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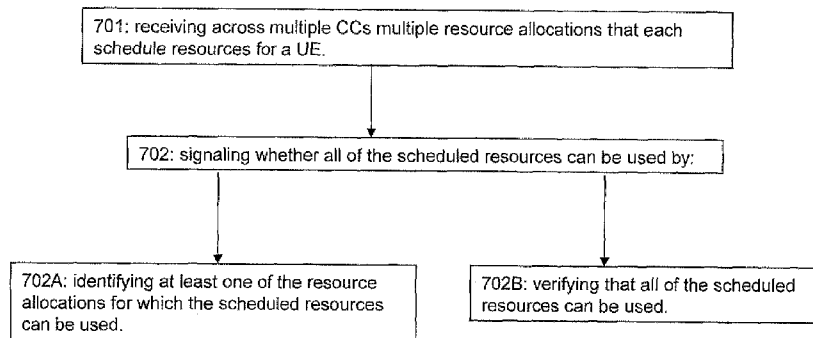


Figure 7A

(57) Abstract: In exemplary embodiments an eNB sends to a user equipment UE, across multiple component carriers, multiple resource allocations that each schedule resources for the UE. There are four different embodiments for DRX signaling. In one embodiment the UE signals whether all of the scheduled resources can be used by identifying at least one of the resource allocations for which the scheduled resources can be used. In other embodiments the UE signals whether all of the scheduled resources can be used by verifying that all of the scheduled resources can be used. The eNB then learns of missing PDCCHs by this DRX signaling.

OVERHEAD COMPRESSION OF EXPLICIT UPLINK FEEDBACK

TECHNICAL FIELD:

[0001] The exemplary embodiments of this invention relate generally to uplink control signaling, such as a user equipment's uplink signaling in response to scheduling information/resource allocations. Particular exemplary embodiments may be practiced in the long term evolution of UTRAN often referred to as 3.9G.

BACKGROUND:

[0002] The following abbreviations are utilized herein:

3GPP	third generation partnership project
ACK	acknowledgement
A/N	ACK/NAK
ARQ	automatic repeat-request
15 CA	carrier aggregation
CC	component carrier
CW	codeword
DAI	downlink assignment index
DL	downlink (Node B/eNB to UE)
20 DTX	discontinuous transmission
E-UTRAN	evolved UMTS terrestrial radio access network
eNB	enhanced Node-B
FDD	frequency division duplex
LTE	long term evolution of UTRAN
25 LTE-A	LTE Advanced (Release 10)
NAK	negative acknowledgement
PDCCH	physical downlink control channel
PDSCH	physical downlink shared channel
Node B	base station
30 TDD	time division duplex
UE	user equipment, such as a mobile station or mobile terminal
UL	uplink (UE to Node B)
UMTS	universal mobile telecommunications system
UTRAN	UMTS terrestrial radio access network

35

[0003] The proposed E-UTRAN (also known as LTE) communication system is a packet-based system that operates under strict control of the BS (eNB). The usage of physical UL/DL resources is signaled from the eNB to the UEs via PDCCHs. Multiple UEs may be scheduled in a single PDCCH, and for those scheduled the PDCCH indicates which physical resources are assigned for UL and DL data transmissions. When data transmission occurs over a wireless medium, there is of

course a risk of error when receiving and detecting the data and so A/N is used in a predetermined ARQ procedure to feedback with minimum signaling overhead what was and was not properly received.

5 [0004] One development in LTE Release 10 (also termed as LTE-A) extends the system bandwidth beyond the LTE Release 8 bandwidth of 20 MHz by means of carrier aggregation. CA is shown by example at Figure 1 in which there are five CCs, at least one of which is backward compatible with LTE Release 8 UEs. The Release 10 UEs may be assigned one or multiple CCs which they are to monitor for its PDCCHs
10 and/or which contains the UL/DL resources assigned to that UE. In this regard the Release 10 UEs can receive on multiple CCs simultaneously whereas Release 8 UEs can only receive on one CC at a time. Figure 1 is exemplary only; in other examples of CA the various CCs may have different bandwidths, some of the CCs may not be Release 8 compatible, and the CCs may not be frequency-adjacent.

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[0005] The CA concept complicates the ACK/NAK/DTX signaling as compared to LTE Release 8. Simply adding more bits for the UE to signal the relevant CC on which the PDCCH was sent is seen by the inventor to be too high of a cost in signaling overhead. This is at least because in the TDD mode one UL subframe may be
20 associated with more than one PDCCH. There may be multiple CCs in the frequency domain if the UE has multiple CCs of its configured CC set activated, and there may be multiple DL subframes in the time domain which depends on configured DL/UL ratio.

25 [0006] Various UL A/N feedback modes have been discussed for the TDD mode of LTE-A but none has yet been adopted. These include A/N full bundling, A/N multiplexing via channel selection, and A/N multiplexing via joint encoding. In LTE there are also discussions for an explicit UL DTX feedback to be incorporated with the A/N regimen. Further details in this regard may be seen at US Patent Application No.
30 12/286,883 (filed October 2, 2008).

[0007] The DTX feedback enables the UE to convey explicit information to the eNB of whether or not there exists a "PDCCH missing" among the scheduled

assignment(s)/PDCCHs. "PDCCH missing" means that the UE has no chance to receive or buffer the accompanied PDSCH transmission. The eNB can use the DTX feedback to help determine if a PDCCH missing exists. In the case the eNB concludes that a PDCCH missing does not exist, this means that the UE could receive/buffer the accompanied PDSCH transmission safely. This is different from a decoding error; if no PDCCH missing exists and the UE receives and buffers the associated PDSCH data, the UE will still send an ACK or NAK to inform the eNB whether the received data was properly decoded.

[0008] The additional DTX signaling gives the opportunity for the eNB to utilize incremental redundancy transmissions, and may increase DL throughput and/or allow PDCCH outer loop adjustment which can help guarantee DL coverage. One challenge for explicit DTX feedback is to keep reasonable UL signaling overhead, which is particularly challenging for the TDD mode of LTE-A.

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[0009] Consider an example. If the UE reserves 3 states (ACK/NAK/DTX) for each assignment as shown in the following table, the additional DTX feedback bit adds 60% to the signaling overhead.

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(Assumption: 5 CCs in frequency domain, 4DL:1UL in time domain, 2 CWs in spatial domain)	
	with ACK/NAK spatial bundling
without explicit DTX	up to 20 ACK/NAK bits
with explicit DTX	up to 32 ACK/NAK/DTX bits

[0010] Exemplary embodiments of this invention are directed toward compressing the signaling overhead used to signal explicit UL DTX feedback.

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SUMMARY:

[0011] In an exemplary aspect of the invention, there is a method comprising: receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and signaling whether all of the scheduled resources can be used by: identifying at least one of the resource allocations for which the scheduled resources can be used, or verifying that all of the scheduled resources can

be used.

[0012] In another exemplary aspect of the invention there is an apparatus comprising at least one processor and at least one memory storing computer program instructions. The at least one memory storing computer program instructions is configured with the at least one processor to cause the apparatus to perform actions comprising: in response to receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment, signaling whether all of the scheduled resources can be used by: identifying at least one of the resource allocations for which the scheduled resources can be used, or verifying that all of the scheduled resources can be used.

[0013] In still another exemplary aspect of the invention there is a memory storing a program of computer readable instructions which when executed by at least one processor result in actions comprising: in response to receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment, signaling whether all of the scheduled resources can be used by: identifying at least one of the resource allocations for which the scheduled resources can be used, or verifying that all of the scheduled resources can be used.

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[0014] In yet another exemplary aspect of the invention there is an apparatus comprising: means for receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and means for signaling whether all of the scheduled resources can be used by: identifying at least one of the resource allocations for which the scheduled resources can be used, or verifying that all of the scheduled resources can be used.

[0015] In accordance with an exemplary aspect of the invention as stated above, the means for receiving comprises a receiver, the means for signaling comprises a transmitter in combination with a processor at least.

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[0016] In another exemplary aspect of the invention there is a method comprising: sending across multiple component carriers multiple resource allocations

that each schedule resources for a user equipment; receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used; and determining from the reply that at least some of the scheduled resources can be used by the user equipment, or using the reply to verify that at all of the scheduled resources can be used by the user equipment.

[0017] In another exemplary aspect of the invention there is an apparatus comprising at least one processor and at least one memory storing computer program instructions. The at least one memory storing computer program instructions is configured with the at least one processor to cause the apparatus to perform actions comprising: sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and in response to receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used: determining from the reply that at least some of the scheduled resources can be used by the user equipment, or using the reply to verify that at all of the scheduled resources can be used by the user equipment.

[0018] In still another exemplary aspect of the invention there is a memory storing a program of computer readable instructions which when executed by at least one processor result in actions comprising: sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and in response to receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used: determining from the reply that at least some of the scheduled resources can be used by the user equipment, or using the reply to verify that at all of the scheduled resources can be used by the user equipment.

[0019] In yet another exemplary aspect of the invention there is an apparatus comprising: means for sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and means, response to receiving a reply from the user equipment that identifies at least one of the resource

allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used: for determining from the reply that at least some of the scheduled resources can be used by the user equipment, or for using the reply to verify that at all of the scheduled resources can be used by the user equipment.

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[0020] In accordance with an exemplary aspect of the invention as stated above, the means for sending comprises a transmitter and the means for determining or the means for using comprises at least a processor.

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BRIEF DESCRIPTION OF THE DRAWINGS:

[0021] Figure 1 illustrates in the frequency domain five equal bandwidth component carriers which together form an exemplary embodiment of a CA system in which embodiments of the invention may be practiced to advantage.

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[0022] Figure 2 compares UL overhead needed for a traditional 3-state (ACK/NAK/DTX) feedback shown at the left side to UL overhead needed for exemplary embodiments of these teachings shown at the right side, assuming $K=2$ signaling bits are allowed for explicit DTX signaling by the UE.

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[0023] Figure 3A is an exemplary lookup table giving meaning to the $K=2$ explicit DTX signaling bits for an example of the first embodiment of the invention.

[0024] Figure 3B is an exemplary set of assignments/PDCCHs sent by the eNB to a UE in a plurality of DAI windows for an example of the first embodiment of the invention.

[0025] Figures 4A-B are similar to Figures 3A-B for an example of the second embodiment of the invention.

30 [0026] Figures 5A-B are similar to Figures 3A-B for an example of the third embodiment of the invention.

[0027] Figures 6A-B are similar to Figures 3A-B for an example of the fourth

embodiment of the invention.

[0028] Figures 7A-B are non-limiting and exemplary process flow diagrams from the perspective of the UE and eNB respectively according to exemplary
5 embodiments of the invention.

[0029] Figure. 8 shows a simplified block diagram of electronic devices that are suitable for use in practicing the exemplary embodiments of the invention.

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DETAILED DESCRIPTION:

[0030] While the below examples are in the context of LTE-A, the broader teachings herein are not limited to that particular wireless protocol but may be employed in any wireless system which uses component carriers. The specific LTE-A
15 terminology used below (PDCCH, PDSCH, etc.) is for a more thorough explanation of the exemplary embodiments but is not intended to be limiting to the broader teachings herein.

[0031] Exemplary embodiments of the invention are in the context of multiple
20 CCs on which the eNB sends PDCCHs that each schedule a PDSCH for a particular UE. In general terms the PDCCH is a radio resource allocation and the scheduled PDSCH is a scheduled radio resource. For the case in which there is a PDCCH missing (DTX), the UE signals this by identifying at least one of the PDCCHs for which it can use the associated PDSCH, or by verifying that all of the scheduled resources can be used.

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[0032] One problem with certain prior art approaches for DTX signaling is that if there is a subframe which is not scheduled by the eNB, the UE will have no way to distinguish whether the subframe is not scheduled or missing. The UE would then have to report that a PDCCH missing exists for that subframe, and this DTX bit would be
30 meaningless to the eNB. Exemplary embodiments of this invention help eliminate such mis-aligned ACKs/NAKs by identifying at least one PDCCH that is not missing. In the fourth embodiment detailed below there is to indicate all PDCCHs before one certain PDCCH have been received correctly and so the eNB can know which PDSCH or

assignment will not be received/buffered by the UE. In the first and third embodiments there is an indication signaled that there is no PDCCH missing, and a second indication which the eNB uses to verify that there is no PDCCH missing. In the second embodiment there is an indication signaled which the eNB can use to verify that there is no PDCCH missing, but different from the first and third embodiments in the second embodiment there is no second indication which is used to verify the first indication of no missing PDCCHs.

[0033] In the four exemplary embodiments below, two are particularly useful for one way of indexing the PDCCHs and two are particularly useful for another way of indexing the PDCCHs. Since the DAI numbering regimen will be understood already between the UE and the eNB in any given wireless protocol, the different embodiments useful for the different DAI numbering regimens do not entail additional signaling overhead to define which DAI numbering is used at a given moment; one particular system (such as for example LTE-A) will use one specific DAI regimen system-wide, at least as applied to the non-legacy UEs which are capable of receiving on multiple CCs.

[0034] Instead of the 3-state ACK/NAK/DTX, exemplary embodiments of the invention use separately pre-defined or high-layer signaling configured number of bits for DTX feedback. The first way of indexing the PDCCHs is to group them into what is termed a 'DAI window'. In the examples below there is one window per DL subframe and that window spans all of the CCs which are in the particular UE's configured and active set. In other implementations the DAI window may be defined differently, but regardless how the DAI window is defined will be known a priori to the eNB and the UE.

[0035] For this DAI window approach the first and second embodiments are particularly useful. In the first embodiment the UE signals two indications to the eNB: whether there is a PDCCH missing among the DAI windows the UE observed, and the number of DAI windows which the UE did observe. These two indications may in an embodiment be jointly encoded as in the below examples, or they may be encoded separately.

[0036] The eNB knows how many DAI windows it sent for that UE, and so if the signaled number sent by the UE matches the number of DAI windows sent by the eNB the eNB knows that the first indication (which indicates for example that there is no missing PDCCH) is valid. In this manner the second indication verifies the first.

[0037] The second embodiment similarly uses the DAI window concept. In this second embodiment there does not need to be a separate indication of whether or not there is a PDCCH missing; in an embodiment the UE signals the number of DAI windows in which there is no PDCCH missing. At the eNB this received number is checked against the total number of DAI windows sent to the UE, and if they match there must not be any missing PDCCHs in any of those windows. If they do not match the eNB interprets this that there must be at least one PDCCH missing since the UE did not report the same number of DAI windows without PDCCH missing as the eNB sent. If the two values differ for example by only one, the eNB knows that the missing (one or more) PDCCHs is/are confined to one window. For this second embodiment, a modulus operation may be implemented in case the number of bits configured for this signaling are not enough to directly indicate all potential values.

[0038] The other DAI regimen for which the third and fourth embodiments are particularly well suited is a pure indexing regimen in which each sequential PDCCH is given a sequential index and once the indexing limit is reached the counting begins again round-robin fashion. Depending on the number of PDCCHs scheduled, the number of CCs in the UE's configured and active set, and the limit of the DAI index, one run of the index may or may not run through all the CCs that are configured and active for a given UE.

[0039] In the third embodiment the UE signals two indications to the eNB: whether there is a PDCCH missing among the PDCCHs the UE observed, and the DAI value of the last-received PDCCH. Note that this first indication is similar to that summarized above for the first embodiment. Like that first embodiment, these two indications signaled by the UE according to this third embodiment may be jointly encoded separately encoded. The DAI value of the last-received assignment allows the

eNB to compare against the assignments it sent to the UE. If the first value tells the eNB there are no missing PDCCHs but the DAI signaled by the second indication does not match what was last sent by the eNB, the eNB knows there is a missing PDCCH somewhere. If the first value tells the eNB there is no missing PDCCHs, the second indication verifies the no-missing PDCCH reported by the first indication if the DAIs match.

[0040] The fourth embodiment similarly uses the pure DAI indexing concept. Like the second embodiment, in this fourth embodiment there does not need to be a separate indication of whether or not there is a PDCCH missing; in an embodiment the UE signals either the DAI value of the last assignment which occurred prior to any missing PDCCH, or alternatively the DAI value of the first assignment for which there is a PDCCH missing. In the former case the eNB can use the signaled DAI value to know that at least that assignment and all assignments prior to it had no missing PDCCH and align to the ACKs/NAKs for the PDSCHs for that assignment. In the latter case the eNB can use the signaled DAI value to know that assignment had a PDCCH missing, and by extension know that assignments prior to that signaled one have no missing PDCCH.

[0041] UE signaling for these four embodiments are summarized below:

For the DAI window case:

- 1st embodiment: PDCCH missing exists or not among the observed DAI window(s) and the number of observed DAI windows.
- 2nd embodiment: the number of DAI windows without PDCCH missing.

[0041] For the pure DAI indexing case:

- 3rd embodiment: PDCCH missing exists or not among the observed assignments & the DAI value of last received assignment.
- 4th embodiment: the DAI value, which means that there are no missing PDCCHs before this reported DAI index, and in the two implementations the signaled DAI value represents either a PDCCH missing or not missing.

[0042] Note that the above signaling is in addition to the ACK/NAK bits for the individual assignments; it represents explicit UL DTX feedback signaling. Note also

that the above two DAI encoding schemes are exemplary and the various embodiments are not limited only to these two schemes.

[0043] At the eNB the signaling received for these four embodiments is interpreted as summarized below:

For the DAI window case:

- 1st embodiment: eNB could check whether the number of DAI windows observed by UE is aligned to that of scheduled by eNB.
 - If they're same, eNB could know that the DTX feedback from UE is valid.
 - Otherwise, eNB could know PDCCH missing exists among the assignments.
- 2nd embodiment: eNB could check whether the number of DAI windows without PDCCH missing is aligned to the number of DAI windows scheduled by eNB.
 - If they're same, eNB could know there is no PDCCH missing exists among the assignments.
 - Otherwise, eNB could know PDCCH missing exists.

For the pure DAI indexing case:

- 3rd embodiment: eNB could check whether the last DAI value observed by UE is aligned to that of assignment scheduled by eNB.
 - If they're same, eNB could know the explicit DTX feedback from UE is valid.
 - Otherwise, eNB could know PDCCH missing exists. And if UE feedback "PDCCH missing does not exist", eNB could know exactly that, at UE side, the last-n-PDCCH missing exists, where the value of n could be got via the DAI value conveyed by UE.
- 4th embodiment: eNB could know exactly that all PDCCHs before the signaled DAI index have been received correctly by UE (and in one implementation also the signaled DAI index is received correctly)..

[0044] Below are specific exemplary examples of the first through third embodiments detailed above. An example of the fourth embodiment follows directly

from the below example for the third embodiment. In these examples it is assumed that two bits ($K=2$) are pre-configured for explicit DTX feedback.

[0045] Figure 2 illustrates a comparison of UL overhead. The integer N is the number of (frequency domain) CCs in the particular UE's configured and active set (N is greater than one in these examples for scheduling the UE across multiple CCs), and the integer M is the number of DL subframes associated with a single UL subframe in the time domain.. In comparison with the overhead compression schemes detailed herein, a traditional 3-state (ACK/NAK/DTX) feedback shown in the table at the left of Figure 2 would lead to a 33% overhead increment, on average, as compared to exemplary embodiments of the invention represented in the table at the right of Figure 2.

[0046] First embodiment example. This example assumes that the DAI encoding is of the 'total in CC domain' as noted above in which DAI windows are pre-defined between the UE and eNB. This pre-defining may be via higher layer signaling, or the DAI windows may be set forth in a wireless standard. In this example the DAI windows each span one DL subframe across all CCs, which from the UE's perspective means only the CCs in that UE's configured and active set. There are K bits available for the UE to indicate whether or not a PDCCH missing exists among the observed DAI window(s), and the number of observed DAI windows. As noted above, in this first embodiment the explicit DTX signaling from the UE carries two indications: a first indication whether or not there is a PDCCH missing, and a second indication that gives the number N of DAI windows the UE observed in determining whether or not a PDCCH missing exists. As noted above, the eNB uses the second indication to verify the first in the case where there is no missing PDCCH.

[0047] The table at Figure 3A illustrates one particular meaning to these $K=2$ signaling bits for the first embodiment. In this example the first and second indications are jointly encoded. The diagram at Figure 3B illustrates graphically the DAI windows for the case the UE has four CCs in its configured and active set. By Figure 3B the eNB has sent assignments in three different DAI windows, offset by ovals. The UE has a missing PDCCH in two of them as indicated by hatching. Using the lookup table at

Figure 3A, the UE will signal its $K=2$ DTX bits as (0,0), indicating there is at least one missing PDCCH among the DAI windows it received. The value of N at table 3A can be any value since the UE is reporting there is a PDCCH missing.

- 5 [0048] If instead the UE were reporting no PDCCHs missing from Figure 3B, the $K=2$ DTX bits from the lookup table at Figure 3A would be signaled as (1,1), indicating that there were no PDCCHs missing and the UE observed $N=3$ DAI windows. In this latter case the eNB would check the reported $N=3$ against how many DAI windows encompassed the assignments it sent to that UE and if the eNB only sent them
- 10 in three DAI windows the eNB knows the reported first indication (no missing PDCCHs) is valid and that the UE can use all of the PDSCHs scheduled by all of the PDCCHs in all of the DAI windows the eNB sent to the UE.

- [0049] Second embodiment example. Like the example at Figures 3A-B, this
- 15 example of the second embodiment assumes that the DAI encoding is of the 'total in CC domain' as noted above in which DAI windows each span one DL subframe across all CCs. There are still $K=2$ bits available for the UE to indicate its UL DTX explicitly. The meaning of these bits is shown by example at Figure 4A. In order to extend for example the possible values of N to greater than four different values as is shown at
- 20 Figure 4A, a modulus operation may be implemented so that still only $K=2$ bits can be used in the UE's UL signaling.

- [0050] The diagram at Figure 4B illustrates graphically the DAI windows for the case the UE has four CCs in its configured and active set, same as in Figure 3B.
- 25 Figure 4A gives an exemplary mapping of bit values to the value for N , which in this second embodiment N as reported by the UE means the number of DAI windows it observed for which there was no missing PDCCH. Like Figure 3B, at Figure 4B the eNB has sent assignments in three different DAI windows, and the UE has a missing PDCCH in two of them as indicated by hatching. Using the lookup table at Figure 4A,
- 30 the UE will signal its $K=2$ DTX bits as (0,1), indicating there is one DAI window in which there is no PDCCH missing.

- [0051] If instead the UE found no PDCCHs missing in any of the three DAI

windows it received at Figure 4A, its explicit DTX bits would be chosen as (1,1) to indicate it has received $N=3$ DAI windows in which there is no PDCCH missing. The eNB knows how many DAI windows were used in sending the PDCCHs to the UE, and so if the reported value for N matches this total number of DAI windows the eNB utilized the eNB verifies there are no missing PDCCHs and that the UE can use all of the PDSCHs scheduled by all of the PDCCHs in all of the DAI windows the eNB sent to the UE. If they do not match the eNB knows that a PDCCH missing exists, and further knows just how many DAI windows had no missing PDCCH (and by extension it knows how many DAI windows did have a missing PDCCH).

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[0052] Third embodiment example. This example assumes that the DAI encoding is of the 'pure counter' type as noted above in which DA indexing continues seriatim through all the available index numbers. At Figure 5B it is shown in this example that the indexing runs 0 through 3 and repeats as necessary for all of the assignments to a particular UE. There is only one missing PDCCH (shown by hatching), which carries DAI #1 and which is located in the second DL subframe and in the third CC of the UE's configured and activated set.

[0053] Recall that in the third embodiment the UE is to report the DAI value for its last-received assignment, which as shown at Figure 5B is DAI #0. To report this DTX for Figure 5B according to the third embodiment the UE refers to the example lookup table at Figure 5A, finds that where there is a missing PDCCH the DAI value does not matter (per the Figure 5A example) and the UE signals (0,0) accordingly.

25 [0054] If instead the UE has no missing PDCCHs, the UE would reply to the assignments of Figure 5B (with none missing) with the bit sequence (0,1), which by the lookup table at Figure 5A tells the eNB that there are no missing PDCCHs and the DAI value for the last-received assignment was DAI #0. If this reported DAI value matches what was the DAI value for the assignment last-sent by the eNB, then the UE's report of no PDCCHs missing is validated or verified by the eNB.

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[0055] Fourth embodiment example. Like the example for the third embodiment, this example of the fourth embodiment assumes that the DAI encoding is

of the 'pure counter' type as noted above in which DAI indexing continues serially through all the available index numbers. For this example refer to Figure 6B for the assignments signaled to the UE, and Figures 6A-B as the lookup tables for the bit meanings for the two different example implementations of this fourth embodiment.

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[0056] In a first implementation of the fourth embodiment the UE uses its explicit $K=2$ (in this example) DTX feedback bits to signal the DAI value of the assignment which did not have a PDCCH missing which occurs last before a PDCCH missing assignment. By Figure 6B the DAI value of that last assignment is DAI #0, which lies in the second DL subframe and which represents the last assignment received before the PDCCH missing which is in another CC of that same second DL subframe. The bit sequence from the middle column of Figure 6A corresponding to DAI #0 is (0,0), which the UE signals to the eNB in the first implementation of this fourth embodiment. From this the eNB knows that all the assignments which were sent prior to the one indicated by the reported DAI value have no missing PDCCHs for this UE and therefore knows the UE can use the associated PDSCHs.

[0057] For the second implementation of this fourth embodiment, the UE signals the value of the DAI for the first assignment with a PDCCH missing. This first missing PDCCH is still the same in Figure 6B, located in the second subframe, but in this second implementation it is the DAI value of the missing PDCCH that is signaled, as opposed to the assignment prior to the first occurrence of a PDCCH missing. In this implementation the DAI index of the first missing PDCCH is DAI=1, and so by the rightmost column of Figure 6A the bit sequence signaled is then (0,1). Note that this second implementation of the fourth embodiment gives the eNB the same information as does the first implementation immediately above, that there are no PDCCHs missing in any of the assignments prior to DAI=1.

[0058] The exemplary embodiments of the invention provide the technical effects of being both simple from a signaling perspective and effective to identify DTX states using reduced signaling overhead as compared to a conventional 3-state ACK/NAK/DTX signaling regimen, and without imposing UE-scheduling constraints on the eNB. From the inventor's review it appears that any loss in DL throughput as

compared to the 3-state signaling approach is more than offset by the savings in UL overhead.

5 **[0059]** Figures 7A-B are non-limiting and exemplary process flow diagrams from the perspective of the UE and eNB respectively according to exemplary embodiments of the invention. As seen at Figure 7A from the UE's perspective the UE (or one or more components thereof) at block 701 receives across multiple component carriers multiple resource allocations (e.g., PDCCHs or more generally assignments) that each schedule resources (e.g., the PDSCHs) for a user equipment. At block 702 the UE signals (e.g., using the K bits for explicit DTX feedback, K=2 in the above examples) whether all of the scheduled resources can be used by either block 702A or 702B. At block 702A according to the fourth embodiment the signaling identifies at least one of the resource allocations for which the scheduled resources can be used. At 10 block 702B according to the first through third embodiments the signaling is for verifying that all of the scheduled resources can be used.

[0060] As seen at Figure 7B from the eNB's perspective the eNB (or one or more components thereof) at block 711 sends across multiple component carriers multiple resource allocations that each schedule resources for a user equipment. At 20 block 712 the eNB receives a reply to block 711 from the user equipment and blocks 712A and 712B give the form of that reply. At block 712A the received reply identifies at least one of the resource allocations for which the scheduled resources can be used and at block 713B the eNB then determines from the block 711/712A reply that at least 25 some of the scheduled resources can be used by the user equipment. Blocks 712A and 713A correspond to the fourth embodiment. According to the first through third embodiments at block 712B the received reply verifies that all of the scheduled resources can be used, and then the eNB at block 713B uses the reply to verify that at all of the scheduled resources can be used by the user equipment (e.g., comparing what is 30 indicated by the reply to what the eNB sent at block 711 and thereby verify that there are no missing PDCCHs).

[0061] Reference is made to Figure 8 for illustrating a simplified block diagram of other electronic devices that are suitable for use in practicing the exemplary

embodiments of this invention. In Figure 8, a wireless network is adapted for communication with a user equipment (UE) 14 via an access node 16, referred to in the above examples as an eNB. The UE 14 includes a data processor (DP) 18, a memory (MEM) 20 coupled to the DP 18, and a suitable RF transmitter TX and receiver RX 22 (which need not be implemented in a same component) coupled to the DP 18. The MEM 20 stores a program (PROG) 24. The TX/RX 22 is for bidirectional wireless communications with the eNB 16. Note that the TX/RX 22 has at least one antenna to facilitate communication; multiple antennas may be employed for multiple-input multiple-output MIMO communications in which case the device may have multiple TXs and/or RXs.

[0062] The eNB 16 includes a data processor (DP) 26, a memory (MEM) 28 coupled to the DP 26, and a suitable RF transmitter TX and receiver RX 30 coupled to the DP 26. The MEM 28 stores a program (PROG) 32. The TX/RX 30 is for bidirectional wireless communications with the UE 14. Note that the TX/RX 30 has at least one antenna to facilitate communication, though in practice an eNB will typically have several. The eNB 16 is coupled via a data path 34 to one or more external networks or systems, such as the internet 36, for example.

[0063] At least one of the PROGs 24, 32 is assumed to include program instructions that, when executed by the associated DP, enable the electronic device to operate in accordance with the exemplary embodiments of this invention, as discussed herein.

[0064] In general, the various embodiments of the UE 14 can include, but are not limited to, cellular phones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

The embodiments of this invention may be implemented by computer software executable by one or more of the DPs 18, 26 of the UE 14 and the eNB 16, or by hardware, or by a combination of software and hardware.

5 [0065] The MEMs 20, 28 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. While only one MEM per device 14, 16 is shown there may be
10 several physically distinct memory units in the device 14, 16. The DPs 18, 26 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multi-core processor architecture, as non-limiting examples. Either or both of the UE 14 and the eNB 16 may have multiple
15 processors, such as for example an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[0066] The terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and
20 may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and printed electrical connections, as well as by the use
25 of electromagnetic energy, such as electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as non-limiting examples.

[0067] The exemplary embodiments of the invention, as discussed above and as
30 particularly described with respect to exemplary methods, may be implemented as a computer program product comprising program instructions embodied on a tangible computer-readable medium. Execution of the program instructions results in operations comprising steps of utilizing the exemplary embodiments or steps of the

method.

[0068] In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, 5 some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto.

While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood 10 that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

15 [0069] Embodiments of the inventions may be practiced in various components such as integrated circuit modules. Embodiments of the invention may be implemented in such a fabricated semiconductor chip, and shown in the design drawings of that chip.

[0070] The foregoing description has provided by way of exemplary and 20 non-limiting examples a full and informative description of the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims, without departing from these teachings. Furthermore, some of the features of certain embodiments detailed above 25 could be used to advantage without the corresponding use of other features. As such, the foregoing description is illustrative but not limiting of the principles of the invention.

CLAIMS

What is claimed is:

- 5 1. A method comprising:
receiving across multiple component carriers multiple resource allocations that
each schedule resources for a user equipment; and
signaling whether all of the scheduled resources can be used by:
identifying at least one of the resource allocations for which the
10 scheduled resources can be used, or
verifying that all of the scheduled resources can be used.
2. The method according to claim 1, in which the resource allocations are physical
downlink control channels (PDCCHs) and the scheduled resources are physical
15 downlink shared channels (PDSCHs).
3. The method according to claim 1, in which the signaling uses a pre-determined
number K of bits for signaling explicit discontinuous transmission, in which K is an
integer greater than one.
20
4. The method according to any one of claims 1 through 3, in which signaling
whether all of the scheduled resources can be used comprises a first indication and a
second indication,
in which the first indication is that all of the scheduled resources can be used by
25 the user equipment and the second indication is used to verify the first indication.
5. The method according to claim 4, in which the multiple resource allocations are
received within a plurality of downlink assignment index windows, and the second
indication indicates a number of the downlink assignment index windows which were
30 received by the user equipment.
6. The method according to claim 4, in which the multiple resource allocations are
each associated with a downlink assignment index number, and the second indication

indicates the downlink assignment index number of the resource allocation that was last-received by the user equipment.

7. The method according to any one of claims 1 through 3, in which the multiple
5 resource allocations are received within a plurality of downlink assignment index windows, and the signaling that verifies that all of the scheduled resources can be used is an indication of a number of downlink assignment windows which were received by the user equipment for which the user equipment could use the respective scheduled resources.

10

8. The method according to any one of claims 1 through 3, in which the multiple resource allocations are each associated with a downlink assignment index number, and the signaling identifies at least one of the resource allocations for which the scheduled resources can be used by indicating a downlink assignment index value of either:

15 the first-received resource assignment for which the user equipment can use the associated scheduled resources which was received immediately prior to another of the resource assignments for which the user equipment cannot use the associated scheduled resources; or

the first-received resource assignment for which the user equipment cannot use
20 the associated scheduled resources.

9. An apparatus comprising:
at least one processor; and
at least one memory storing computer program instructions;
25 in which the at least one memory storing computer program instructions is configured with the at least one processor to cause the apparatus to perform actions comprising:
in response to receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment, signaling whether all of the scheduled resources can be used by:

30 identifying at least one of the resource allocations for which the scheduled resources can be used, or
verifying that all of the scheduled resources can be used.

10. The apparatus according to claim 9, in which the resource allocations are physical downlink control channels (PDCCHs) and the scheduled resources are physical downlink shared channels (PDSCHs).

5 11. The apparatus according to claim 9, in which the signaling uses a pre-determined number K of bits for signaling explicit discontinuous transmission, in which K is an integer greater than one.

12. The apparatus according to any one of claims 9 through 11, in which signaling
10 whether all of the scheduled resources can be used comprises a first indication and a second indication,

in which the first indication is that all of the scheduled resources can be used by the user equipment and the second indication is used to verify the first indication.

15 13. The method according to claim 12, in which the multiple resource allocations are received within a plurality of downlink assignment index windows, and the second indication indicates a number of the downlink assignment index windows which were received by the user equipment.

20 14. The apparatus according to claim 12, in which the multiple resource allocations are each associated with a downlink assignment index number, and the second indication indicates the downlink assignment index number of the resource allocation that was last-received by the user equipment.

25 15. The apparatus according to any one of claims 9 through 11, in which the multiple resource allocations are received within a plurality of downlink assignment index windows, and the signaling that verifies that all of the scheduled resources can be used is an indication of a number of downlink assignment windows which were received by the user equipment for which the user equipment could use the respective
30 scheduled resources.

16. The apparatus according to any one of claims 9 through 11, in which the multiple resource allocations are each associated with a downlink assignment index

number, and the signaling identifies at least one of the resource allocations for which the scheduled resources can be used by indicating a downlink assignment index value of either:

the first-received resource assignment for which the user equipment can use the associated scheduled resources which was received immediately prior to another of the resource assignments for which the user equipment cannot use the associated scheduled resources; or

the first-received resource assignment for which the user equipment cannot use the associated scheduled resources.

10

17. The apparatus according to any one of claims 9 through 11, in which the apparatus comprises the user equipment.

18. A memory storing a program of computer readable instructions which when executed by at least one processor result in actions comprising:

15

in response to receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment, signaling whether all of the scheduled resources can be used by:

identifying at least one of the resource allocations for which the scheduled resources can be used, or

20

verifying that all of the scheduled resources can be used.

19. The memory according to claim 18, in which the resource allocations are physical downlink control channels (PDCCHs) and the scheduled resources are physical downlink shared channels (PDSCHs).

25

20. An apparatus comprising:

means for receiving across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and

means for signaling whether all of the scheduled resources can be used by:

30

identifying at least one of the resource allocations for which the scheduled resources can be used, or

verifying that all of the scheduled resources can be used.

21. A method comprising:
sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment;
- 5 receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used; and
determining from the reply that at least some of the scheduled resources can be used by the user equipment, or using the reply to verify that at all of the scheduled
10 resources can be used by the user equipment.
22. The method according to claim 21, in which the resource allocations are physical downlink control channels (PDCCHs) and the scheduled resources are physical downlink shared channels (PDSCHs).
- 15 23. The method according to claim 21, in which the reply comprises a pre-determined number K of bits for signaling explicit discontinuous transmission, in which K is an integer greater than one.
- 20 24. The method according to any one of claims 21 through 23, in which the reply comprises a first indication and a second indication,
and in which using the reply to verify that at all of the scheduled resources can be used by the user equipment comprises using the first indication to determine that all of the scheduled resources can be used by the user equipment and using the second
25 indication to verify the first indication.
25. The method according to claim 24, in which the multiple resource allocations are sent within a plurality of downlink assignment index windows,
the second indication indicates a number of the downlink assignment index
30 windows which were received by the user equipment, and
using the second indication to verify the first indication comprises comparing the indicated number to a number of downlink assignment windows in which the multiple resource allocations were sent.

26. The method according to claim 24, in which the multiple resource allocations are each associated with a downlink assignment index number,

the second indication indicates the downlink assignment index number of the
5 resource allocation that was last-received by the user equipment, and

using the second indication to verify the first indication comprises comparing the indicated downlink assignment index number to an index number of the resource allocation that was last sent to the user equipment.

10 27. The method according to any one of claims 21 through 23, in which the multiple resource allocations are received within a plurality of downlink assignment index windows,

the reply comprises a number of downlink assignment index windows which were received by the user equipment; and

15 using the reply to verify that at all of the scheduled resources can be used by the user equipment comprises comparing the number of downlink assignment indexes from the reply to a number of downlink assignment indexes in which the multiple resource allocations were sent.

20 28. The method according to any one of claims 21 through 23, in which the multiple resource allocations are each associated with a downlink assignment index number,

the reply identifies at least one of the resource allocations for which the scheduled resources can be used and comprises a downlink assignment index value of either:

25 the first-received resource assignment for which the user equipment can use the associated scheduled resources which the user equipment received immediately prior to another of the resource assignments for which the user equipment cannot use the associated scheduled resources, or the resource assignment first-received by the user equipment for which the user equipment cannot use the associated scheduled resources;
30 and

determining from the reply that at least some of the scheduled resources can be used by the user equipment comprises comparing the downlink assignment index value of the reply to a downlink assignment index number for a corresponding one of the

resource allocations sent to the user equipment.

29. An apparatus comprising:

at least one processor; and

5 at least one memory storing computer program instructions;

in which the at least one memory storing computer program instructions is configured with the at least one processor to cause the apparatus to perform actions comprising:

sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and

10 in response to receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used:

determining from the reply that at least some of the scheduled resources can be used by the user equipment, or

15 using the reply to verify that at all of the scheduled resources can be used by the user equipment.

30. The apparatus according to claim 29, in which the resource allocations are physical downlink control channels (PDCCHs) and the scheduled resources are
20 physical downlink shared channels (PDSCHs).

31. The apparatus according to claim 29, in which the reply comprises a pre-determined number K of bits for signaling explicit discontinuous transmission, in which K is an integer greater than one.
25

32. The apparatus according to any one of claims 29 through 31, in which the reply comprises a first indication and a second indication,

and in which using the reply to verify that at all of the scheduled resources can be used by the user equipment comprises using the first indication to determine that all
30 of the scheduled resources can be used by the user equipment and using the second indication to verify the first indication.

33. The apparatus according to claim 32, in which the multiple resource allocations

are sent within a plurality of downlink assignment index windows,

the second indication indicates a number of the downlink assignment index windows which were received by the user equipment, and

using the second indication to verify the first indication comprises comparing
5 the indicated number to a number of downlink assignment windows in which the multiple resource allocations were sent.

34. The apparatus according to claim 32, in which the multiple resource allocations are each associated with a downlink assignment index number,

10 the second indication indicates the downlink assignment index number of the resource allocation that was last-received by the user equipment, and

using the second indication to verify the first indication comprises comparing the indicated downlink assignment index number to an index number of the resource allocation that was last sent to the user equipment.

15

35. The apparatus according to any one of claims 29 through 31, in which the multiple resource allocations are received within a plurality of downlink assignment index windows,

the reply comprises a number of downlink assignment index windows which
20 were received by the user equipment; and

using the reply to verify that at all of the scheduled resources can be used by the user equipment comprises comparing the number of downlink assignment indexes from the reply to a number of downlink assignment indexes in which the multiple resource allocations were sent.

25

36. The apparatus according to any one of claims 29 through 31, in which the multiple resource allocations are each associated with a downlink assignment index number,

the reply identifies at least one of the resource allocations for which the
30 scheduled resources can be used and comprises a downlink assignment index value of either:

the first-received resource assignment for which the user equipment can use the associated scheduled resources which the user equipment received immediately

prior to another of the resource assignments for which the user equipment cannot use the associated scheduled resources, or the resource assignment first-received by the user equipment for which the user equipment cannot use the associated scheduled resources; and

- 5 determining from the reply that at least some of the scheduled resources can be used by the user equipment comprises comparing the downlink assignment index value of the reply to a downlink assignment index number for a corresponding one of the resource allocations sent to the user equipment.

- 10 37. The apparatus according to any one of claims 29 through 31, in which the apparatus comprises an eNB.

38. A memory storing a program of computer readable instructions which when executed by at least one processor result in actions comprising:

- 15 sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment;

 in response to receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or that verifies that all of the scheduled resources can be used:

- 20 determining from the reply that at least some of the scheduled resources can be used by the user equipment, or

 using the reply to verify that at all of the scheduled resources can be used by the user equipment.

- 25 39. The memory according to claim 38, in which the resource allocations are physical downlink control channels (PDCCHs) and the scheduled resources are physical downlink shared channels (PDSCHs).

40. An apparatus comprising:

- 30 means for sending across multiple component carriers multiple resource allocations that each schedule resources for a user equipment; and

 means, response to receiving a reply from the user equipment that identifies at least one of the resource allocations for which the scheduled resources can be used or

that verifies that all of the scheduled resources can be used:

for determining from the reply that at least some of the scheduled resources can be used by the user equipment, or

for using the reply to verify that at all of the scheduled resources can be
5 used by the user equipment.

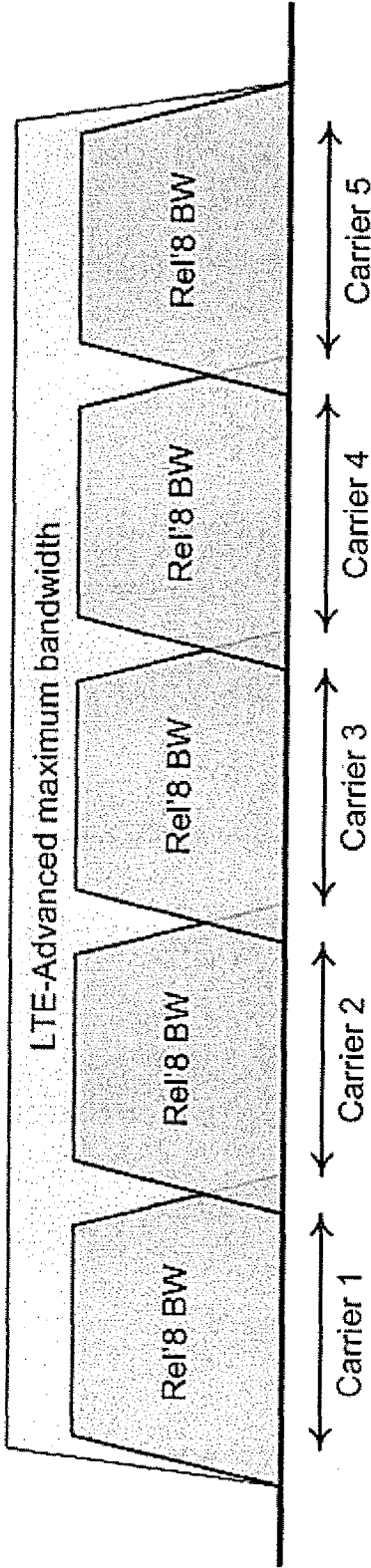


Figure 1

w/ spatial bundling, Full explicit DTX FB				
Overhead	M=1	M=2	M=3	M=4
N=2	3	7	10	13
N=3	5	10	15	20
N=4	7	13	20	26
N=5	8	16	24	32

w/ spatial bundling, compressed DTX FB, K=2				
Overhead	M=1	M=2	M=3	M=4
N=2	4	6	8	10
N=3	5	8	11	14
N=4	6	10	14	18
N=5	7	12	17	22

Figure 2

Figure 3A

States of 2-bit	DTX feedback & Observed DAI windows (N)
(0,0)	With PDCCH missing, any N value.
(0,1)	Without PDCCH missing, N=1 or 4
(1,0)	Without PDCCH missing, N=2
(1,1)	Without PDCCH missing, N=3

Figure 3B

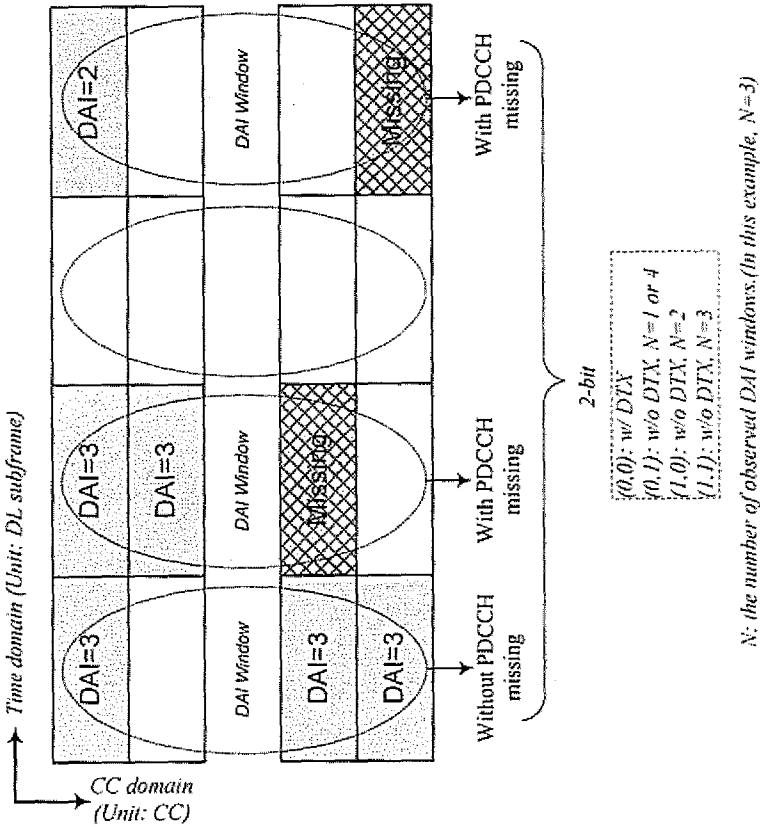


Figure 4A

States of 2-bit	Number (N) of observed DAI windows without PDCCH missing
(0,0)	0
(0,1)	1
(1,0)	2
(1,1)	3

Figure 4B

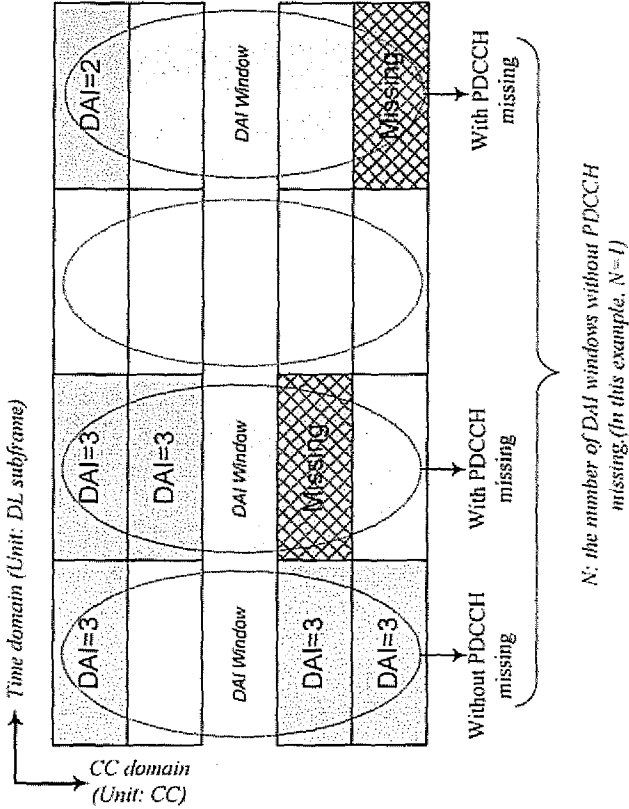


Figure 5A

States of 2-bit	DTX feedback & the DAI value of last received assignment
(0,0)	With PDCCH missing, any DAI value.
(0,1)	Without PDCCH missing, DAI=0 or 3
(1,0)	Without PDCCH missing, DAI=1
(1,1)	Without PDCCH missing, DAI=2

Figure 5B

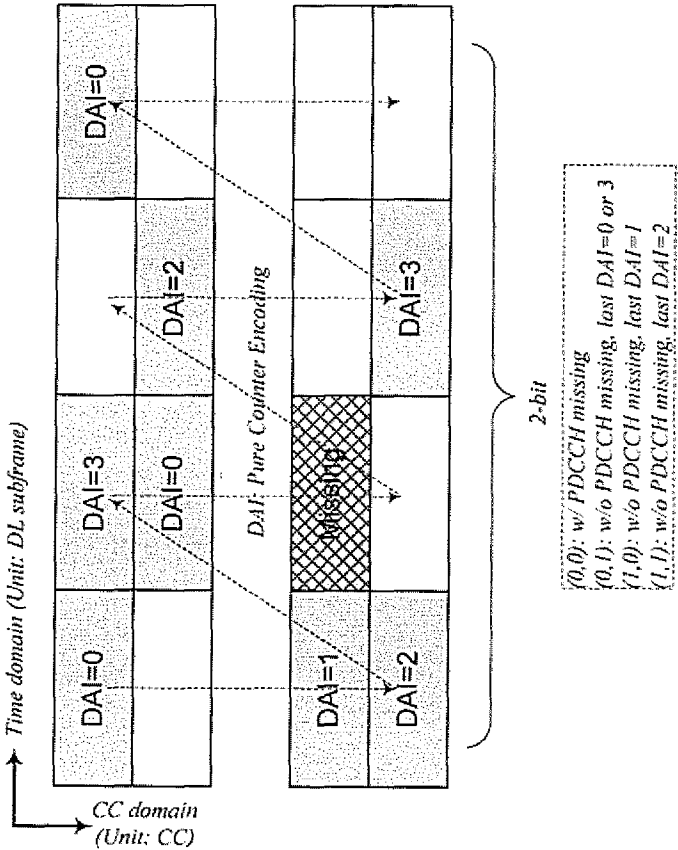
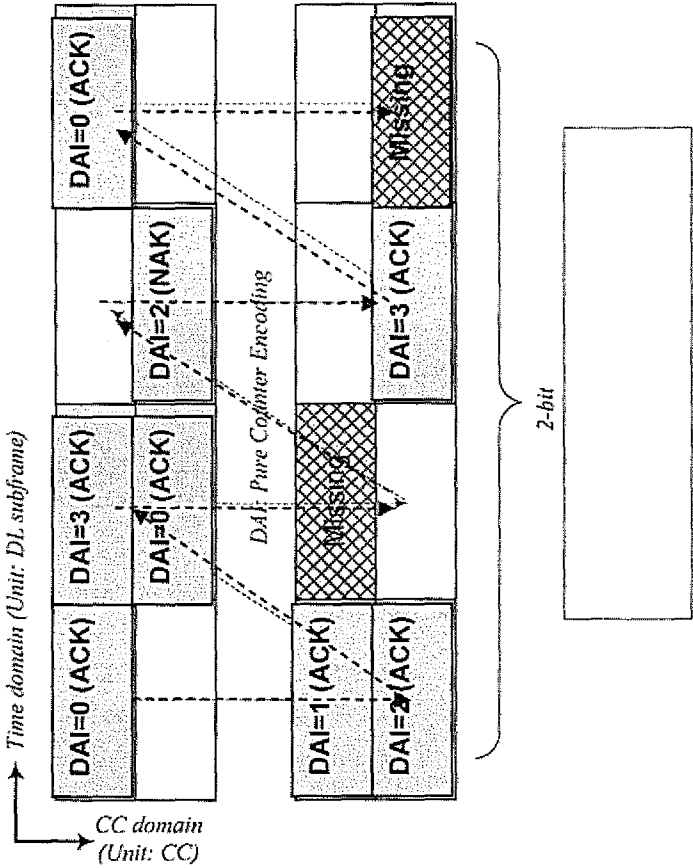


Figure 6A

States of 2-bit	DAI value of last assignment without PDCCH missing	DAI value of first assignment with PDCCH missing
(0,0)	0	0
(0,1)	1	1
(1,0)	2	2
(1,1)	3	3

Figure 6B



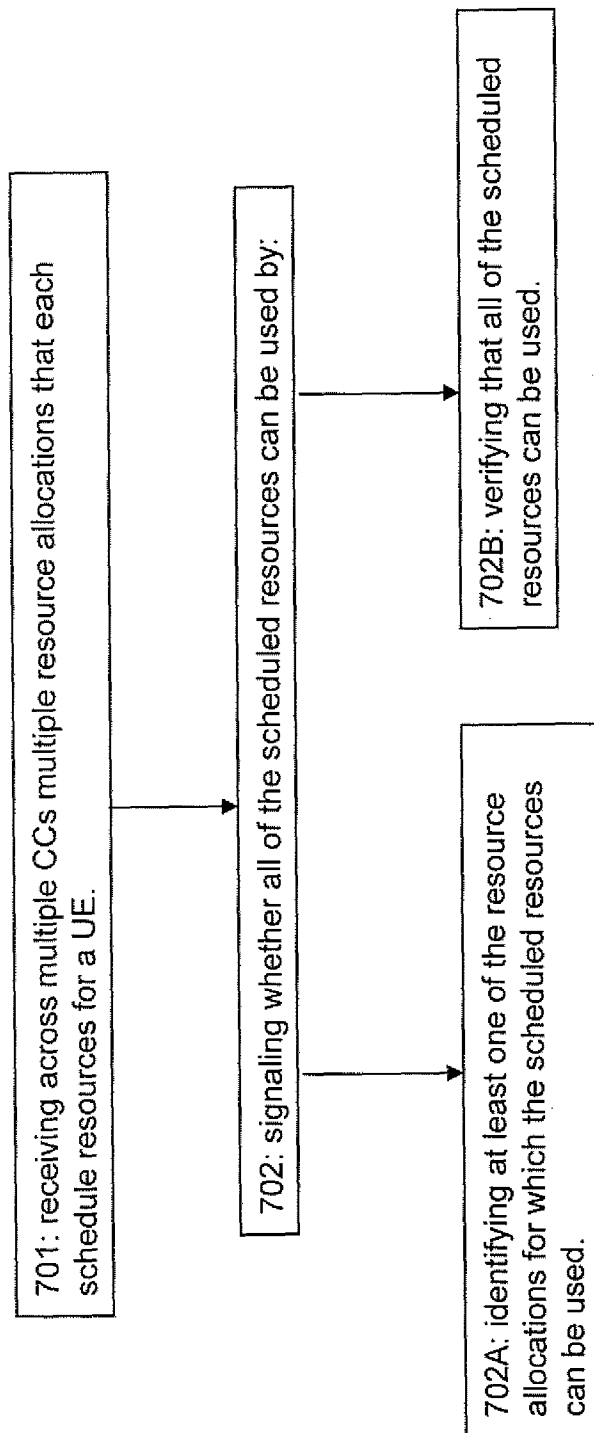


Figure 7A

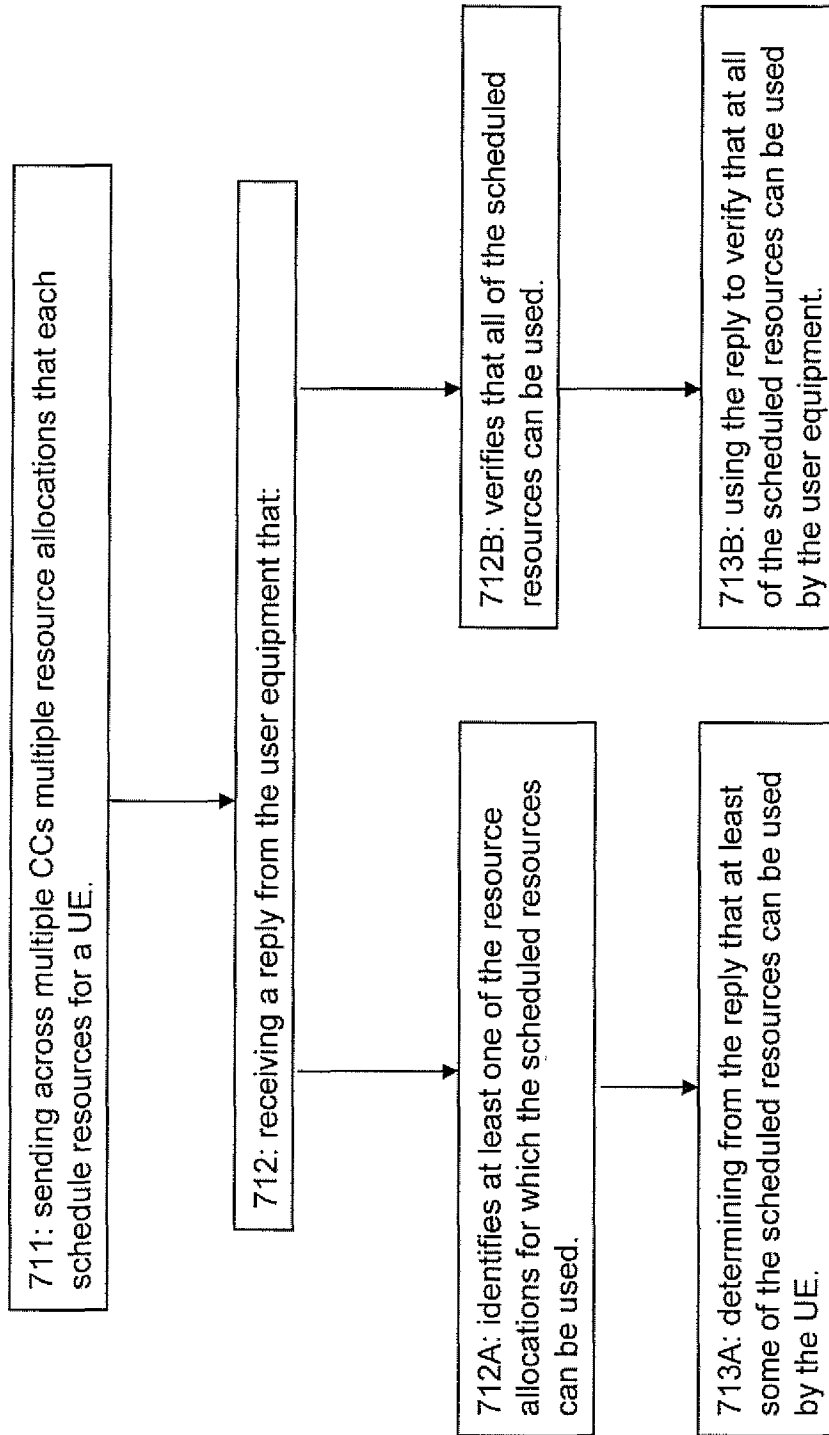


Figure 7B

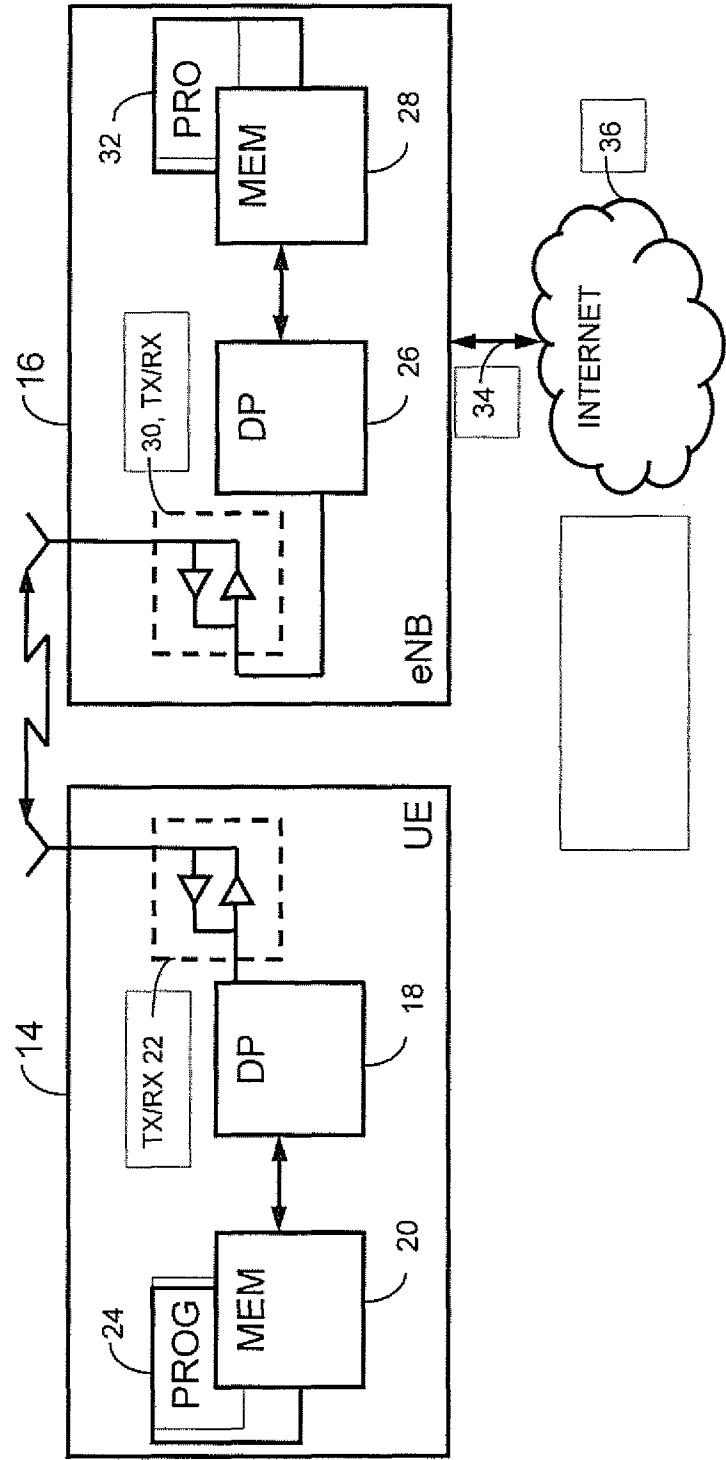


FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2010/075956

A. CLASSIFICATION OF SUBJECT MATTER

H04W52/02 (2009.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W; H04L12/-; H04L29/-; H04Q 7/-

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)

CNPAT, CNKI, WPI, EPODOC, IEEE: wireless, communication?, network, LTE, LTE-A, CCs, CA, across, carrier?, aggregation, component, multiple, control, channel, PDCCH, PDSCH, associat+, resource?, allocate+, schedule, identify+, verify+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO2010078365 A1 (INTERDIGITAL PATENT HOLDINGS INC. et al.) 08 Jul. 2010 (08.07.2010) see paragraphs 0025-0089, figures 2-6, abstract	1-40
A	EP2197235 A2 (ELECTRONICS AND TELECOMMUNICATIONS RES. INST.) 16 Jun. 2010 (16.06.2010) see the whole document	1-40
A	WO2010088950 A1 (NOKIA SIEMENS NETWORKS OY. et al.) 12 Aug. 2010 (12.08.2010) see the whole document	1-40

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

* Special categories of cited documents:	“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
“A” document defining the general state of the art which is not considered to be of particular relevance	“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“E” earlier application or patent but published on or after the international filing date	“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
“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)	“&” document member of the same patent family
“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	

Date of the actual completion of the international search 28 Apr. 2011 (28.04.2011)	Date of mailing of the international search report 19 May 2011 (19.05.2011)
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 ZHAO, Jingjing Telephone No. (86-10)62413526

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2010/075956

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO2010078365 A1	08.07.2010	US2011002281 A1	06.01.2011
EP2197235 A2	16.06.2010	US2010150082 A1	17.06.2010
		KR20100067342 A	21.06.2010
WO2010088950 A1	12.08.2010	None	