operates in the capacity of an eNB to those R-UEs 14 it serves. The current problem is associated with the D-eNB 10 measurement on the backhaul. In addition to re-defining the measurement parameters as specified in TS 36.314 to suit the backhaul, new measurement parameters need to be defined. For instance, in the case of mobile relays it is important that any RN performs the RACH (random access channel) procedure whilst operating in the capacity of a relay node, especially at the time of handover in order to minimize the latency. This requires

definition of a relay – packet random access channel (R-PRACH) and a new parameter to measure the Received Random Access Preambles. This measurement parameter is applicable to R-PRACH. Likewise, new MBSFN-related parameters may have to be standardized.

In the case of existing measurement parameters as specified in TS 36.314, the present arrangement provides for relay nodes to apply L2 measurement procedures as specified in TS 36.314 on the access link. Some measurements taken on the access link per UE and QCI can be a good representation of those on the backhaul link as it will be explained below. This is because the support of R-UEs on the access link (Uu interface) depends on the capability of backhaul link (Un interface). The radio resources being used on the backhaul and the access links are controlled by in-band signalling by D-eNB 10 and some relay nodes. Given that different Uu QCIs are mapped onto Un due to DRB limitations, the Uu measurement will closely approximate what QCIs are supported. Hence, the relay node periodically takes measurements as stipulated by TS 36.314, and sends them to the D-eNB and so that it can use these in its own measurements.

Measurement 1: measuring the number of active UEs

In order to calculate the number of active UEs, the following will apply:

Let N^{i}_{R-UEs} be the number of active R-UEs being served by Relay-i

Let N_{M-UEs} be the number of active M-UEs being served by the D-eNB directly

Hence, the total number of active UEs to be considered for D-eNB measurement

$$= N_{M-UEs} + \sum_{i}(N^{i}_{R-UEs}) \quad \text{----------(1)}$$

Thus, the D-eNB is operable to determine the total number of UEs (i.e., M-UEs) directly connected, and the total number of UEs (i.e., R-UEs) connected to the relay node, and use the combination of these totals to perform certain L2 measurements as described below.

Hence, the number of active UEs to be considered by a D-eNB is given by equation (1). Thus a RN is represented as having the same number of M-UEs as those R-UEs being served by the given RN. This formula applies to both the uplink and the downlink. A relay node will typically serve a plurality of R-UE, and hence may be considered as consisting of a number of M-UEs that is equal to the number of R-UEs being served on the access link. The following thus applies:

Let N^{i,QCI_j}_{R-UEs} be the number of active R-UEs being served by Relay-i and supporting QCIj

Let $N_{M-UEs}^{QCI_j}$ be the number of active M-UEs being served by the D-eNB directly and supporting QCIj

Hence, the total number of active UEs to be considered per QCIj for any D-eNB measurement

$$= N_{M-UEs}^{QCI_j} + \sum_i (N_{R-UEs}^{i,QCI_j}) \quad \text{----------(2)}$$

The number of Active UEs in the downlink per QCI in either direction is given by equation (2). This equation may be considered a subset of equation 1. Equation 2 allows for the eNB to make measurements concerning the scheduled IP throughout.

It should be noted that formulas (1) and (2) apply to a single D-eNB.

Measurement 2: Physical Resource Block usage

In order to measure a resource or the total PRB (physical resource block) usage by a D-eNB, the existing procedure can be used.

The following procedure is used to calculate the PRB usage per traffic class.

Let $PRB_{Access,\,R-UEs}^{i,QCI_j}$ be the total PRB used by R-UEs being served by Relay-i on the access link and supporting QCIj

Let $PRB_{Backhaul,\,R-UEs}^{i,QCI_j}$ be the total PRB used by R-UEs being served by Relay-i on the backhaul link and supporting

QCIj

Let $PRB_{M-UEs}^{QCI_j}$ be the total PRB used by M-UEs being served by the D-eNB directly and supporting QCIj

Hence, the total PRB usage per traffic class (i.e., QCIj) for any D-eNB measurement

$$= PRB_{M-UEs}^{QCI_j} + \sum_i (PRB_{Access,\ R-UEs}^{i,QCI_j} + PRB_{Backhaul,\ R-UEs}^{i,QCI_j}) \quad \text{----------(3a)}$$

Using the Logical Channel Identifier (LCID), the D-eNB can take measurement of the corresponding amount of resource or PRB usage on the backhaul per a given R-UE being served by a relay per QCIj. Combining this resource or PRB usage per QCIj by all R-UEs being served by a given relay, $PRB_{Backhaul,\ R-UEs}^{i,QCI_j}$ can be determined. However, in order to save the computational time involved, the following assumption is made for the reasons mentioned underneath:

$$PRB_{Access,\ R-UEs}^{i,QCI_j} = PRB_{Backhaul.\ R-UEs}^{i,QCI_j}$$

In the case of Type-1, 1a, and 1b in-band relay nodes, the amount of resource to be used by an R-UE on both the access link and the backhaul link can be considered as being approximately the same if the same modulation and coding schemes are employed irrespective of the link qualities – hence, this assumption is made in the present arrangement, although it is acknowledged that in reality it may differ due to time-varying channel quality. In this case the total amount of PRBs or resource to be used by a D-eNB to serve an R-UE is twice as that being required on the access link. Accordingly,

suppose the access link needs R amount of radio resources to serve an R-UE, the total amount of D-eNB resources being used to serve the same R-UE both on the access and backhaul links is 2*R. This is also true for a given QCI traffic on the access link.

Hence, the total PRB usage per traffic class (i.e., QCIj) for any D-eNB measurement

$$= PRB_{M-UEs}^{QCI_j} + 2*\sum_i (PRB_{R-UEs}^{i,QCI_j}) \quad \text{----------(3b)}$$

Measurement 3: Receive Random Access Preambles

3GPP Rel-10 relay nodes access the network in the same manner as a UE, in order to calculate Received Random Access Preambles being applicable to PRACH, a Rel-10 RN can be considered as a M-UE. For mobile relays, this measurement has to be split such that a D-eNB will calculate the Received Random Access Preambles being applicable to PRACH from the M-UEs only and the Received Random Access Preambles being applicable to R-PRACH from relays.

Measurement 4: Packet Delay

In the case of Packet Delay measurement per QCI in either direction, the same principles as applied in relation to equations (1), (2) or (3a/b) can be used. Accordingly, suppose:

Let $tArriv_{R-UEs}^{i,QCI_j}(k)$ be the point in time when PDCP SDU k belonging to QCIj arrives in Relay-i

Let $tAck_{R-UEs}^{i,QCI_j}(k)$ be point in time when the last piece of PDCP SDU k belonging to QCIj was received by the R-UE according to received HARQ feedback information

Let $tArriv_{M-UEs}^{QCI_j}(k)$ be the point in time when PDCP SDU k belonging to QCIj arrives in D-eNB being destined to an M-UE

Let $tAck_{M-UEs}^{QCI_j}(k)$ be point in time when the last piece of PDCP SDU k belonging to QCIj was received by the M-UE according to received HARQ feedback information

Let k, $K(T)$ and T respectively be a PDCP SDU that arrives at the PDCP upper SAP during time period T, Total number of PDCP SDUs k and the time-period during which the measurement is performed

Hence, the Packet Delay in the DL per traffic class (i.e., QCIj) for any D-eNB measurement is given by:

$$PacketDelay(T,qci) = \left\lfloor \frac{\left(\sum_{\forall k} \left(tAck_{M-UEs}^{QCI_j}(k) - tArriv_{M-UEs}^{QCI_j}(k) \right) + 2 * \left(tAck_{R-UEs}^{i,QCI_j}(k) - tArriv_{R-UEs}^{i,QCI_j}(k) \right) \right)}{K(T)} \right\rfloor$$

(4)

Measurement 5: Data Loss

In the case of Packet Discard Rate measurement per QCI in either direction, the same principles as applied in relation to equations (1), (2), (3a/b) or (4) can be used. Accordingly, suppose:

Let $Dloss^{i}_{R-UEs}(T,qci)$ be the number of downlink packets destined to R-UEs, for which no part has been transmitted over the air by Relay-i, of a data radio bearer with QCI = qci, that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than hand-over,

Let $Dloss_{M-UEs}(T,qci)$ be the number of downlink packets destined to M-UEs, for which no part has been transmitted over the air by the given D-eNB, of a data radio bearer with QCI = qci , that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than hand-over,

Let $N(T,qci)$ and T respectively be the number of downlink packets of bearer with QCI = qci that has entered PDCP upper SAP during time period T and the time-period during which the measurement is performed

Hence, the Packet Discard Rate in the DL per traffic class (i.e., QCIj) for any D-eNB measurement is given by:

$$PacketDiscardRate(T,qci) = \left\lfloor \frac{\left(Dloss_{M-UEs}(T,qci) + 2 * Dloss^{i}_{R-UEs}(T,qci)\right) * 1000000}{N(T,qci)} \right\rfloor \quad \text{--(5)}$$

The same principles apply in the UL in order determine the Packet Loss Rate in the UL per QCI.

Measurement 6: Scheduled IP Throughput

In order to measure Scheduled IP Throughput, the same

principle that applied before can be applied with an exception that the IP throughput being measured on the access link is the IP throughput of the backhaul – hence, there is no need to double the value unlike performed in the previous cases. Again, this can be measured per UE or QCI – both on DL and UL. Equation 2, shown above, allows for the QCI per UE to be determined.

Preferably, the system is operable, for received random access preamble measurements, to treat a relay node as a single directly connected UE. It is preferred, for PRB usage, number of active UEs, data loss, packet delay and scheduled IP throughput measurements that a relay node is considered to represent the same number of direct link UEs as there are UEs connected to said relay node.

It is preferred that the relay node is a type 1 relay node.

Preferably, when considering PRB usage, the eNB is operable to approximate the resource usage on the backhaul link of a UE connected to a relay to its usage on the access link.

It is preferred, when making measurements relating to PRB usage, data loss and packet delay, the resource uasge on

the access link of UEs connected to a relay node is determined, and doubled by the eNB prior making said measurements. This is because, if the relay resource on the access link to serve a UE is R, the total amount of a eNB's radio resource to serve the UE connected to a relay on both the access link and backhaul link is 2xR.

Preferably the eNB considers the or each relay node as a UE directly linked thereto for the purposes of taking measurements for received random access preambles,

It is preferred that the eNB determines the number of UEs connected to the or each relay node, and considers that the or each relay node corresponds to said number of direct link UEs for the purpose of making PRB usage, number of active UE, packet delay, data loss and scheduled IP throughput measurements.

It is preferred that the number of active UEs is determined by the following equation:

$$\text{number of active UEs} = N_{M-UEs} + \sum_i (N^i_{R-UEs})$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to a relay node. It will be appreciated that the an eNB may support a plurality of relay nodes, and hence it is required to sum the

total number of UEs support by each of the relay nodes supported by the eNB.

It is preferred that the total number of active UEs per QCI is determined by the following equation:

$$\text{number of active UEs per QCI} = N_{M-UEs}^{QCI_j} + \sum_i (N_{R-UEs}^{i,QCI_j})$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to a relay node.

It is preferred that the PRB usage per QCI is determined by the following equation:

$$\text{total PRB usage per QCI} = PRB_{M-UEs}^{QCI_j} + 2 * \sum_i (PRB_{R-UEs}^{i,QCI_j})$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to a relay node.

It is preferably that the packet delay in the downlink per QCI is determined by the following equation:

$$PacketDelay(T, qci) = \left\lfloor \frac{\left(\sum_{\forall k} \left(tAck_{M-UEs}^{QCI_j}(k) - tArriv_{M-UEs}^{QCI_j}(k) \right) + 2 * \left(tAck_{R-UEs}^{i,QCI_j}(k) - tArriv_{R-UEs}^{i,QCI_j}(k) \right) \right)}{K(T)} \right\rfloor$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to a relay node,

$tArriv_{R-UEs}^{i,QCI_j}(k)$ is the point in time when PDCP SDU k belonging to QCIj arrives in Relay-I, $tAck_{R-UEs}^{i,QCI_j}(k)$ is the point in time when the last piece of PDCP SDU k belonging to QCIj was received by the R-UE according to received HARQ feedback information, Let $tArriv_{M-UEs}^{QCI_j}(k)$ is the point in time when PDCP SDU k belonging to QCIj arrives in D-eNB being destined to an M-UE, $tAck_{M-UEs}^{QCI_j}(k)$ is the point in time when the last piece of PDCP SDU k belonging to QCIj was received by the M-UE according to received HARQ feedback information and k, $K(T)$ and T are, respectively, a PDCP SDU that arrives at the PDCP upper SAP during time period T, Total number of PDCP SDUs k and the time-period during which the measurement is performed.

It is preferred that the data loss in the downlink per QCI is determined by the following equation:

$$PacketDiscardRate(T,qci) = \left\lfloor \frac{\left(Dloss_{M-UEs}(T,qci) + 2 * Dloss^{i}_{R-UEs}(T,qci)\right) * 1000000}{N(T,qci)} \right\rfloor$$

wherein $Dloss^{i}_{R-UEs}(T,qci)$ id the number of downlink packets destined to R-UEs, for which no part has been transmitted over the air by Relay-i, of a data radio bearer with QCI = qci, that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than hand-over, $Dloss_{M-UEs}(T,qci)$ is the number of downlink packets destined to M-UEs, for which no part has been transmitted

over the air by the given D-eNB, of a data radio bearer with QCI = qci , that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than hand-over, $N(T,qci)$ and T ,respectively, are the number of downlink packets of bearer with QCI = qci that has entered PDCP upper SAP during time period T and the time-period during which the measurement is performed.

It will be appreciated that the above described embodiments are done so for reference only, and that modification and variations are possible.

The invention being thus described, it will be obvious that the same way may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS

1. A mobile telecommunications system comprising an eNB, a relay node and a plurality of User Equipments (UEs), wherein:

1) at least one of said UEs is directly connected with said eNB; and

2) at least one of said UEs is connected to the relay node, wherein,

the eNB is operable to determine the total number of UEs directly connected, and the total number of UEs connected to the relay node, and use the combination of these totals to perform certain L2 measurements.

2. A mobile telecommunications system according to claim 1, wherein the system is operable, for received random access preamble measurements, to treat the relay node as a single directly connected UE.

3. A mobile telecommunications system according to claim 1 or claim 2, wherein for Physical Resource Block (PRB) usage, number of active UEs, data loss, packet delay and scheduled IP throughput measurements, a relay node is considered to represent the same number of direct link UEs as there are UEs connected to said relay node.

4. A mobile telecommunications system according to any preceding claim, wherein the relay node is a type 1 relay node.

5. A mobile telecommunications system according to any preceding claim, wherein when considering PRB usage, the eNB is operable to approximate a resource usage on a backhaul link of a UE connected to the relay to its usage on an access link.

6. A mobile telecommunications system according to claim 3, wherein, once measurements relating to PRB usage, data loss and packet delay, the resource usage on an access link of UEs connected to a relay node is determined, they are doubled by the eNB and added to the respective measurements taken in connection with UEs connected to the eNB directly.

7. A mobile communications system comprising a eNB operable to take L2 measurements, wherein said system comprises one or more relay nodes connected with the eNB, and wherein the eNB is operable to consider the one or more relay nodes in different ways, depending upon the measurements being taken.

8. A mobile telecommunications system according to claim 7, wherein the eNB considers the or each relay node as a User Equipment (UE) directly linked thereto for the purposes of taking measurements for received random access preambles,

9. A mobile telecommunications system according to claim 7 or 8, wherein the eNB determines the number of UEs connected to the or each relay node, and considers that the or each relay node corresponds to the same number of direct link UEs as there are UEs connected to the or each relay node for the purpose of making Physical Resource Block (PRB) usage, number of active UE, packet delay, data loss and scheduled IP throughput measurements on a per QCI and/or per UE basis.

10. A mobile telecommunications system according to claim 3 or claim 9, wherein the number of active UEs is determined by the following equation:

$$\text{number of active UEs} = N_{M-UEs} + \sum_{i} (N^{i}_{R-UEs})$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to a relay node.

11. A mobile telecommunications system according to

claim 3 or claim 9, wherein the total number of active UEs per quality of service class identifier (QCI) is determined by the following equation:

$$\text{number of active UEs per QCI} = N_{M-UEs}^{QCI_j} + \sum_i (N_{R-UEs}^{i,QCI_j})$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to a relay node.

12. A mobile telecommunications system according to claim 3 or claim 9, wherein the PRB usage per quality of service class identifier (QCI) is determined by the following equation:

$$\text{total PRB usage per QCI} = PRB_{M-UEs}^{QCI_j} + 2*\sum_i (PRB_{R-UEs}^{i,QCI_j})$$

where M-UE is the number of UEs directly linked to the eNB, and R-UE is the number of UEs connected to the relay node.

13. A mobile telecommunications system according to claim 3 or claim 9, wherein the packet delay in the downlink per quality of service class identifier (QCI) is determined by the following equation:

$$PacketDelay(T,qci) = \left\lfloor \frac{\left(\sum_{\forall k}\left(tAck_{M-UEs}^{QCI_j}(k) - tArriv_{M-UEs}^{QCI_j}(k)\right) + 2*\left(tAck_{R-UEs}^{i,QCI_j}(k) - tArriv_{R-UEs}^{i,QCI_j}(k)\right)\right)}{K(T)} \right\rfloor$$

where M-UE is the number of UEs directly linked to the eNB,

and R-UE is the number of UEs connected to a relay node, $tArriv_{R-UEs}^{i,QCI_j}(k)$ is the point in time when PDCP SDU k belonging to QCIj arrives in Relay-I, $tAck_{R-UEs}^{i,QCI_j}(k)$ is the point in time when the last piece of PDCP SDU k belonging to QCIj was received by the R-UE according to received HARQ feedback information, Let $tArriv_{M-UEs}^{QCI_j}(k)$ is the point in time when PDCP SDU k belonging to QCIj arrives in D-eNB being destined to an M-UE, $tAck_{M-UEs}^{QCI_j}(k)$ is the point in time when the last piece of PDCP SDU k belonging to QCIj was received by the M-UE according to received HARQ feedback information and k, $K(T)$ and T are, respectively, a PDCP SDU that arrives at the PDCP upper SAP during time period T, Total number of PDCP SDUs k and the time-period during which the measurement is performed.

14. A mobile telecommunications system according to claim 3 or claim 9, wherein the data loss in the downlink per quality of service class identifier (QCI) is determined by the following equation:

$$PacketDiscardRate(T,qci) = \left\lfloor \frac{\left(Dloss_{M-UEs}(T,qci) + 2 * Dloss'_{R-UEs}(T,qci)\right) * 1000000}{N(T,qci)} \right\rfloor$$

wherein $Dloss'_{R-UEs}(T,qci)$ id the number of downlink packets destined to R-UEs, for which no part has been transmitted over the air by Relay-i, of a data radio bearer with QCI = qci, that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than

hand-over, $Dloss_{M-UEs}(T,qci)$ is the number of downlink packets destined to M-UEs, for which no part has been transmitted over the air by the given D-eNB, of a data radio bearer with QCI = qci , that are discarded during time period T in the PDCP, RLC or MAC layers due to reasons other than hand-over, $N(T,qci)$ and T ,respectively, are the number of downlink packets of bearer with QCI = qci that has entered PDCP upper SAP during time period T and the time-period during which the measurement is performed.

FIG. 1

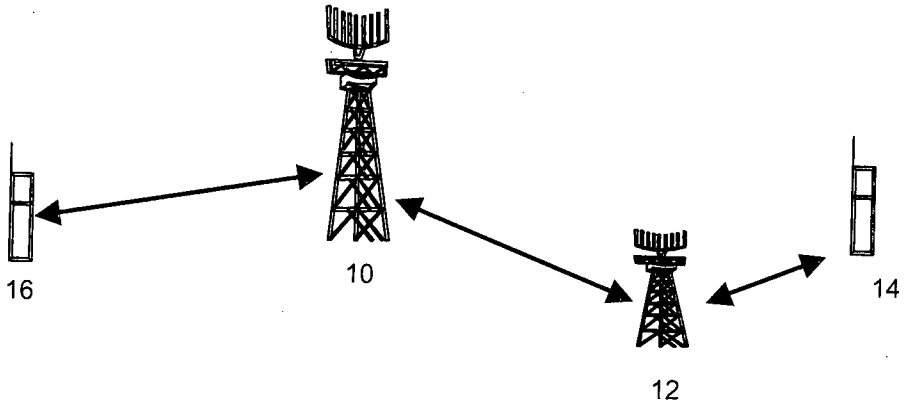
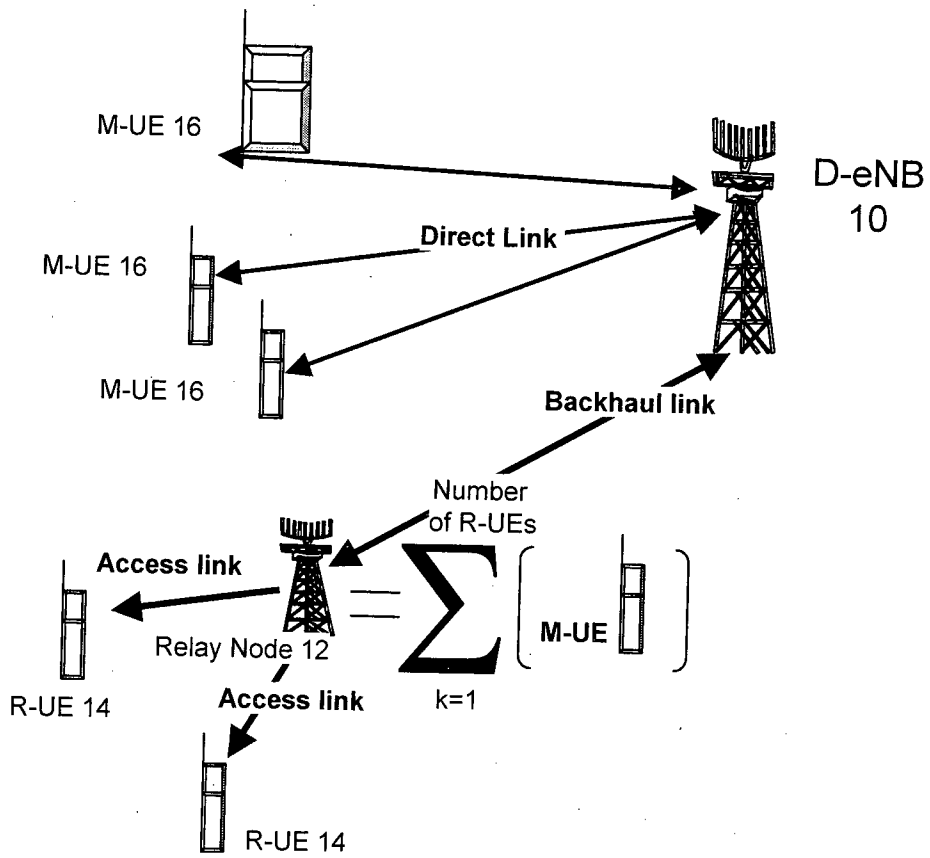

16
10
12
14

FIG. 2


M-UE 16
D-eNB
10
Direct Link
M-UE 16
M-UE 16
Backhaul link
Number
of R-UEs
Access link
Relay Node 12
M-UE
R-UE 14
Access link
k=1
R-UE 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/075523

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H04W24/02(2009.01)i, H04W16/26(2009.01)i, H04W24/08(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)

Int.Cl. H04W24/02, H04W16/26, H04W24/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2012
Registered utility model specifications of Japan 1996-2012
Published registered utility model applications of Japan 1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CATT, L2 measurements of RN, 3GPP TSG RAN WG2 Meeting #72 R2-106318, 2010.11.15, whole document.[retrieved on 2012-01-27].Retrieved from the Internet: <URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_72/Docs/R2-106318.zip>	1-14
A	Ericsson, ST-Ericsson, L2 measurements in DeNB and RN, 3GPP TSG-RAN WG2 #72 Tdoc R2-106472, 2010.11.15, whole document.[retrieved on 2012-01-27].Retrieved from the Internet: <URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_72/Docs/R2-106472.zip>	1-14

☑ 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
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"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
27.01.2012	07.02.2012

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/075523

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CATT, Impacts on L2 measurements, 3GPP TSG RAN WG2 Meeting #71bis R2-105385, 2010.10.11, whole document.[retrieved on 2012-01-27].Retrieved from the Internet: <URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_71bis/Docs/R2-105385.zip>	1-14