

(51) International Patent Classification:
H04W 72/00 (2009.01)(21) International Application Number:
PCT/CN2013/081200(22) International Filing Date:
9 August 2013 (09.08.2013)

(25) Filing Language: English

(26) Publication Language: English

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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, 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, SA, 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, KM, ML, MR, NE, SN, TD, TG).**Published:**

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

(54) Title: METHOD TO DETERMINE THE STARTING SUBFRAME OF DATA CHANNEL

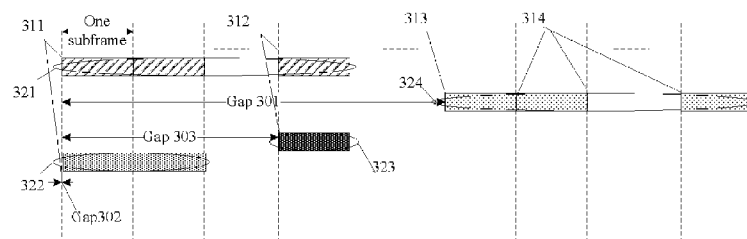


FIG. 3

(57) **Abstract:** These disclosed embodiments describe a method for a mobile station to determine the starting subframe of a data channel, the method comprising: monitoring a set of control channel candidates wherein each candidate occupies radio resources from a plurality of subframes; decoding a control channel intended for the mobile station; and determining the starting subframe of a data channel from the decoded control channel. In one embodiment, wherein determining the starting subframe of a data channel from the decoded control channel further comprising: detecting the number of subframes occupied by the decoded control channel; and determining the starting subframe of the data channel based on the detected number of subframes occupied by the decoded control and a known gap from the starting subframe of the data channel to the end subframe of the control channel. In another embodiment, wherein determining the starting subframe of a data channel from the decoded control channel further comprising: obtaining a subframe indicator in the decoded control channel; and determining the starting subframe of the data channel based on the subframe indicator and a known gap from the starting subframe of the data channel to the end subframe of the control channel.



METHOD TO DETERMINE THE STARTING SUBFRAME OF DATA CHANNEL

FIELD OF INVENTION

5 This disclosure relates generally to wireless communications and, more particularly, to determine the starting subframe of data channel reception or transmission.

BACKGROUND OF THE INVENTION

Machine-to-Machine (M2M) applications required low-cost devices and improved
10 coverage other than current cellular communication system. For example, some smart-metering devices suffer a significantly larger path-loss (e.g., 20dB path loss) than that in the typical operation condition of normal devices, which are often installed in the basements of residential buildings or locations shielded by foil-backed insulation, metalized windows, or traditional thick-walled building construction. In order to serve these devices, 3rd generation partnership
15 project (3GPP) RAN1 working group have studied for coverage improvement and cost reduction for these MTC devices in coverage hole scenario. Some potential solutions have been identified such as repetition of the physical channels to improve the coverage. In addition, cost reduction techniques are studied, including reducing the data buffer size and operation bandwidth, reducing receiving the antenna number and so on. With repetition of most of the
20 physical channels, there may be misunderstanding between base station and mobile station on the start time of the transmission of some physical channels. Therefore, it is important to have a method to determine the start subframe of the physical channels. The benefit of determining the start subframe is not limited to the examples above.

25 SUMMARY OF THE INVENTION

A method for a mobile station to determine the starting subframe of a data channel is provided.

In one novel aspect, the method comprising: monitoring a set of control channel candidates wherein each candidate occupies radio resources from a plurality of subframes; decoding a
30 control channel intended for the mobile station; and determining the starting subframe of a data channel from the decoded control channel.

In one example, wherein determining the starting subframe of a data channel from the decoded control channel further comprising: determining the starting subframe of the data

channel based on the starting subframe of the control channel and a known gap from the starting subframe of the data channel to the starting subframe of the decoded control channel.

In another example, wherein determining the starting subframe of a data channel from the decoded control channel further comprising: detecting the number of subframes occupied by the decoded control channel; and determining the starting subframe of the data channel based on the detected number of subframes occupied by the decoded control and a known gap from the starting subframe of the data channel to the end subframe of the decoded control channel.

In another example, wherein determining the starting subframe of a data channel from the decoded control channel further comprising: obtaining a subframe indicator in the decoded control channel; and determining the starting subframe of the data channel based on the subframe indicator.

Other embodiments and advantages are described in the detailed description below. This summary does not purport to define the invention. The invention is defined by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, where like numerals indicate like components, illustrate embodiments of the invention.

Figure 1 illustrates a wireless communication system.

Figure 2 illustrates an example of starting subframe of data channel determining in accordance with embodiments of the present invention.

Figure 3 illustrates an example of starting subframe of data channel determining with the starting subframe of the decoded control channel and a known gap in accordance with embodiments of the present invention.

Figure 4 illustrates an example of starting subframe of data channel determining with the detected number of subframes occupied by the decoded control channel and a known gap in accordance with embodiments of the present invention.

Figure 5 illustrates an example of determining the starting subframe of a data channel based on a subframe indicator in the decoded control channel in accordance with embodiments of the present invention.

Figure 6 illustrates some examples of the subframe indicator in accordance with embodiments of the present invention.

Figure 7 illustrates an example of determining the starting subframe of a data channel with a subframe indicator and a known gap in accordance with embodiments of the present invention.

Figure 8 illustrates some examples of the subframe indicator conveyed in control

information in accordance with embodiments of the present invention.

Figure 9 illustrates simplified block diagrams of system structure, comprising a base station and a mobile station in accordance with embodiments of the present invention.

5 DETAILED DESCRIPTION

Reference will now be made in detail to some embodiments of the invention, examples of which are illustrated in the accompanying drawings.

Figure 1 illustrates a mobile communication network 100 in accordance with one novel aspect. In Figure 1, the wireless communication system 100 includes one or more fixed base
10 infrastructure units forming a network distributed over a geographical region. The base unit may also be referred to as an access point, access terminal, base station, Node-B, eNode-B, or by other terminology used in the art. In Figure 1, the one or more base stations 101 and 102 serve a number of mobile stations 103 and 104 within a serving area, for example, a cell, or within a cell sector. In some systems, one or more base stations are communicably coupled to a
15 controller forming an access network that is communicably coupled to one or more core networks. The disclosure however is not intended to be limited to any particular wireless communication system.

Generally, the serving base station 101 and 102 transmit downlink communication signals 112 and 113 to mobile station in the time and/or frequency domain. Mobile station 103 and 104
20 communicate with one or more base units 101 and 102 via uplink communication signals 113 and 114. In Figure 1, the mobile communication network 100 is an OFDM/OFDMA system comprising a base station eNB 101 eNB 102 and a plurality of mobile station 103 and mobile station 104. When there is a downlink packet to be sent from eNodeB to mobile station, each mobile station gets a downlink assignment, e.g., a set of radio resources in a physical downlink
25 shared channel (PDSCH). When a UE needs to send a packet to eNodeB in the uplink, the mobile station gets a grant from the eNodeB that assigns a physical downlink uplink shared channel (PUSCH) consisting of a set of uplink radio resources. The mobile station gets the downlink or uplink scheduling information from a physical downlink control channel (PDCCH) or an enhanced physical downlink control channel (EPDCCH) that is targeted specifically to
30 that mobile station. The downlink or uplink scheduling information and the other control information, carried by PDCCH, is referred to as downlink control information (DCI). In current LTE system, PDCCH or EPDCCH is transmitted in one subframe and PDSCH is transmitted in the same subframe. PUSCH start to transmit 4 subframes after the subframe transmitting PDCCH or EPDCCH for FDD. For TDD, different subframe gaps between

PUSCH and the PDCCH conveying the uplink scheduling information or corresponding or Physical Hybrid ARQ Indicator Channel (PHICH) are defined for different uplink-downlink configurations in 3GPP TS 36.213. More than one transmission timing interval (TTI) can be bundled for a PUSCH transmission.

5 In one embodiment, the communication system utilizes OFDMA or a multi-carrier based architecture including Adaptive Modulation and Coding (AMC) on the downlink and next generation single-carrier (SC) based FDMA architecture for uplink transmissions. SC based FDMA architectures include Interleaved FDMA (IFDMA), Localized FDMA (LFDMA), DFT-spread OFDM (DFT-SOFDM) with IFDMA or LFDMA. In OFDMA based systems, remotes
10 units are served by assigning downlink or uplink radio resources that typically consists of a set of sub-carriers over one or more OFDM symbols. Exemplary OFDMA based protocols include the developing Long Term Evolution (LTE) of the 3GPP UMTS standard and IEEE 802.16 standard. The architecture may also include the use of spreading techniques such as multi-carrier CDMA (MC-CDMA), multi-carrier direct sequence CDMA (MC-DS-CDMA),
15 Orthogonal Frequency and Code Division Multiplexing (OFCDM) with one or two dimensional spreading, or may be based on simpler time and/or frequency division multiplexing/multiple access techniques, or a combination of these various techniques. In alternate embodiments, communication system may utilize other cellular communication system protocols including, but not limited to, TDMA or direct sequence CDMA.

20 For coverage hole devices, PDCCH or EPDCCH may need repetitions across multiple subframes. In the meanwhile, the PDSCH and/or PUSCH of the devices may also need across subframe (re)transmission (or repetitions). The repetitions number (or the number of subframes occupied by data channel or control channel) may or may not be the same. Therefore, a method to determine the starting subframe of data channel reception or transmission is necessary.

25 In one embodiment of the disclosure, a method for a mobile station to determine the starting subframe of a data channel includes: monitoring a set of control channel candidates wherein each candidate occupies radio resources from a plurality of subframes; decoding a control channel intended for the mobile station; determining the starting subframe of a data channel from the decoded control channel. In one example, the data channel is downlink data
30 channel (e.g., PDSCH in LTE system). In another example, the data channel is uplink data channel (e.g., PUSCH in LTE system). The control channel is PDCCH or EPDCCH in LTE system. Alternatively, the control channel can be a physical channel for hybrid ARQ indicator transmission (e.g., PHICH in LTE system).

In one embodiment, the determining the starting subframe of a data channel from the

decoded control channel further includes: determining the starting subframe of the data channel based on the starting subframe of the decoded control channel and a known gap from the starting subframe of the data channel to the starting subframe of the decoded control channel. In one example, the gap is predefined. Alternatively, the gap is configured by a higher-layer message (e.g., Radio Resource Control (RRC) message in LTE system). Because the gap is known to the mobile station, the mobile station knows the starting subframe of the data channel corresponding to each control channel candidate when the mobile station monitors the set of control channel candidates. In one embodiment, the gap is big enough to insure the starting subframe of data channel is always after the end subframe of the decoded control channel, especially for uplink data channel transmission. The mobile station may obtain the resource allocation (or the uplink grant) of the data channel in each subframe in the decoded control channel. The mobile station may only receiving or buffer the data channel resources indicated by the decoded control channel. In another embodiment, the mobile station may not know the resource allocation for the data channel. For example, the starting subframe of the data channel is before the end subframe of the decoded control channel, or mobile station cannot decode the control channel intended for the mobile station conveying the resource allocation of the data channel in time. The mobile station needs to buffer all the potential data channel resources from the starting subframe of the data channel. The potential data channel resources may be the whole resources in one subframe. Alternatively, the potential data channel resources is a subset of the whole resources and the subset is known to the mobile station. The subset may be predefined or configured by a higher-layer message.

It is noted that, with the number of subframes occupied by the decoded control channel and the gap from the starting time of the data channel to the end of the decoded control channel, the gap from the starting time of the data channel to the starting time of the decoded control channel can be calculated and is also known to the mobile station. However, the number of subframes occupied by the decoded control channel may be unknown to the mobile. The mobile station needs to detect the number of subframes occupied by the decoded control channel.

The number of the plurality of subframes occupied by the each control channel candidate may be unknown to the mobile station before successfully decoded one or more of the control channel candidates (i.e., the decoded control channel intended for the mobile station). The mobile station needs to detect the number of subframes occupied by the decoded control channel. In another embodiment, determining the starting subframe of a data channel from the decoded control channel further includes: detecting the number of subframes occupied by the decoded control channel; and determining the starting subframe of the data channel based on

the detected number of subframes occupied by the decoded control channel and a known gap from the starting subframe of the data channel to the end subframe of the decoded control channel. In one example, the gap is predefined. Alternatively, the gap is configured by a higher-layer message (e.g., Radio Resource Control (RRC) message in LTE system). The gap equal to
5 zero is a special case, which means the data channel starts on the end subframe of the decoded control channel. The gap can also be smaller than zero, and this means the data channel starts before the end subframe of the decoded control channel. In this case, the mobile station needs to buffer all the potential data channel resources from the starting subframe of the data channel. When the gap is bigger than zero, the data channel starts after the end subframe of the decoded
10 control channel. For uplink data channel transmission, the gap is always bigger than zero.

The mobile station can detect the number of subframes occupied by the decoded control channel. However, the control channel may be transmitted in more subframes than the mobile station detected. For example, the control channel may be repeated in plurality of subframes with the repetition of the same contented. As a result, the mobile station may early decode the
15 control channel. In this case, there may be a misunderstanding between the mobile station and the base station about the number of subframes occupied by the decoded control channel. Therefore, the number of subframes occupied by the decoded control channel needs to be predefined or configured. In one embodiment, the number of subframes occupied by the control channel is configured by a higher-layer message. In another embodiment, the number of
20 subframes occupied is indicated in the decoded control channel.

In one embodiment, the determining the starting subframe of a data channel from the decoded control channel further includes: obtaining a subframe indicator in the decoded control channel; and determining the starting subframe of the data channel based on the subframe indicator. In one embodiment, the subframe indicator signals the number of subframes between
25 the starting subframe of the data channel and the starting subframe of the decoded control channel. In another embodiment, the subframe indicator signals the number of subframes between the starting subframe of the data channel and the end subframe of the decoded control channel. In another embodiment, the subframe indicator signals the subframe index on which the data channel starts. The subframe index can be comprised of one or more periodic indexes.
30 For example, the subframe index can be comprised of both the radio frame index and the subframe index within one radio frame. It also can be one periodic index such as the subframe index within a fixed period. In another example, the subframe index can be a subframe gap to a reference subframe known to both the mobile station and the base station.

In another embodiment, determining the starting subframe of a data channel from the

decoded control channel further includes: obtaining a subframe indicator in the decoded control channel; and determining the starting subframe of the data channel based on the subframe indicator and a known gap from the starting subframe of the data channel to the end subframe of the decoded control channel. The gap can be predefined or configured by a higher-layer message. The subframe indicator may signal the number of subframes occupied by the control channel that contains the subframe indicator.

In another embodiment, the determining the starting subframe of a data channel from the decoded control channel further includes: obtaining a subframe indicator in the decoded control channel; and determining the starting subframe of the data channel based on the subframe indicator and a predefined rule. In one embodiment, the predefined rule further basing on mobile station index. For example, the mobile station index can be a group index shared with at least another mobile station configured by the base station. In another example the mobile station index is mobile station identity (ID) or an RNTI configured by the base station. In another embodiment, the predefined rule further bases on the base station identity (ID). The base station ID can be a physical ID or a virtual ID.

The mobile station can obtain the subframe indicator after decoded the control channel. If the mobile station knows that the starting subframe of data channel is always after the end subframe of the control channel intended for the mobile station(e.g., pre-defined), the mobile station may only receiving or buffer the data channel resources indicated by the decoded control channel. In another example, the starting subframe of data channel may not always be before the end subframe of control channel. This may only happen to downlink data channel receiving. In this case, the mobile station needs to buffer all the potential data channel resources from the starting subframe of the data channel.

Moreover, the data channel may also occupy one or more subframes, for example, need repetitions across multiple subframes. The mobile station needs to know the number of subframe occupied by the data channel (or repetition number of the data channel) before decoding or transmission. In one embodiment, the number of subframes occupied by the data channel can be configured by high-layer message. In another embodiment, the number of subframes occupied by the data channel can be indicated in the decoded control channel. Alternatively, the number of subframes occupied by the data channel can be implied by the number of subframes occupied by the decoded control channel, e.g., the same with the number of subframes occupied by the decoded control channel.

Some further details are the above embodiments are given below.

Referring now to Figure 2, Figure 2 illustrates an example of starting subframe of data

channel determining in accordance with embodiments of the present invention. In one embodiment of the disclosure, a method for a mobile station to determine the starting subframe of a data channel includes: monitoring a set of control channel candidates, for example channel candidate 211 and 212, wherein each candidate occupies radio resources 221, 222 from a plurality of subframes 201, 202 and 203; decoding a control channel intended for the mobile station, for example, the control channel candidate 211 is decoded by the mobile station; determining the starting subframe of a data channel 231 from the decoded control channel 211. The control channel candidate may occupy radio resources for more than one subframe. For example, the control channel candidate 211 occupies radio resources 221 in subframe 201 and 202 and the control channel candidate 212 occupies radio resources 222 from subframe 201, 202 and 203. The mobile station blindly detects for a control channel intended for the mobile station. For example, the mobile station may detect the control channel candidates 211 and 212, but only decodes the control channel 211. In one embodiment, the data channel 231 and 232 is uplink data channel. In another embodiment, the data channel 231 and 232 is downlink data channel. In one embodiment, the control channel 211 or 212 is PHICH. In another embodiment, the control channel is PDCCH or EPDCCH.

Referring now to Figure 3, Figure 3 illustrates an example of starting subframe of data channel determining with the starting subframe of the decoded control channel and a known gap in accordance with embodiments of the present invention. In one embodiment, the determining the starting subframe of a data channel from the decoded control channel further comprising further includes: determining the starting subframe of the data channel (e.g., data channel 322, 323, 324) based on the starting subframe 311 of the control channel 321 and a known gap (shown as gap 301, 303, 304) from the starting subframe (e.g., subframe 311, 312, 313) of the data channel 322, 323, 324 to the starting subframe (e.g., subframe 311) of the decoded control channel.

As Figure 3 shows, the gap 301 is 5 subframes and it is big enough to insure the starting subframe 313 of data channel 324 is after the end subframe 312 of the decoded control channel 321. The mobile station may obtain the resource allocation (or the uplink grant) of the data channel 324 in each subframe 313 and 314 conveying by the decoded control channel 321. The mobile station may only receiving or buffer the data channel resources indicated by the decoded control channel 321. In another embodiment, the starting subframe (e.g., 311 or 312) of the data channel is before or on the end subframe 312 of the decoded control channel 321. In another example, the mobile station cannot decode the control channel 321 conveying the resource allocation of the data channel 324 in time (e.g., cannot decode the control channel 321 before

subframe 313 when the data channel 324 starts). The mobile station needs to buffer all the potential data channel resources from the starting subframe 313 of the data channel 324.

Referring now to Figure 4, Figure 4 illustrates an example of starting subframe of data channel determining with the detected number of subframes occupied by the decoded control channel and a known gap in accordance with embodiments of the present invention. In another embodiment of the disclosure, determining the starting subframe of a data channel from the decoded control channel further includes: detecting the number of subframes 400 occupied by the decoded control channel 421; and determining the starting subframe (e.g., subframe 411, 412, 413) of the data channel (e.g., 423, 424, 422) based on the detected number of subframes 400 occupied by the decoded control channel 411 and a known gap (e.g., 402, 403, 401) from the starting subframe (e.g., 411, 412, 413) of the data channel (e.g., 423, 424, 422) to the end subframe (412) of the decoded control channel 412.

The gap can be predefined, for example, 4 subframes gap between the starting subframe of an uplink data channel and the end subframe of the corresponding control channel conveying the uplink grant for the uplink data channel. In another example, one subframe gap between the starting subframe of data channel and the end of the corresponding control channel. With this one subframe gap, the mobile station can decode the control channel and obtain the radio resources information of the data channel. Therefore, the mobile station can only receive and buffer the radio resources of the data channel. This will save the mobile station buffer size and give the base station more flexibility for scheduling. The radio resources information of the data channel can be the number of subframes occupied by the data channel, the physical resource block in each subframe and so on. Alternatively, the gap is configured by higher-layer message, for example RRC message.

The gap equal to zero is a special case, for example gap 403 in Figure 4. This means the data channel 424 starts to transmit in the same subframe 412 with the end subframe of the decoded control channel 421. The gap can also be smaller than zero, for example gap 402, and this means the data channel 423 starts to transmit in the subframe 411 before the end subframe 412 of the decoded control channel 421. In this case, the mobile station needs to receive and buffer the radio resources which may convey the data channel 423 before decoding for the control channel 421 and decode the data channel after decoded the control channel. When the gap is bigger than zero such as gap 401, the data channel 422 starts to transmit in subframe 413 after the end subframe 412 of the decoded control channel 421.

Referring now to Figure 5, Figure 5 illustrates an example of determining the starting subframe of a data channel based on a subframe indicator in the decoded control channel in

accordance with embodiments of the present invention. In one embodiment, the determining the starting subframe of a data channel from the decoded control channel further includes: obtaining a subframe indicator 531 in the decoded control channel 521; and determining the starting subframe 504 of the data channel 512 based on the subframe indicator 531.

Referring now to Figure 6, Figure 6 illustrates some examples of the subframe indicator in accordance with embodiments of the present invention. In one embodiment, in order to determine the starting subframe 611 of the data channel 622, the mobile station obtains a subframe indicator 631 in the decoded control channel 621; and determining the starting subframe 611 of the data channel 622 based on the subframe indicator 631. In one example, the subframe indicator 631 signals the number of subframes 601 between the starting subframe 611 of the data channel 622 and the starting subframe 610 of the decoded control channel 621. In another example, the subframe indicator 631 signals the number of subframes 620 between the starting subframe 611 of the data channel 622 and the end subframe 612 of the decoded control channel 621. In another example, the subframe indicator 631 signals the subframe index 611 on which the data channel 622 starts. The subframe index can be comprised of one or more periodic indexes. For example, the subframe index can be: System Frame Number (SFN) multiplies number of subframe in one radio frame and plus the subframe index within one SFN. In LTE system, SFN (e.g, from 0~1023) is indicated in Master information block (MIB) and each radio frame has 10 subframes with subframe index # 0~9. In this case, the range of the subframe index can be from 0 ~ 10239. In another embodiment, it also can be one periodic index such as the subframe index within a fixed period, e.g., the subframe index from 0 to 9.

Referring now to Figure 7, Figure 7 illustrates an example of determining the starting subframe of a data channel with a subframe indicator and a known gap in accordance with embodiments of the present invention. In one embodiment, the mobile station obtains the subframe indicator 731 in the decoded control channel 723; and determining the starting subframe 715 of the data channel 722 based on the subframe indicator 731 and a known gap 700 from the starting subframe 715 of the data channel 722 to the end subframe 713 of the decoded control channel 721 (actually transmitted control channel). The gap can be predefined or configured by a higher-layer message. The subframe indicator 731 signals the number of subframes 701 occupied by the control channel 721 intended for the mobile station. In one practical embodiment, the control channel is transmitted from subframe 711 to subframe 713 with the number of subframes 701. The control channel repeated in multiple subframes and each subframe carries full information of the control channel. The mobile station attempts to decode the control channel and it may early successfully decode the control channel with 702

subframes. Without an additional indicator of the number of subframes occupied by the control channel 721 intended for the mobile station, the mobile station may determine the starting subframe of a data channel as subframe 714 with a known gap 700 and the wrong end subframe 712 of the decoded control channel with the number 702 of subframes. In order to avoid this situation, the indicator of number of subframes occupied by the decoded control channel can be carried in the decoded control channel. The indicator signals the actual number of subframes occupied by the decoded control channel. Alternatively, a mapping rule of the indicator and the number of subframes can be pre-defined. Table 1 gives an example of pre-defined rule of subframe indicator and the number of subframes occupied by the control channel. After the mobile station decoded the control channel, the mobile station knows the number 701 of subframes occupied by the control channel via the subframe indicator in the decoded control channel. Therefore, the mobile station can calculate the end subframe of the decoded control channel, e.g., subframe 713 shown in Figure 7.

Table 1. An example of pre-defined rule of subframe indicator and the number of subframes occupied by the control channel

Value of the subframe indicator	The subframe number of control channel
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128

In another embodiment, the mobile station can obtain a subframe indicator in the decoded control channel; and determine the starting subframe of the data channel based on the subframe indicator and a predefined rule. In one embodiment, the predefined rule further basing on mobile station index (e.g., mobile station identity (ID) or RNTI) and/or base station identity. For example, the predefined rule requires the starting subframe of the data channel is the subframe with smallest index after the decoded control channel and it can meet:

$$N \bmod N_{ID} = A$$

where N is the subframe index, N_{ID} is the mobile station index and A is the indicator of the subframe index. In another example, N_{ID} is the base station ID. The base station ID can be a physical ID or a virtual ID.

The subframe indicator can be carried in control information in the decoded control
5 channel. For example, the subframe indicator can be some information field in downlink control information (DCI) format. Referring now to Figure 8, Figure 8 illustrates some examples of the subframe indicator conveyed in control information in accordance with embodiments of the present invention. In the embodiment, some original field 811 in DCI format 801 can be redefined as the subframe indicator 821. In another embodiment, the
10 subframe indicator 822 in new field 812 is added to a new DCI format 802.

Figure 9 illustrates simplified block diagrams of system structure 900, wherein comprising a base station 901 and a mobile station 911 in accordance with embodiments of the present invention. The one or more base station may comprise one or more transmitters and one or more receivers that serve the mobile stations. The mobile stations may be fixed or mobile user
15 terminals. The mobile stations may also be referred to as subscriber units, users, terminals, remote units, subscriber stations, user equipment (UE), user terminals, or by other terminology used in the art. The mobile stations may also comprise one or more transmitters and one or more receivers. The mobile stations may have half duplex (HD) or full duplex (FD) transceivers. Half-duplex transceivers do not transmit and receive simultaneously whereas full duplex
20 terminals do.

For base station 901, antenna 907 transmits and receives radio signals. RF transceiver module 906, coupled with the antenna, receives RF signals from the antenna, converts them to baseband signals and sends them to processor 903. RF transceiver 906 also converts received baseband signals from the processor, converts them to RF signals, and sends out to antenna 907.
25 Processor 903 processes the received baseband signals and invokes different functional modules to perform features in base station 901. Memory 902 stores program instructions and data 909 to control the operations of the base station.

Similar configuration exists in mobile station 911 where antenna 917 transmits and receives RF signals. RF transceiver module 916, coupled with the antenna, receives RF signals
30 from the antenna, converts them to baseband signals and sends them to processor 913. The RF transceiver 916 also converts received baseband signals from the processor, converts them to RF signals, and sends out to antenna 917. Processor 913 processes the received baseband signals and invokes different functional modules to perform features in mobile station 911.

Memory 912 stores program instructions and data 919 to control the operations of the mobile station.

The base station 901 and mobile station 911 also include several functional modules to carry out some embodiments of the present invention. The different functional modules can be implemented by software, firmware, hardware, or any combination thereof. The function modules, when executed by the processors 903 and 913 (e.g., via executing program codes 909 and 919), for example, allow base station 901 to encode and transmit control channels to mobile station 911, and allow mobile station 911 to receive and decode the control channels accordingly. In one example, base station 901 configures a set of radio resources for control channels; encode the control channel via processors 903, for example a control module. In one embodiment, the base station 901 inserts indicators to each control channel via processors 903, for example a control module. The data channels are modulated and encoded via data channel module 904. The base station 901 transmits the encoded control channels and data channels by transceiver 906 via antenna 907. Mobile station 911 receives the control channels and data channels by transceiver 916 via antenna 917. Mobile station 911 monitors the control channel candidates, decodes a control channel intended for mobile station 911. In one embodiment, mobile station 911 determines the starting subframe of a data channel from the decoded control channel processors 913, for example a control module or a determining module. In another embodiment, mobile station 911 obtains the indicator in the decoded control channel via processors 913, for example a control module. Based on this subframe indicator, mobile station 911 determines the starting subframe of the data channel via processors 913, for example a control module. From the determined starting subframe of the data channel, mobile station 911 starts to receive the data channel via antenna 917 and decode the data channel via processors 913, for example a data channel module. In another embodiment, the data channel is modulated and encoded via processors 913, for example a data channel module, and transmitted by transceiver 916 via antenna 917 from the determined starting subframe of the data channel by mobile station 911.

While the present disclosure and the best modes thereof have been described in a manner establishing possession and enabling those of ordinary skill to make and use the same, it will be understood and appreciated that there are equivalents to the exemplary embodiments disclosed herein and that modifications and variations may be made thereto without departing from the scope and spirit of the inventions, which are to be limited not by the exemplary embodiments but by the appended claims.

CLAIMS

1. A method for a mobile station to determine the starting subframe of a data channel, the method comprising:

5 monitoring a set of control channel candidates wherein each candidate occupies radio resources from a plurality of subframes;

decoding a control channel intended for the mobile station; and

determining the starting subframe of a data channel from the decoded control channel.

10 2. The method of claim 1, wherein determining the starting subframe of a data channel from the decoded control channel further comprising:

determining the starting subframe of the data channel based on the starting subframe of the control channel and a known gap from the starting subframe of the data channel to the starting subframe of the decoded control channel.

15 3. The method of claim 2, wherein the known gap is predefined.

4. The method of claim 2, wherein the known gap is configured by a higher-layer message.

20 5. The method of claim 1, wherein determining the starting subframe of a data channel from the decoded control channel further comprising:

detecting the number of subframes occupied by the decoded control channel; and

determining the starting subframe of the data channel based on the detected number of subframes occupied by the decoded control and a known gap from the starting subframe of the data channel to the end subframe of the decoded control channel.

25 6. The method of claim 5, wherein the known gap is predefined.

7. The method of claim 5, wherein the known gap is configured by a higher-layer message.

30 8. The method of claim 1, wherein determining the starting subframe of a data channel from the decoded control channel further comprising:

obtaining a subframe indicator in the decoded control channel; and

determining the starting subframe of the data channel based on the subframe indicator.

9. The method of claim 8, wherein the subframe indicator signals the number of subframes between the starting subframe of the data channel and the starting subframe of the decoded control channel.

5 10. The method of claim 8, wherein the subframe indicator signals the number of subframes between the starting subframe of the data channel and the end subframe of the decoded control channel.

10 11. The method of claim 8, wherein the subframe indicator signals the subframe index on which the data channel starts.

12. The method of claim 11, wherein the subframe index is comprised of at least one periodic index.

15 13. The method of claim 1, wherein determining the starting subframe of a data channel from the decoded control channel further comprising:

obtaining a subframe indicator in the decoded control channel; and

20 determining the starting subframe of the data channel based on the subframe indicator and a known gap from the starting subframe of the data channel to the end subframe of the decoded control channel.

14. The method of claim 13, wherein the subframe indicator signals the number of subframes occupied by the decoded control channel that contains the subframe indicator.

25 15. The method of claim 13, wherein the known gap is predefined.

16. The method of claim 13, wherein the known gap is configured by a higher-layer message.

30 17. The method of claim 1, wherein determining the starting subframe of a data channel from the decoded control channel further comprising:

obtaining a subframe indicator in the decoded control channel; and

determining the starting subframe of the data channel based on the subframe indicator and a predefined rule.

18. The method of claim 17, wherein the predefined rule further basing on mobile station index.

19. The method of claim 18, wherein the mobile station index is a group index with at least
5 another mobile station.

20. The method of claim 17, wherein the predefined rule further basing on base station identity.

10 21. The method of claim 1, wherein the data channel is a downlink data channel.

22. The method of claim 1, wherein the data channel is an uplink data channel.

23. The method of claim 1, wherein the number of the plurality of subframes occupied by
15 each control channel candidate is unknown to the mobile station.

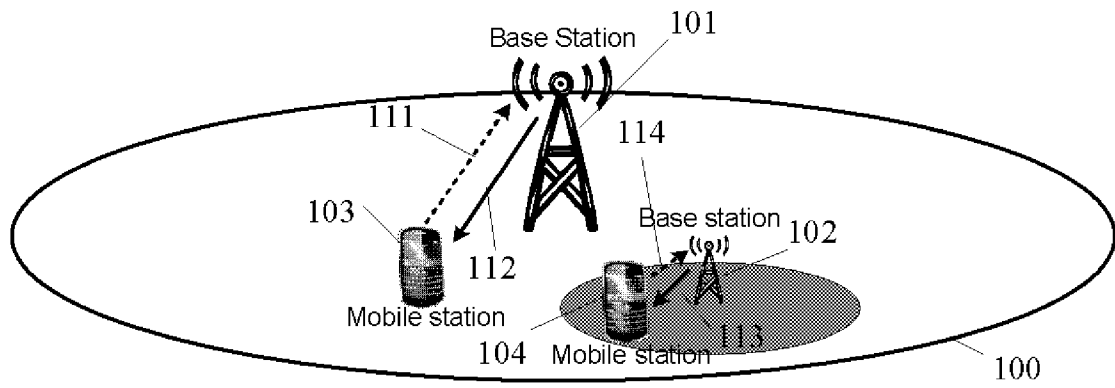


FIG. 1

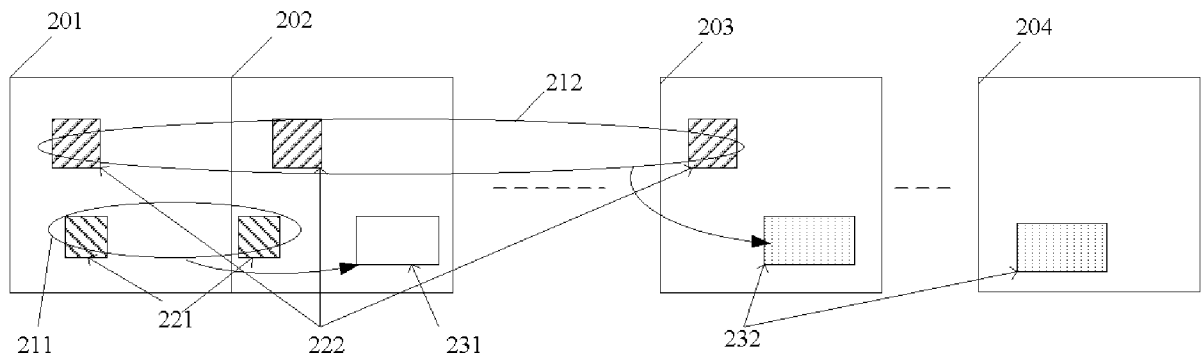


FIG. 2

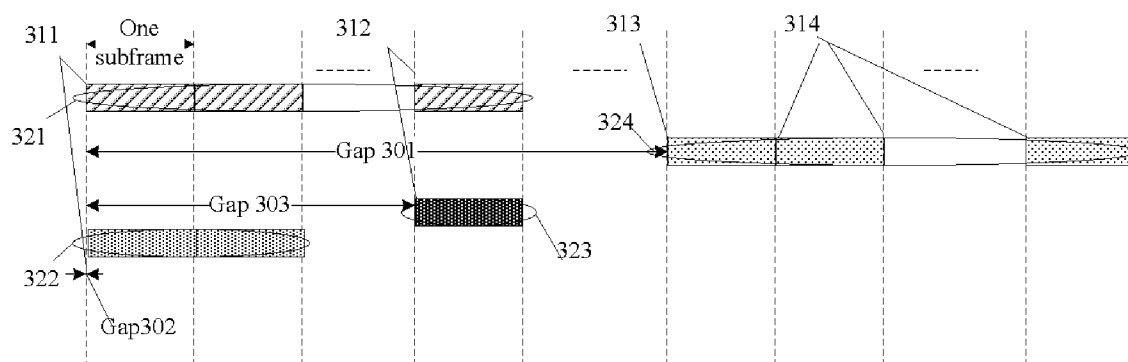


FIG. 3

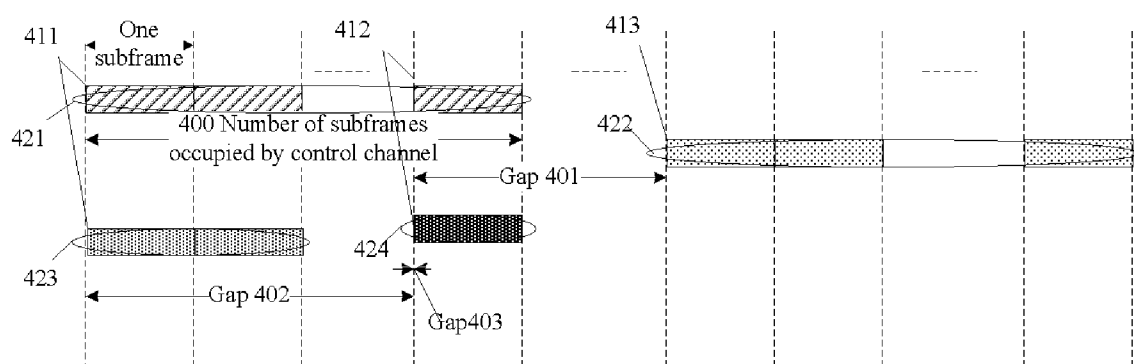


FIG. 4

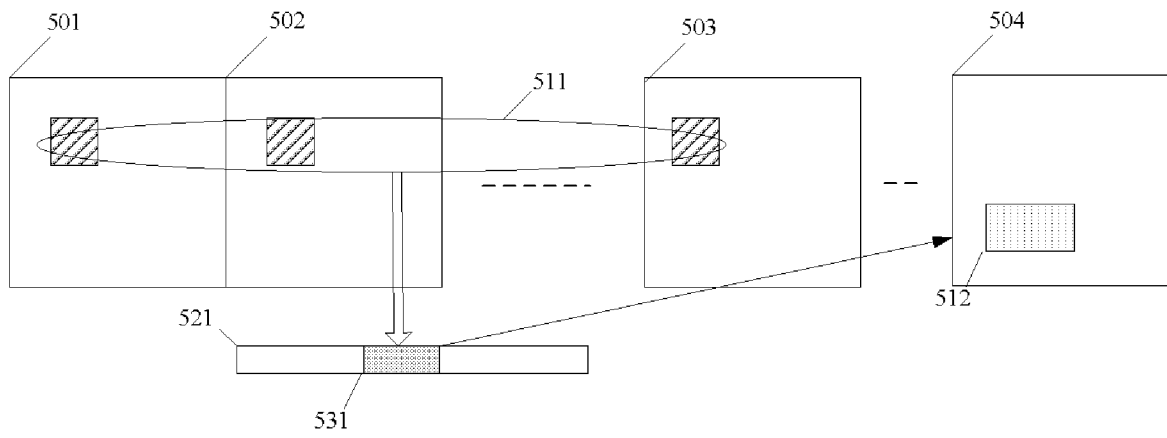


FIG. 5

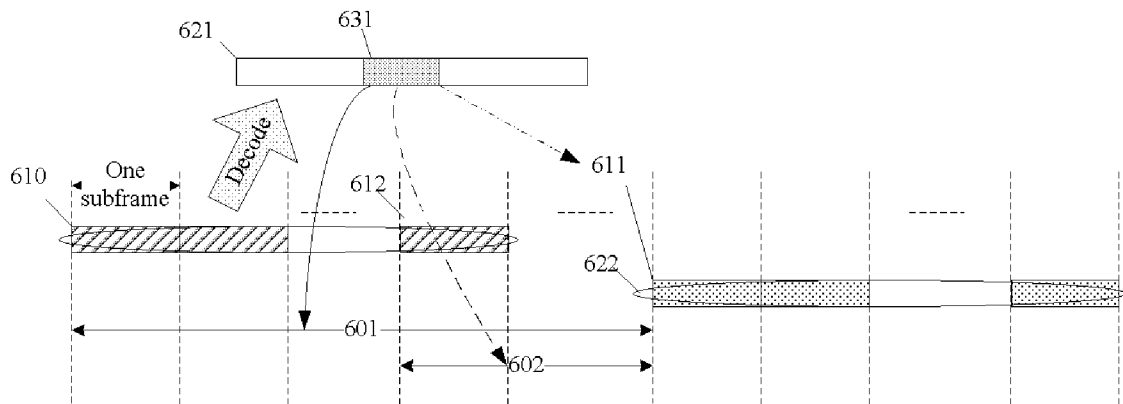


FIG. 6

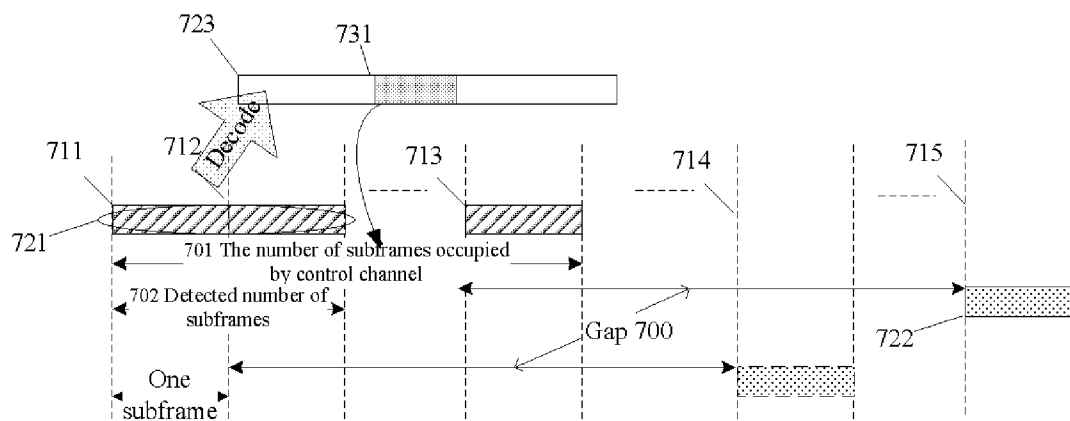


FIG. 7

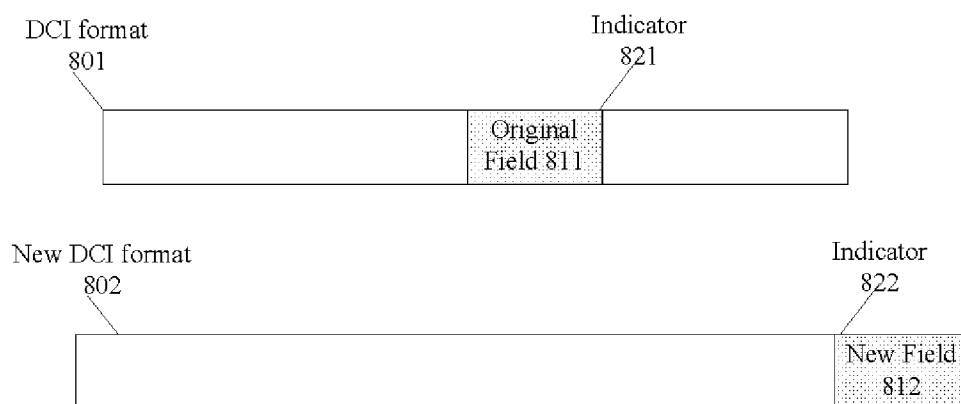


FIG. 8

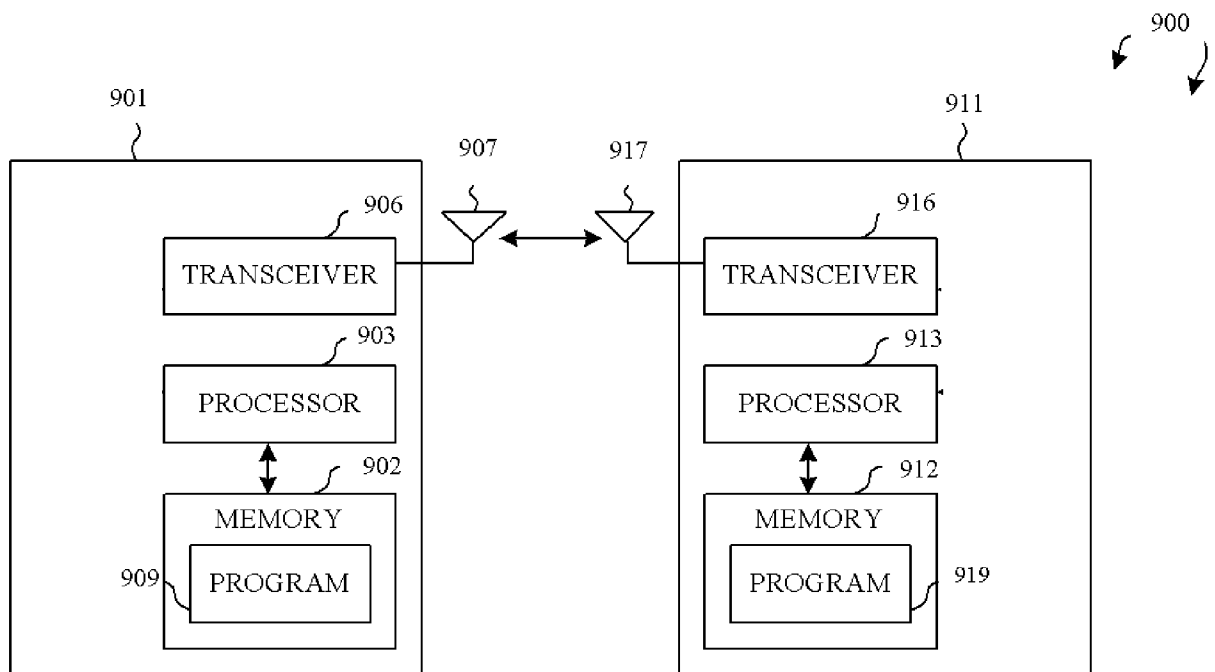


FIG.9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/081200**A. CLASSIFICATION OF SUBJECT MATTER**

H04W 72/00 (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)

H04W; 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)

GOOGLE, WPI, EPODOC, CNPAT, CNKI:start+ or end+, subframe, data channel, control channel, PDCCH OR EPDCCH or PHICH, PDSCH OR PUSCH, gap, number, indicator, decod+, repetition?, M2M or MTC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012109542A1 (INTERDIGITAL PATENT HOLDINGS INC.) 16 August 2012 (2012-08-16) description, paragraphs [0060]-[0085] and [0205]-[0240]	1, 21-23
A	CN 101945403A (ZTE CORP.) 12 January 2011 (2011-01-12) the whole document	1-23
A	CN 101754329A (HUAWEI TECHNOLOGIES CO., LTD) 23 June 2010 (2010-06-23) the whole document	1-23

☐ 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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“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)

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“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

22 April 2014

Date of mailing of the international search report

21 May 2014

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2013/081200

Patent document cited in search report		Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO	2012109542A1	16 August 2012	CN 103518415A	15 January 2014
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			US 2013039284A1	14 February 2013
			EP 2674007A1	18 December 2013
			TW 201246856A	16 November 2012
			KR 20130132603A	04 December 2013
			JP 2014508471W	03 April 2014
CN	101945403A	12 January 2011	WO 2012016414A1	09 February 2012
CN	101754329A	23 June 2010	None	