

(51) International Patent Classification:
H04W 16/14 (2009.01)(21) International Application Number:
PCT/CN2012/082178(22) International Filing Date:
27 September 2012 (27.09.2012)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (for all designated States except US): **BROADCOM CORPORATION** [US/US]; 5300 California Avenue, Irvine, California 92617 (US).

(72) Inventors; and

(71) Applicants (for US only): **ZHANG, Lili** [CN/CN]; Room #1704, Building B of Chang Kun Ming Ju, Ban Bi Jie South Road, Num 2, Haidian District, Beijing 100089 (CN). **WANG, Haiming** [CN/CN]; Room 1403, Unit 5, Building 101, Jiang Fu Jia Yuan, Jiang Tai Road, Chaoyang District, Beijing 100015 (CN). **HONG, Wei** [CN/CN]; Room 712, Tower C South, Raycom Infotech Park, No. 2 Ke Xue Yuan South Road, Zhong Guan Cun, Haidian District, Beijing 100190 (CN).(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Center, 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, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, 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, PA, 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, 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).

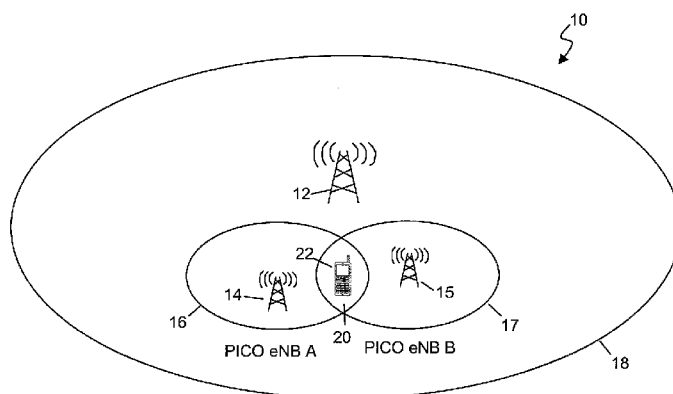
Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

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

(54) Title: METHOD TO COORDINATE RESOURCE ALLOCATION TO ADDRESS INTER-CELL INTERFERENCE

**FIG. 1**

(57) Abstract: A method to coordinate ABS resource allocation to address inter-cell interference comprises sending a first message by a first eNB to a second eNB, the first message specifying an interference level and a target cell identifier of a target eNB; receiving, by the target eNB, a second message sent by the second eNB, the second message specifying a resource allocation and a target cell identifier of the target eNB; and the target eNB operating according to the resource allocation specified in the second message.

METHOD TO COORDINATE RESOURCE ALLOCATION TO ADDRESS INTER-CELL INTERFERENCE

FIELD

5 [0001] The present disclosure relates the field of wireless communications, and more particularly to a method to coordinate resource allocation to address inter-cell interference.

BACKGROUND

 [0002] The Third Generation Partnership Project (3GPP) unites six telecommunications standards bodies, known as “Organizational Partners,” and provides their members with a stable
10 environment to produce the highly successful Reports and Specifications that define 3GPP technologies. A mobile device, also called a User Equipment (UE), may operate in a wireless communication network that provides high-speed data and/or voice communications. The wireless communication networks may implement circuit-switched (CS) and/or packet-switched (PS) communication protocols to provide various services. For example, the UE may operate in
15 accordance with one or more of an Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, Single-Carrier FDMA (SC-FDMA) networks, etc. The terms “networks” and “systems” are often used interchangeably. A CDMA network may implement a radio technology such as Universal Terrestrial Radio Access (UTRA), cdma2000,
20 etc. UTRA: includes Wideband-CDMA (W-CDMA) and Low Chip Rate (LCR) cdma2000 covers IS-2000, IS-95 and IS-856 standards. A TDMA network may implement a radio technology such as Global System for Mobile Communications (GSM). An OFDMA network may implement a radio technology such as Evolved UTRA (E-UTRA), IEEE 802.11, IEEE 802.16, IEEE 802.20, Flash-OFDM®, etc. UTRA, E-UTRA, and GSM are part of Universal

Mobile Telecommunication System (UMTS). Long Term Evolution (LTE) is an upcoming release of UMTS that uses E-UTRA. UTRA, E-UTRA, GSM, UMTS and LTE are described in documents from an organization named “3rd Generation Partnership Project” (3GPP). cdma2000 is described in documents from an organization named “3rd Generation Partnership Project 2” (3GPP2). These various radio technologies and standards are known in the art.

[0003] LTE (Long Term Evolution) is a new standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA (Universal Mobile Telecommunication System/High Speed Packet Access) network technologies, increasing the capacity and speed using new modulation techniques. The IP-based LTE network architecture, called the Evolved Packet Core (EPC) supports seamless handovers for both voice and data to cell towers with older network technology such as GSM, UMTS and CDMA2000. The LTE technology is adapted for a smooth evolution from earlier 3GPP systems. In LTE networking, technologies such as inter-cell interference coordination (ICIC) in the frequency domain and enhanced ICIC (eICIC) in the time domain have been developed for a new heterogeneous network topology in LTE-Advanced technology.

[0004] Heterogeneous networks arose due to the rapidly increasing numbers of mobile subscribers and demand for bandwidth, and the inadequacy of traditional macro base stations to meet subscriber requirements. Homogenous networks consisting of solely traditional macro base stations may have blind spots in coverage that adversely impact user experience. With the introduction of lower power base stations, including pico cells, femtocells, and relay nodes, LTE network topology becomes a heterogeneous network (HetNet) that is able to deliver more complete coverage. In a HetNet defined in 3GPP Release 10, low power nodes (LPNs), such as

RRU/RRH, pico eNB (Enhanced Node B), home eNB, and relay node, are deployed inside the macro base station or enhanced node B coverage cell.

[0005] The concept of an Almost Blank Subframe (ABS) was introduced in eICIC to address control channel interference between a macro eNB and a smaller base station such as a
5 pico eNB in the time domain. Almost blank subframes are transmitted at low power and only contain limited signals. The interfering base station is configured to include ABSs in its transmission so that the ABS may be used by the interfered cell to provide service for the User Equipment that previously experienced strong interference. By coordinating the transmissions of the macro eNB and the pico eNB using ABS, inter-cell interference is avoided.

10 SUMMARY

[0006] A method to coordinate resource allocation to address inter-cell interference comprises sending a first message by a first eNB to a second eNB, the first message specifying an interference level and a target cell identifier of a target eNB; receiving, by the target eNB, a
15 second message sent by the second eNB, the second message specifying a resource allocation and a target cell identifier of the target eNB; and the target eNB operating according to the resource allocation specified in the second message.

[0007] A method to coordinate resource allocation to address inter-cell interference comprises sending, by a first eNB, a first LOAD INFORMATION message to a second eNB, the first message specifying an amount of Almost Blank Subframe resource needed; receiving, by
20 the first eNB, a second LOAD INFORMATION message sent by the second eNB, the second message specifying an Almost Blank Subframe resource allocation; and the first eNB operating according to the Almost Blank Subframe resource allocation specified in the second LOAD INFORMATION message.

[0008] A method of coordinating allocated resources between a first and a second eNB having an overlapped coverage area comprises allocating a bandwidth resource; allocating a first set of the allocated bandwidth resource to the first eNB; allocating a second set of the allocated bandwidth resource to the second eNB, the second set of the allocated bandwidth and the first set of the allocated bandwidth having overlapped allocated resource and non-overlapped allocated resource; notifying the allocation to the first and second eNBs; and enabling the first eNB and second eNB to transmit data to user equipment in the overlapped coverage area using non-overlapped allocated resource.

BRIEF DESCRIPTION OF THE DRAWINGS

10 [0009] FIG. 1 is a simplified diagram of an exemplary heterogeneous network comprising a macro base station or enhanced node B (eNB) and two pico enhanced node B with overlapping cells;

[0010] FIG. 2 is a simplified diagram of downlink subframes of the two overlapping pico cells according to the teachings of the present disclosure;

15 [0011] FIG. 3 is a simplified diagram showing the enhanced LOAD INFORMATION message structure of an exemplary embodiment according to the teachings of the present disclosure;

[0012] FIG. 4 is a simplified diagram showing the enhanced RESOURCE STATUS REQUEST message structure of an exemplary embodiment according to the teachings of the present disclosure;

20 [0013] FIG. 5 is a simplified diagram showing the enhanced RESOURCE STATUS UPDATE message structure of an exemplary embodiment according to the teachings of the present disclosure;

[0014] FIG. 6 is a simplified message flow diagram of an exemplary embodiment according to the teachings of the present disclosure; and

[0015] FIG. 7 is a simplified message flow diagram of another exemplary embodiment according to the teachings of the present disclosure.

5 **DETAILED DESCRIPTION**

[0016] FIG. 1 is a simplified diagram of an exemplary heterogeneous network 10 comprising a macro base station or Enhanced Node B (eNB) 12 and two pico Enhanced Node Bs, pico eNB A 14 and pico eNB B 15, with overlapping cells 16 and 17 within the macro cell 18. One or more mobile device or User Equipment 22 may operate in the overlap region 20 of the
10 two pico cells 16 and 17. The User Equipment 22 may be serviced by pico eNB A 14, but it may experience significant interference from the other pico station, pico eNB B 15. This interference may be exacerbated especially if the association of the User Equipment 22 to pico eNB A 14 is due to Cell Range Expansion or CRE.

[0017] In order to operate multiple cells with overlapping coverage on a carrier
15 frequency in the heterogeneous network 10, it may become necessary to have coordination between the cells so the transmissions from neighbouring network nodes do not interfere with one another. A time domain technique has been developed to coordinate interference between a macro cell and a lower power cell like a pico cell. Specifically, a cell can be configured with a pattern of Almost Blank Subframes (ABS) in which little or no transmission is scheduled.
20 Generally in Almost Blank Subframes, only a very restricted set of data is transmitted. However, the 3GPP standard does not address the situation in which two low-power eNBs with overlapping cells are operating within a macro cell. FIG. 2 is a simplified diagram of exemplary downlink subframes of the two overlapping pico cells 16 and 17 according to the teachings of the

present disclosure. More specifically, FIG. 2 may reference exemplary ABS patterns of the Physical Downlink Control Channel (PDCCH) of the two pico cells. It may be seen that in the allocated ABS patterns to the pico cells 16 and 17, there are overlapping ABS and non-overlapping ABS.

5 [0018] Referring to FIG. 3, which is a simplified diagram showing an exemplary enhanced LOAD INFORMATION message structure 30 that may be transmitted by an initiating pico eNB. The LOAD INFORMATION message 30 has been defined by *3GPP Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 Application Protocol (X2AP,)* Release 11, TS 36.423 (2012-06). The
10 existing LOAD INFORMATION message is used to initiate the Load Indication procedure for the purpose of transferring load and interference coordination information between eNBs controlling intra-frequency neighbouring cells. The present disclosure provides for the addition of certain new information elements or parameters to the existing LOAD INFORMATION message to enable overlapping pico cell ABS coordination. The enhanced LOAD
15 INFORMATION message 30 includes an existing information element called ABS INFORMATION, which was designed to provide information about which subframes the sending eNB is configuring as Almost Blank Subframes and which subset of Almost Blank Subframes are recommended for configuring measurements towards the User Equipment. A further added information element to the ABS INFORMATION is the TARGET CELL ID
20 information element 32 that is used to specify the identifier of the cell for which the ABS INFORMATION is meant. This TARGET CELL ID 32 would enable inter-pico cell coordination on the ABS usage.

[0019] The enhanced LOAD INFORMATION message 30 further includes an existing INVOKE INDICATION information element used to indicate which types of information the sending eNB would like the receiving eNB to send back. In the INVOKE INDICATION information element, new information elements are added: TARGET CELL ID information element 34, and INTERFERENCE LEVEL information element 36 which includes EXPECTED NON-OVERLAPPED ABS NUMBER 37 and ASSOCIATED INTERFERED/INTERFERING eNB ID 38. The TARGET CELL ID information element 34 contains the identifier of the cell for which the Invoke Indication request is meant. The EXPECTED NON-OVERLAPPED ABS NUMBER 37 contains the expected number of non-overlapped Almost Blank Subframes that should be allocated to adequately meet user demands. This parameter may be determined by taking into account of the bandwidth requirement in the overlapped area of the pico cells, such as the number of User Equipment, the traffic load, and the like. The ASSOCIATED INTERFERED/INTERFERING eNB ID 38 is used to specify the cell identifier of the eNB that is expected to respond to the Invoke Indication request, which may be the interfering pico eNB or the interfered pico eNB.

[0020] 3GPP Release 11 further provides for a Resource Status Reporting Initiation procedure that may be used by an eNB to request the reporting of load measurements to another eNB. This procedure is initiated with a RESOURCE STATUS REQUEST message sent from a first eNB to a second eNB. Upon receipt, the second eNB initiates the requested measurement according to the parameters specified in the request. FIG. 4 is a simplified diagram showing the RESOURCE STATUS REQUEST message structure 40 of an exemplary embodiment according to the teachings of the present disclosure. The enhanced RESOURCE STATUS REQUEST message 40 includes two new bits of data in the REPORT CHARACTERISTICS bitmap

information element. More specifically, a 6th bit is now included to provide NON-OVERLAPPED ABS STATUS PERIODIC 44, and a 7th bit is now included to provide OVERLAPPED ABS STATUS PERIODIC 46. These two added bits in the bitmap indicate the overlap and non-overlap ABS status on which the second eNB is requested to report.

5 [0021] FIG. 5 is a simplified diagram showing an enhanced RESOURCE STATUS UPDATE message structure 50 of an exemplary embodiment according to the teachings of the present disclosure. The RESOURCE STATUS UPDATE message 50 is sent by the eNB receiving the RESOURCE STATUS REQUEST message 40 to report the results of the requested measurements. Three new information elements or parameters are added to the existing
10 RESOURCE STATUS UPDATE message: DL NON-OVERLAPPED ABS STATUS 52, DL OVERLAPPED ABS STATUS 54, and TARGET CELL ID 56. The new DL NON-OVERLAPPED ABS STATUS information element 52 is used to report the percentage of resource blocks of non-overlapped ABS allocated for User Equipment protected by non-overlapped ABS from inter-cell interference. The new DL OVERLAPPED ABS STATUS
15 information element 54 is used to report the percentage of resource blocks of overlapped ABS allocated for User Equipment protected by overlapped ABS from inter-cell interference. The TARGET CELL ID 56 is used to indicate the identifier of the cell for which the downlink ABS status is meant. Therefore, the DL NON-OVERLAPPED ABS STATUS 52 and DL OVERLAPPED ABS STATUS 54 provide information about ABS resource utilization.

20 [0022] FIG. 6 is a simplified message flow diagram of an exemplary embodiment according to the teachings of the present disclosure. In general in the first exemplary embodiment, an initiating pico eNB reports the INTERFERENCE LEVEL with respect to the overlapping one or more pico cells to the macro eNB, and the macro eNB determines the

corresponding ABS pattern allocation and measurement for the overlapping pico cells. As shown in FIG. 6, the pico eNB A 14 initiates the Load Indication procedure by sending an enhanced LOAD INFORMATION message 60 to the macro eNB 12. The initiating pico eNB may be the interfering eNB or the interfered eNB. In other words, the initiating pico eNB may be the serving node that is experiencing interference from a neighbouring cell, or the eNB that is interfering with the transmissions of another eNB. The enhanced LOAD INFORMATION message 60 includes the enhanced INVOKE INDICATION information element that includes the added TARGET CELL ID information element 34 and INTERFERENCE LEVEL information element 36. Using the enhanced LOAD INFORMATION message 60, the macro eNB 12 is informed of the pico cells that experience interference, and the amount of protected resource that should be allocated to address the interference problem. In the example message flow shown in FIG. 6, the TARGET CELL ID information element 32 specifies the cell identifier of pico eNB B 15. In situations where more than two cells overlap and interfere with one another, the TARGET CELL ID information element 32 may include multiple cell identifiers.

[0023] Using the information reported by the initiating pico eNB A 14, the macro eNB 12 may decide on the protected ABS resource allocation and notify the ABS INFORMATION to the pico eNB B 15, as well as the initiating pico eNB A 14. The macro eNB 12 sends the LOAD INFORMATION messages 61 and 62 to the pico eNBs with overlapping cells, with the enhanced ABS INFORMATION element that specifies the TARGET CELL ID. The ABS INFORMATION element includes information on the ABS pattern, so that the targeted eNB is notified as to which subframes are designated as ABS. The overlapping pico cells are therefore operating with different ABS patterns that may have some overlapping Almost Blank Subframes, and some non-overlapping Almost Blank Subframes, as shown in FIG. 2. The number of non-

overlapped Almost Blank Subframes allocated by the macro eNB 12 is determined in consideration of the interference level information reported by the initiating pico eNB A 14.

[0024] Accordingly, each pico eNB is operable to transmit to the User Equipment it serves in the overlapped coverage area using its respective non-overlapped ABS resource. For those User Equipment that are outside the overlapped coverage area, each pico eNB is operable to transmit using its respective overlapped ABS resource. Other pico cells not identified by the TARGET CELL ID are not affected and transmits normally. Further, the User Equipment operating inside the overlapped coverage area of the pico cells are configured by the respective pico eNB to use non-overlapped ABS resources for Channel State Information (CSI) measurement report. Likewise, the User Equipment operating outside of the overlapped coverage area of the pico cells are configured by the respective pico eNB to use overlapped ABS resources for Channel State Information (CSI) measurement report.

[0025] Continuing to refer to FIG. 6, a pico eNB may be triggered to report the non-overlapped ABS status and the overlapped ABS status by the occurrence of certain events. For example, a triggering event may be when the non-overlapped ABS STATUS or percentage of resource blocks of non-overlapped ABS allocated for User Equipment protected by non-overlapped ABS from inter-cell interference is higher than a predefined threshold. A triggering event may also be when the overlapped ABS STATUS or percentage of resource blocks of overlapped ABS allocated for User Equipment protected by overlapped ABS from inter-cell interference is higher than a predefined threshold. Other triggering events may be contemplated, such as the receipt of a RESOURCE STATUS REQUEST message that asks for the overlapped and non-overlapped ABS STATUS, for example. In response to a triggering event, the pico eNB A 14 sends a RESOURCE STATUS UPDATE message 63 to the macro eNB 12. The

RESOURCE STATUS UPDATE message 63 provides information about ABS resource utilization in the added DL NON-OVERLAPPED ABS STATUS 52, DL OVERLAPPED ABS STATUS 54, and TARGET CELL ID 56 information elements, as described above.

[0026] In response to receiving the RESOURCE STATUS UPDATE message 63 from one or more pico cells, the macro eNB 12 may consider the data and decide whether to adjust the ABS allocation. For example, the macro eNB 12 may determine whether to adjust the ABS pattern in response to the non-overlapped and overlapped ABS STATUS. The macro eNB 12 may also determine the appropriate ratio of non-overlapped ABS resource to overlapped ABS resource in the ABS pattern.

[0027] FIG. 7 is a simplified message flow diagram of another exemplary embodiment according to the teachings of the present disclosure. In general in the second exemplary embodiment, an initiating pico eNB reports the interference level with respect to the overlapping one or more pico cells to the macro eNB, and the macro eNB determines the corresponding ABS pattern allocation and measurement for the overlapping pico cells. As shown in FIG. 7, the pico eNB A 14 initiates the Load Indication procedure by sending an enhanced LOAD INFORMATION message 70 to the macro eNB 12. The initiating pico eNB may be the interfered eNB in this instance. In other words, the initiating pico eNB may be the serving node that is experiencing interference from a neighbouring cell. The enhanced LOAD INFORMATION message 70 includes the enhanced INVOKE INDICATION information element that includes the added INTERFERENCE LEVEL information element 36. Using the enhanced LOAD INFORMATION message 70, the interfering pico eNB B 15 is informed of the interference in the overlap region, and the amount of protected resource that should be allocated.

[0028] Using the information reported by the initiating pico eNB A 14, the interfering pico eNB B 15 may decide on the protected ABS resource allocation and notify the ABS information to the pico eNB A 14. The pico eNB B 15 sends the LOAD INFORMATION message 71 to the pico eNB A with the enhanced ABS INFORMATION element. The ABS INFORMATION element includes information on the ABS pattern, so that the pico eNB A 14 is notified of which subframes are designated as ABS by the macro eNB 12, and the subset of that ABS allocation that may be used by the interfered pico eNB A 14. The overlapping pico cells may therefore operate using different ABSs that have been allocated by the macro eNB 12. The number of ABS allocated to the interfered pico eNB A 14 is determined in consideration of the interference level information reported by the interfered pico eNB A 14. It should be noted that it may be necessary to notify the macro eNB 12 to allocate further ABS resources due to the expected bandwidth demand in the overlapped region. The macro eNB 12 may also be kept informed of the ABS allocation that has been provided to the interfered pico eNB A 14.

[0029] Accordingly, each pico eNB is operable to transmit to the User Equipment it serves in the overlapped coverage area using its respective ABS resource. Accordingly, the pico eNBs 14 and 15 use different ABS allocated by the macro eNB when transmitting to User Equipment in the overlapping coverage area.

[0030] Continuing to refer to FIG. 7, a pico eNB may be triggered to report the overlapped ABS status by the occurrence of certain events. For example, a triggering event may be when the overlapped ABS STATUS or percentage of resource blocks of overlapped ABS allocated for User Equipment protected by overlapped ABS from inter-cell interference is higher than a predefined threshold. Other triggering events may be contemplated, such as the receipt of a RESOURCE STATUS REQUEST message that asks for the overlapped ABS STATUS, for

example. In response to a triggering event, the pico eNB A 14 sends a RESOURCE STATUS UPDATE message 74 to the pico eNB B 15. The RESOURCE STATUS UPDATE message 74 provides information about ABS resource utilization in the added DL OVERLAPPED ABS STATUS 54 information element, as described above.

5 [0031] In response to receiving the RESOURCE STATUS UPDATE message 74 from one or more pico cells, the pico eNB B 15 may consider the data and decide whether to adjust the ABS allocation.

10 [0032] Further, the User Equipment served by the pico eNB A 14 operating inside the overlapped coverage area of the pico cells are configured by the pico eNB A 14 to use the ABS resources allocated by the macro eNB 12 and pico eNB B 15 for Channel State Information (CSI) measurement report. Likewise, the User Equipment served by the pico eNB A 14 operating outside of the overlapped coverage area of the pico cells are configured by the pico eNB A 14 to use ABS resources allocated by the macro eNB 12 minus the ABS resources allocated by pico eNB B 15 for Channel State Information (CSI) measurement report.

15 [0033] The features of the present invention which are believed to be novel are set forth below with particularity in the appended claims. However, modifications, variations, and changes to the exemplary embodiments described above will be apparent to those skilled in the art, and the system and method described herein thus encompass such modifications, variations, and changes and are not limited to the specific embodiments described herein.

20 [0034] GLOSSARY

 [0035] 3GPP Third Generation Partnership Project

 [0036] ABS Almost Blank Subframe

 [0037] CDMA Code Division Multiple Access

	[0038]	CS	Circuit Switched
	[0039]	CSI	Channel State Information
	[0040]	CRE	Cell Range Expansion
	[0041]	DL	Downlink
5	[0042]	eICIC	Enhanced Inter-Cell Interference Coordination
	[0043]	eNB	Enhanced Node B
	[0044]	eNodeB	Enhanced Node B
	[0045]	EPC	Evolved Packet Core
	[0046]	E-UTRAN	Evolved Universal Terrestrial Radio Access Network
10	[0047]	FDMA	Frequency Division Multiple Access
	[0048]	GSM	Global System for Mobile Communications
	[0049]	HetNet	Heterogeneous Network
	[0050]	HSPA	High Speed Packet Access
	[0051]	LTE	Long Term Evolution
15	[0052]	PDCCH	Physical Downlink Control Channel
	[0053]	TDMA	Time Division Multiple Access
	[0054]	UE	User Equipment
	[0055]	UMTS	Universal Mobile Telecommunication System
	[0056]	UTRAN	UMTS Terrestrial Radio Access Network
20	[0057]	WCDMA	Wideband Code Division Multiple Access

WHAT IS CLAIMED IS:

1. A method to coordinate resource allocation to address inter-cell interference, comprising:

5 sending a first message by a first eNB to a second eNB, the first message specifying an interference level and a target cell identifier of a target eNB;

receiving, by the target eNB, a second message sent by the second eNB, the second message specifying a resource allocation and a target cell identifier of the target eNB; and

the target eNB operating according to the resource allocation specified in the second message.

10

2. The method of claim 1, wherein sending a first message by a first eNB comprises sending the first message by a first pico eNB to a macro eNB.

3. The method of claim 2, further comprising receiving a second message by the first
15 pico eNB sent by the macro eNB, the second message specifying a resource allocation and a target cell identifier of the first pico eNB.

4. The method of claim 2, further comprising receiving a second message by a
second pico eNB sent by the macro eNB, the second message specifying a resource allocation
20 and a target cell identifier of the second pico eNB.

5. The method of claim 1, wherein sending a first message by a first eNB comprises sending the first message by a first pico eNB to a second pico eNB.

6. The method of claim 1, further comprising:

5 monitoring allocated resource usage; and
reporting, by the first eNB, the status of allocated resource to the second eNB.

7. The method of claim 1, wherein sending a first message comprises sending a first message specifying an expected resource need as the interference level.

10

8. The method of claim 1, wherein sending a first message comprises sending a first message, by the first eNB, specifying an expected number of Almost Blank Subframes needed to service user equipment in an overlap region between the first eNB and the target eNB as the interference level.

15

9. The method of claim 1, wherein sending a first message comprises sending a first message, by the first eNB, specifying an expected number of Almost Blank Subframes needed to service user equipment in an overlap region between the first eNB and the second eNB as the interference level.

10. A method to coordinate resource allocation to address inter-cell interference, comprising:

sending, by a first eNB, a first LOAD INFORMATION message to a second eNB, the first message specifying an amount of Almost Blank Subframe resource needed;

5 receiving, by the first eNB, a second LOAD INFORMATION message sent by the second eNB, the second message specifying an Almost Blank Subframe resource allocation; and
the first eNB operating according to the Almost Blank Subframe resource allocation specified in the second LOAD INFORMATION message.

10 11. The method of claim 10, wherein sending a first LOAD INFORMATION message by a first eNB comprises sending the first LOAD INFORMATION message by a first pico eNB to a macro eNB.

12. The method of claim 10, wherein sending a first LOAD INFORMATION
15 message by a first eNB comprises sending, by a first pico eNB, the first LOAD INFORMATION message to a macro eNB specifying the Almost Blank Subframe needed and a target cell identifier of a second pico eNB.

13. The method of claim 11, wherein receiving a second LOAD INFORMATION
20 message by the first eNB sent by the macro eNB, the second LOAD INFORMATION message specifying an Almost Blank Subframe resource allocation and a target cell identifier of the first eNB.

14. The method of claim 13, further comprising receiving a third LOAD INFORMATION message by a third eNB sent by the macro eNB, the third LOAD INFORMATION message specifying an Almost Blank Subframe resource allocation and a target cell identifier of the third eNB.

5

15. The method of claim 14, further comprising the first and third pico eNBs transmitting to user equipment suffering from the inter-cell interference using allocated non-overlapped Almost Blank Subframe resources.

10 16. The method of claim 10, wherein sending a first LOAD INFORMATION message by a first eNB comprises sending the first LOAD INFORMATION message by a first pico eNB to a second pico eNB.

15 17. The method of claim 14, wherein sending a first LOAD INFORMATION message comprises sending a first LOAD INFORMATION message by a first pico eNB to a second pico eNB, and receiving a second LOAD INFORMATION message comprises receiving the second LOAD INFORMATION message sent by the second pico eNB to the first pico eNB.

20 18. The method of claim 10, further comprising:
monitoring allocated resource usage; and
reporting status of the Almost Blank Subframe resource allocation by the first eNB to the second eNB.

19. The method of claim 10, wherein sending a first LOAD INFORMATION message comprises sending a first LOAD INFORMATION message specifying an expected number of Almost Blank Subframes needed as the interference level.

5 20. A method of coordinating allocated resources between a first and a second eNB having an overlapped coverage area, comprising:

allocating a bandwidth resource;

allocating a first set of the allocated bandwidth resource to the first eNB;

10 allocating a second set of the allocated bandwidth resource to the second eNB, the second set of the allocated bandwidth and the first set of the allocated bandwidth having overlapped allocated resource and non-overlapped allocated resource;

notifying the allocation to the first and second eNBs; and

enabling the first eNB and second eNB to transmit data to user equipment in the overlapped coverage area using non-overlapped allocated resource.

15 21. The method of claim 20, wherein allocating a bandwidth resource comprises allocating Almost Blank Subframes.

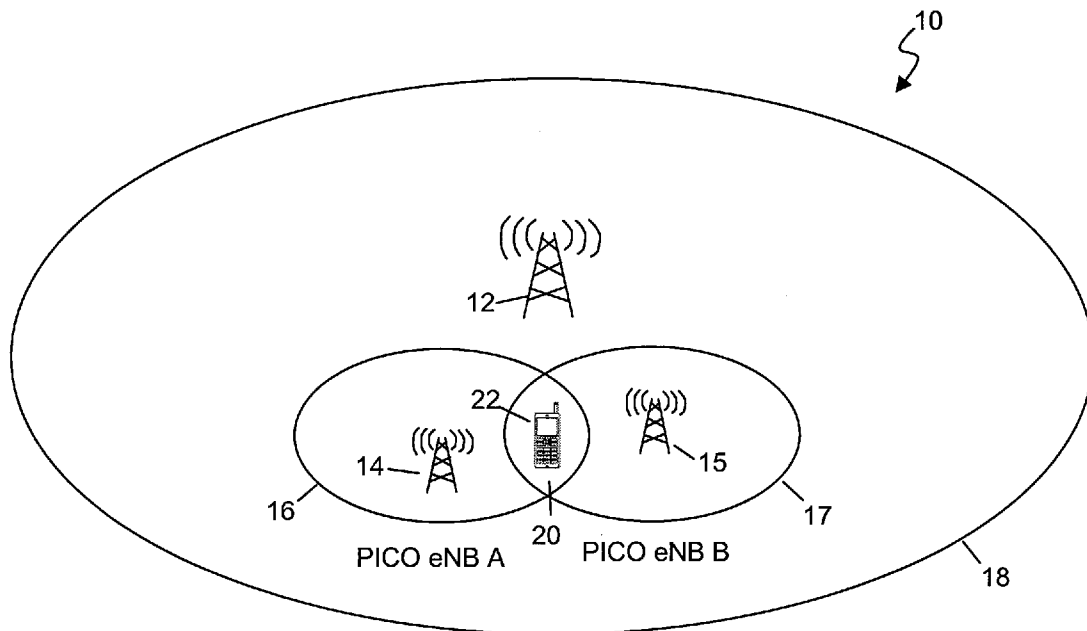


FIG. 1

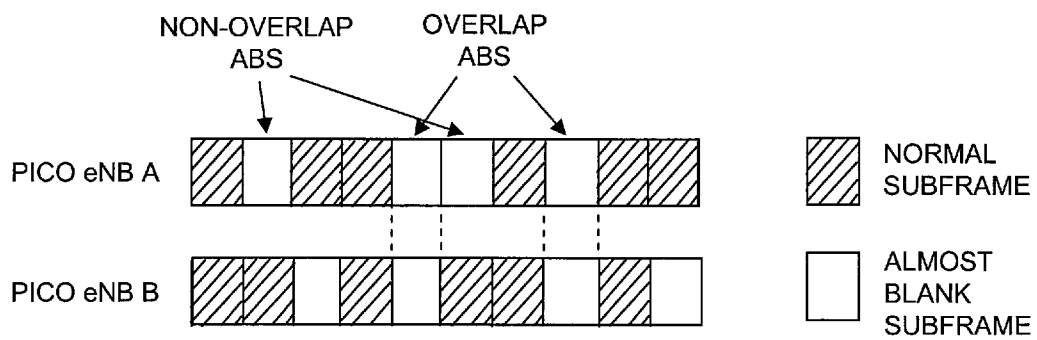


FIG. 2

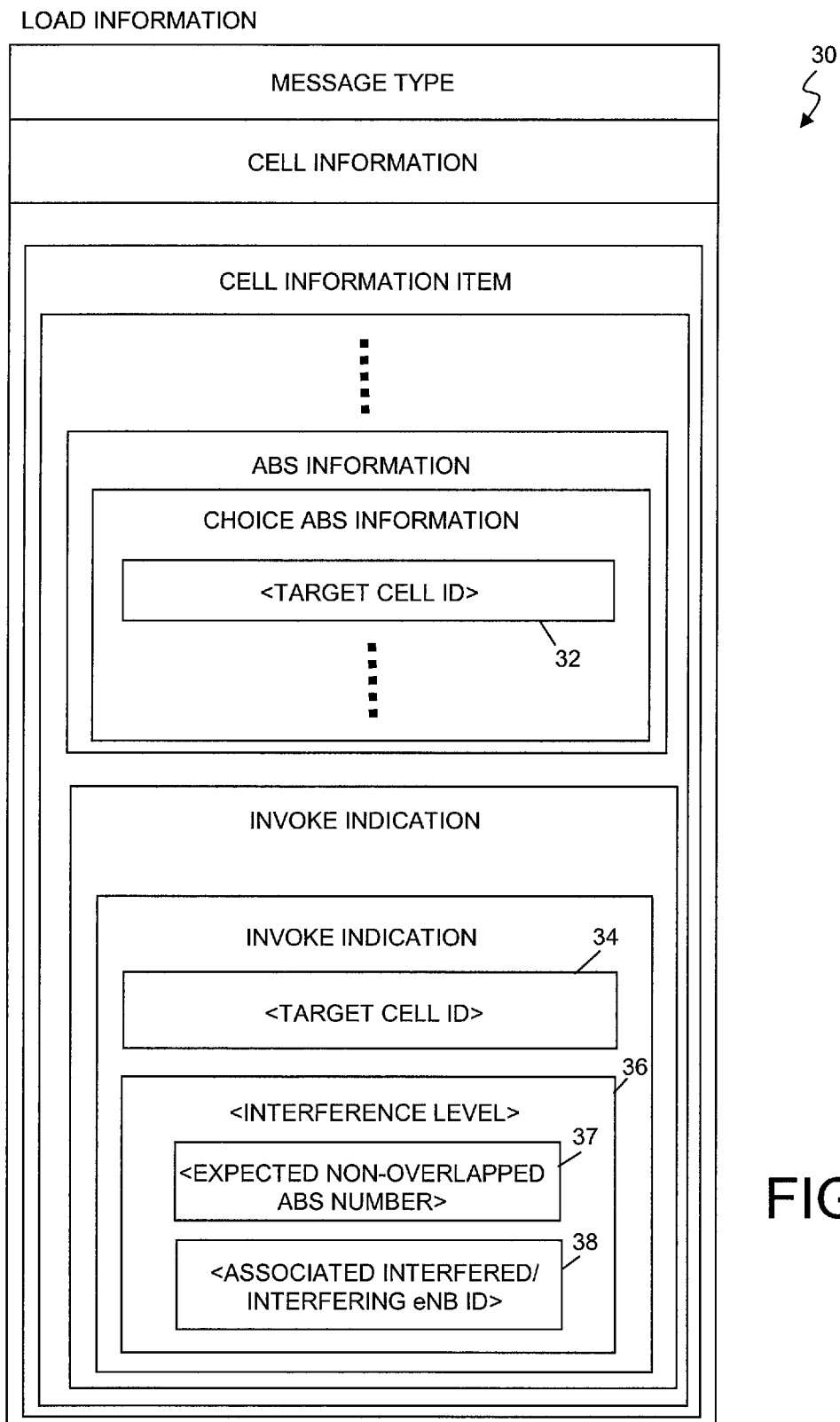


FIG. 3

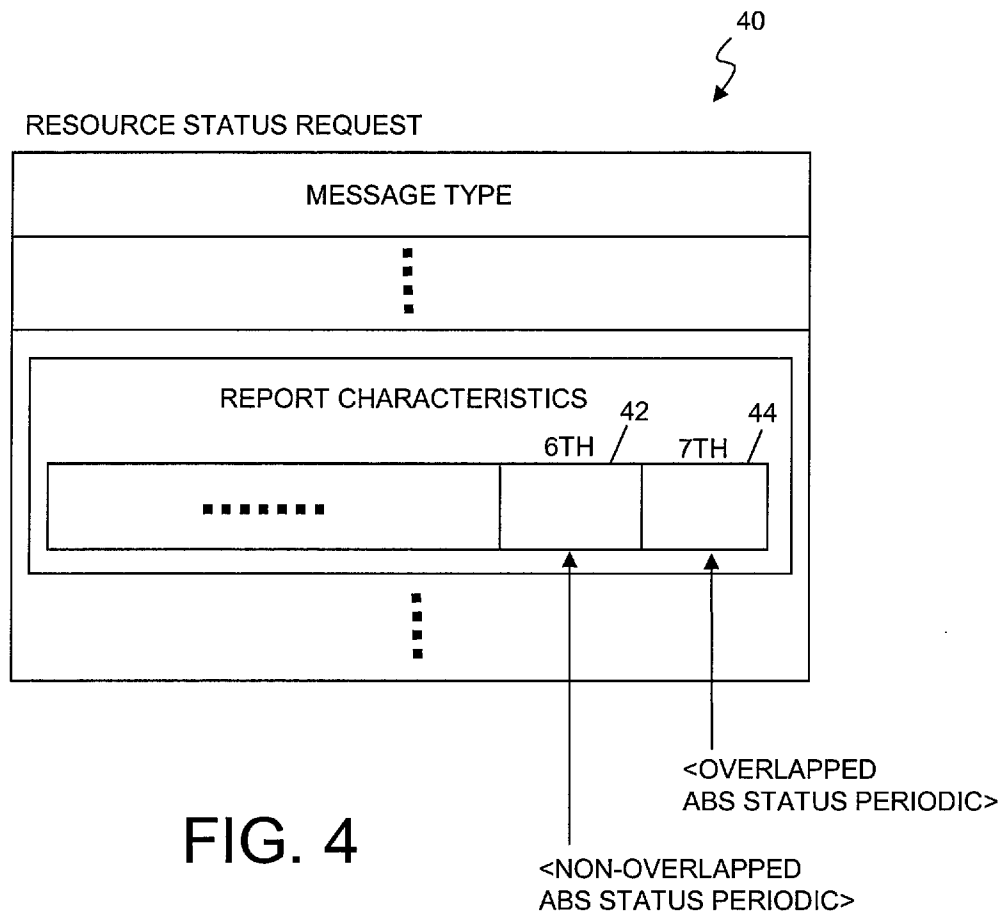


FIG. 4

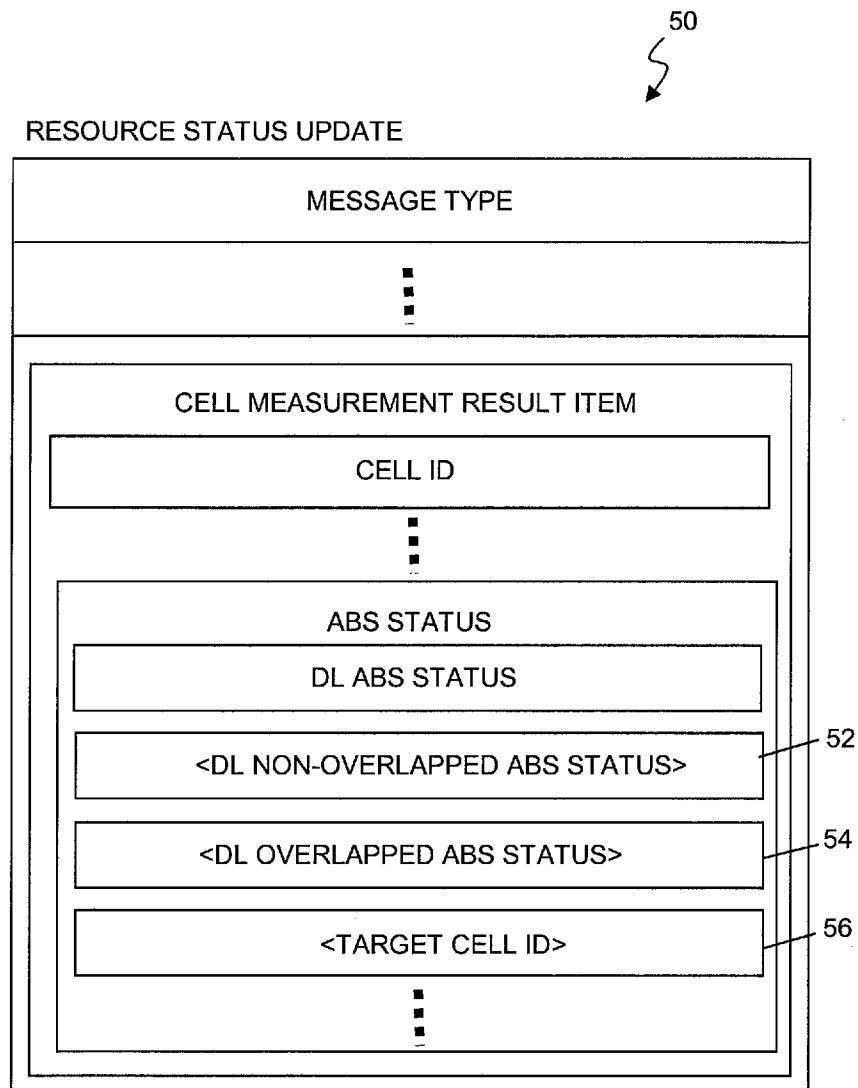


FIG. 5

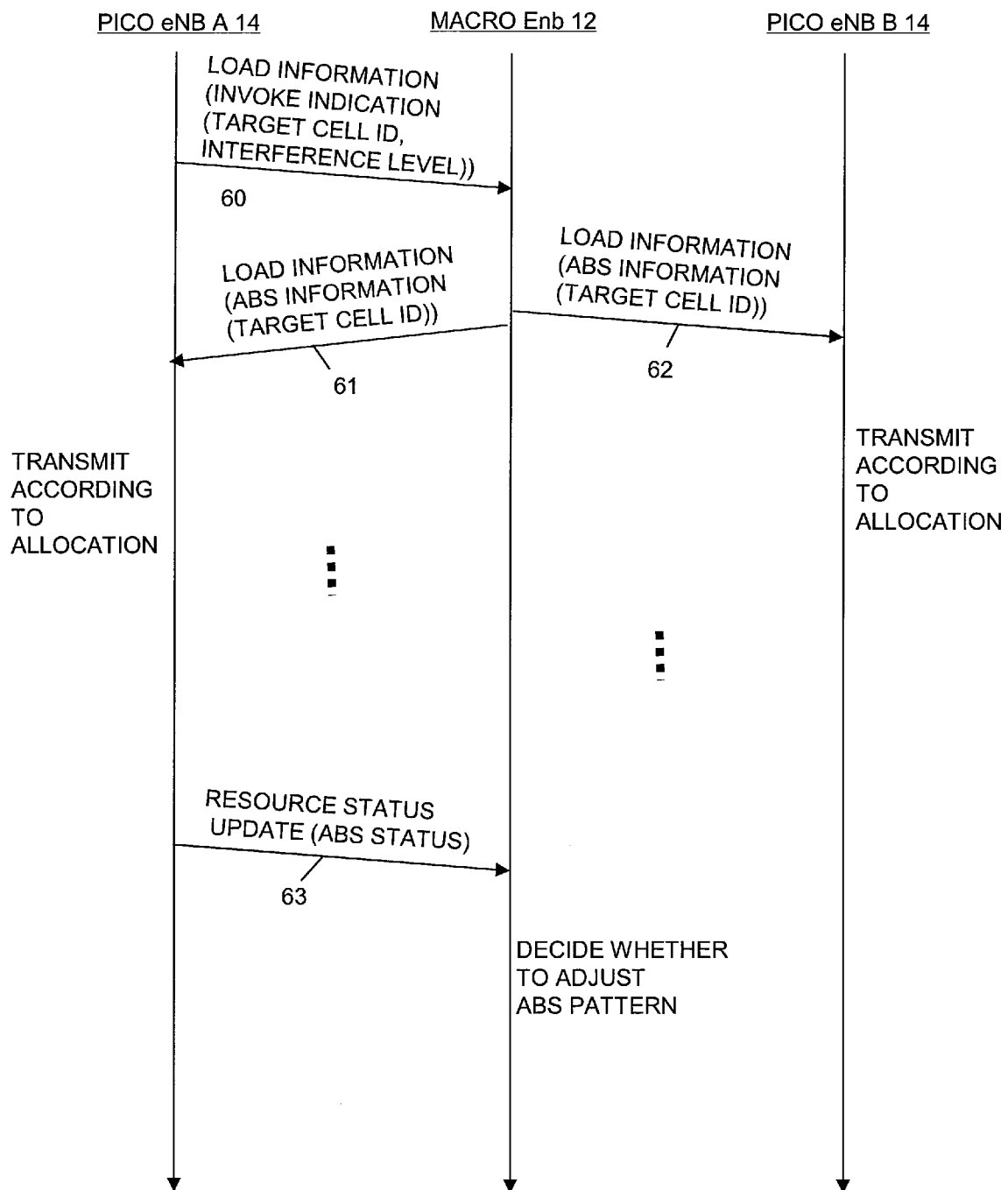


FIG. 6

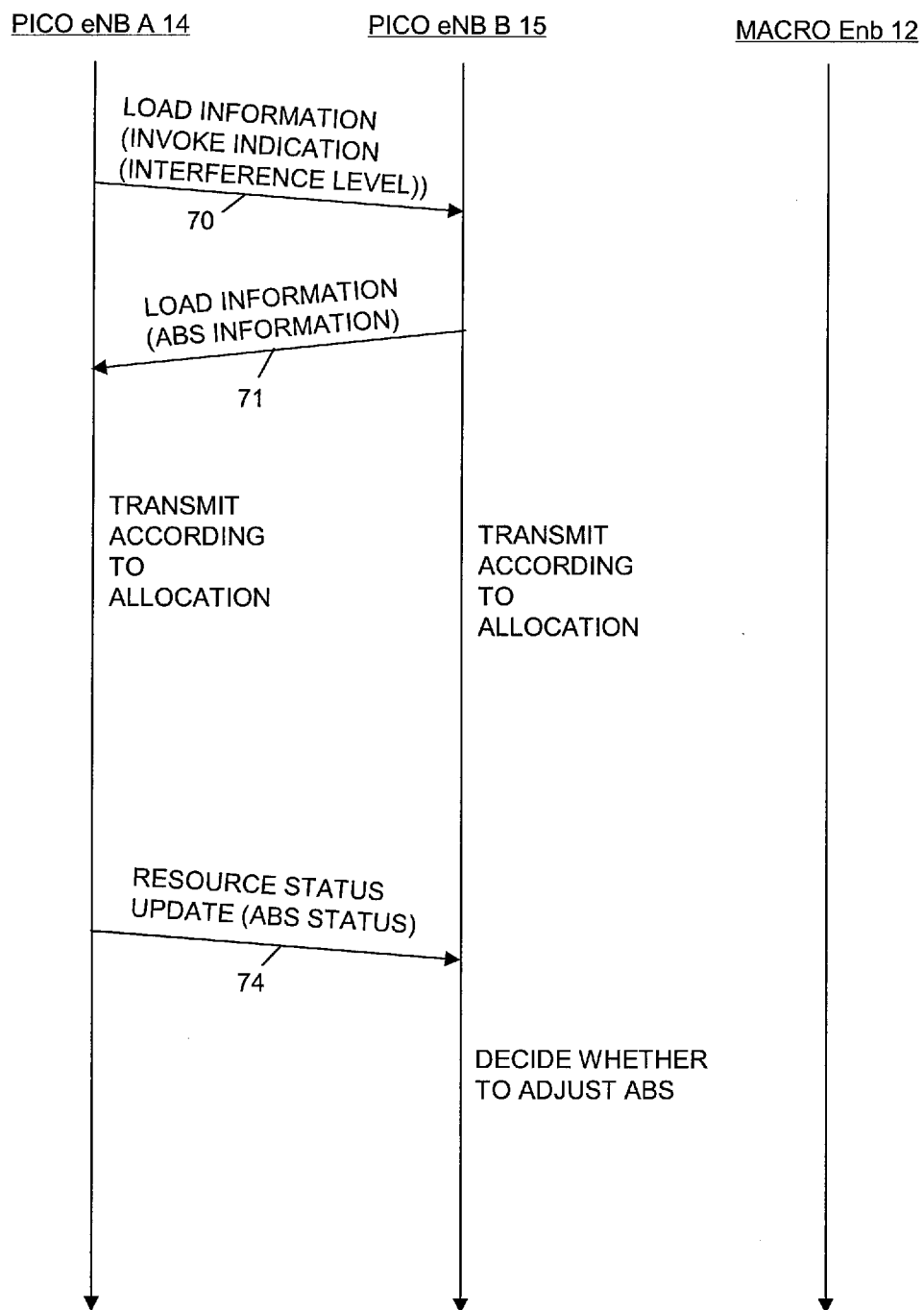


FIG. 7

INTERNATIONAL SEARCH REPORT		International application No. PCT/CN2012/082178
A. CLASSIFICATION OF SUBJECT MATTER		
H04W 16/14 (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:H04Q; H04M; H04B; H04W; H04J; H04L		
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;IEEE;CNPAT: interference level, target cell identifier, ABF, almost blank frame, ICIC, EICIC, ID, identifier, LOAD INFORMATION, MACRO, pico, allocat+		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim
X	CN 102457912 A (SHANGHAI CO., LTD., CHINA MOBILE GROUP) 16 May 2012 (16.05.2012) description, paragraphs [0022]-[0068], and figures 2 to 4	1, 2, 4, 5
Y		6, 7, 9
A		3, 8, 10-21
X	WO 2011/159988 A1 (INTERDIGITAL PATENT HOLDINGS, INC.) 22 December 2011 (22.12.2011) description, paragraphs [0085]-[0093], and figure 4	10, 18, 19
Y		6, 7, 9
A		1-5, 8, 11-17, 20, 21
☒ 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 23 May 2013 (23.05.2013)		Date of mailing of the international search report 27 Jun. 2013 (27.06.2013)
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 ZHANG Jiakai Telephone No. (86-10)62413525

INTERNATIONAL SEARCH REPORT		International application No. PCT/CN2012/082178
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101951610 A (NTT DOCOMO, INC.) 19 January 2011 (19.01.2011) description, paragraphs [0043]-[0048], [0062]-[0071], [0124]-[0129], figures 1, 5 and 12	20, 21
A		1-19
A	JP 2012-90122 A (NTT DOCOMO, INC.) 10 May 2012 (10.05.2012) the whole document	1-21

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/082178

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

I: Claims 1 and 10 directed to resource allocation by messages transmitted among eNBs.

II: Claim 20 directed to resource allocation in overlapped area.

The reasons for which the inventions are not so linked as to form a single general inventive concept, as required by PCT Rule 13.1, are as follows: the common or corresponding features between said inventions are that coordinating allocated resource between eNBs, specifying a resource allocation in a message transmitted among eNBs, and operating according to the resource allocation. All of these features are well known in the art. Therefore, the groups of claims are not linked by common or corresponding special technical features and define two different inventions not linked by a single general inventive concept.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT Information on patent family members			International application No. PCT/CN2012/082178
Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 102457912 A	16.05.2012	None	
WO 2011/159988 A1	22.12.2011	TW 201215187 A1	01.04.2012
		US 2012/0149362 A1	14.06.2012
CN 101951610 A	19.01.2011	EP 2273813 A2	12.01.2011
		JP 2011-019203 A	27.01.2011
		US 2011/0009141 A1	13.01.2011
		US 2013/0059616 A1	07.03.2013
JP 2012-90122 A	10.05.2012	None	