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(54) Title: PUCCH RESOURCE ALLOCATION AND FALLBACK OPERATION

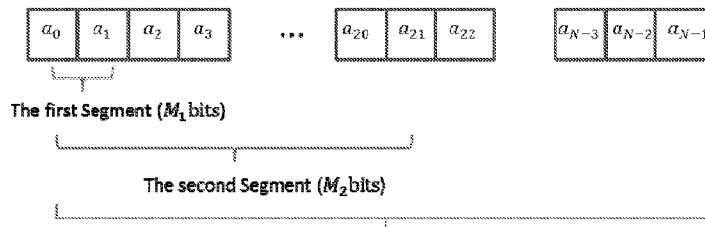


Fig.1

(57) Abstract: A method of resource allocation for new PUCCH format is provided. According to the method, the resources are allocated based on different PUCCH format, wherein a new PUCCH format is to use legacy PUCCH format 3 or modified PUCCH format 3 on multiple PRBs.



PUCCH RESOURCE ALLOCATION AND FALLBACK OPERATION

The present invention relates to LTE, Carrier aggregation, PUCCH format 3.

BACKGROUND

5 Carrier aggregation

The use of LTE carrier aggregation (CA), introduced in Rel-10 and enhanced in Rel-11, offers means to increase the peak data rates, system capacity and user experience by aggregating radio resources from multiple carriers that may reside in the same band or different bands and, for the case of inter-band TDD CA, may be
10 configured with different UL/DL configurations. In Rel-12, carrier aggregation between TDD and FDD serving cells is introduced to support UE connecting to them simultaneously.

In Rel-13, LAA (Licensed-Assisted Access) has attracted a lot of interest in extending the LTE carrier aggregation feature towards capturing the spectrum
15 opportunities of unlicensed spectrum in the 5GHz band. WLAN operating in the 5GHz band nowadays already supports 80MHz in the field and 160MHz is to follow in Wave 2 deployment of IEEE 802.11ac. There are also other frequency bands, such as 3.5 GHz, where aggregation of more than one carrier on the same band is possible, in addition to the bands already widely in use for LTE. Enabling the utilization of at
20 least similar bandwidths for LTE in combination with LAA as IEEE 802.11ac Wave 2 will support calls for extending the carrier aggregation framework to support more than 5 carriers. The extension of the CA framework beyond 5 carriers was approved to be one work item for LTE Rel-13. The objective is to support up to 32 carriers in both UL and DL.

25 Compared to single-carrier operation, a UE operating with CA has to report feedback for more than one DL component carriers. Meanwhile, a UE does not need to support DL and UL CA simultaneously. For instance, the first release of CA capable UEs in the market only supports DL CA but not UL CA. This is also the underlying assumption in the 3GPP RAN4 standardization. Therefore, an enhanced
30 UL control channel, i.e. PUCCH format 3 was introduced for CA during Rel-10

timeframe. However, in order to support more component carriers in Rel-13, the UL control channel capacity becomes a limitation.

PUCCH format 3

In LTE Rel-8, PUCCH format 1/1a/1b and PUCCH format 2/2a/2b are supported for SR, HARQ-ACK and periodic CSI reporting. The PUCCH resource is represented by a single scalar index, from which the phase rotation and the orthogonal cover sequence (only for PUCCH format 1/1a/1b) are derived. The use of a phase rotation of a cell-specific sequence together with orthogonal sequences provides orthogonality between different terminals in the same cell transmitting PUCCH on the same set of resource blocks. In LTE Rel-10, PUCCH format 3 was introduced for carrier aggregation and TDD, when there are multiple downlink transmissions, (either on multiple carriers or multiple downlink subframes) but single uplink (either single carrier or single uplink subframe) for HARQ-ACK, SR and CSI feedback.

Similarly, the PUCCH format 3 resource is also represented by a single scalar index from which the orthogonal sequence and the resource-block number can be derived. A length-5 orthogonal sequence is applied for PUCCH format 3 to support code multiplexing within one resource-block pair [2] and a length-4 orthogonal sequence is applied for shorted PUCCH. Denote the PUCCH format 3 resource as $n_{\text{PUCCH}}^{(3)}$, the resource block number of the PUCCH format 3 resource m is determined by the following

$$m = \lfloor n_{\text{PUCCH}}^{(3)} / N_{\text{SF},0}^{\text{PUCCH}} \rfloor$$

The orthogonal sequence applied for the two slots are derived by the following

$$n_{\text{oc},0} = n_{\text{PUCCH}}^{(3)} \bmod N_{\text{SF},1}^{\text{PUCCH}}$$

$$n_{\text{oc},1} = \begin{cases} (3n_{\text{oc},0}) \bmod N_{\text{SF},1}^{\text{PUCCH}} & \text{if } N_{\text{SF},1}^{\text{PUCCH}} = 5 \\ n_{\text{oc},0} \bmod N_{\text{SF},1}^{\text{PUCCH}} & \text{otherwise} \end{cases}$$

Where $N_{SF,0}^{PUCCH}$ and $N_{SF,1}^{PUCCH}$ are the length of the orthogonal sequence for the two slots respectively, $N_{SF,0}^{PUCCH} = N_{SF,1}^{PUCCH} = 5$ holds for both slots in a subframe using normal PUCCH format 3 while $N_{SF,0}^{PUCCH} = 5, N_{SF,1}^{PUCCH} = 4$ holds for the first slot and second slot in a subframe using shortened PUCCH format 3.

5 The PUCCH format 3 resource is determined according to higher layer configuration and a dynamic indication from the downlink assignment. In detail, the TPC field in the DCI format of the corresponding PDCCH/EPDCCH is used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 1 [1]. For FDD, the
 10 TPC field corresponds to the PDCCH/EPDCCH for the scheduled secondary serving cells. For TDD, the TPC field corresponds to the PDCCH/EPDCCH for the primary cell with DAI value in the PDCCH/EPDCCH larger than '1'. A UE shall assume that the same PUCCH resource values are transmitted in each DCI format of the corresponding PDCCH/EPDCCH assignments.

15 Table 1: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

Value of 'TPC command for PUCCH' or 'HARQ-ACK resource offset'	$n_{PUCCH}^{(3,7)}$
'00'	The 1st PUCCH resource value configured by the higher layers
'01'	The 2 nd PUCCH resource value configured by the higher layers
'10'	The 3 rd PUCCH resource value configured by the higher layers
'11'	The 4 th PUCCH resource value configured by the higher layers

New PUCCH format to support up to 32 DL CCs

In 3GPP up to Rel-12, the maximum downlink component carriers are 5. PUCCH format 1b with channel selection and PUCCH format 3 are introduced for
 20 HARQ feedback and corresponding fallback operations are defined. The fallback operation is beneficial not only from HARQ-ACK performance perspective but also useful for UE during the transition period. However, in Rel-13, maximum 32

downlink carriers can be configured for one UE and hence a new PUCCH format will be introduced to carry more HARQ-ACK bits due to the aggregation of 32 DL CCs.

5 Currently, there are three design options to support larger payload size on PUCCH:

- Opt 1: PUCCH format 3 with multiple PRBs
- Opt 2: PUCCH format 3 with multiple OCCs
- Opt 3: PUCCH format 3 with both multiple PRBs and OCCs
- Opt 4: PUSCH-like structure

10 **PUCCH format fallback**

PUCCH format 1b with channel selection and PUCCH format 3 are introduced in 3GPP Rel-10 to support HARQ-ACK feedback with carrier aggregation. PUCCH fallback operation is also introduced for both PUCCH format 1b with channel selection and PUCCH format 3 in a specific condition.

15 PUCCH format 1b with channel selection involves configuring up to four PUCCH format 1b resources ('channels'); the selection of one of these resources indicates some of the ACK/NACK information to be conveyed. There are mapping tables specified for the cases of two, three or four ACK/NACK bits to define the mapping of ACK/NACK combinations to the configured PUCCH resources. These
20 tables are designed to support fallback to Release 8 operation. More specifically, in the case of a single scheduled carrier i.e. PCell, 1 or 2 ACK/NACK bits will be transmitted by PUCCH format 1a/1b as in Rel-8.

Similarly for PUCCH format 3, if no (E)PDCCH corresponding to PDSCH on SCells is received and PDSCH is received on PCell, 1 or 2 ACK/NACK bits will be
25 transmitted by PUCCH format 1a/1b as in Rel-8. For TDD, when PDSCH is only received from the PCell in one DL subframe where the DAI value is set to '1', PUCCH format 1a/1b is used for HARQ-ACK transmission.

In 3GPP Rel-13, maximum 32 downlink carriers can be configured for one

UE and hence a new PUCCH format will be introduced. Several design options are of great interest as described in section "**New PUCCH format to support up to 32 DL CCs**". But it is not clear how to do PUCCH resource allocation and fallback operation for the new PUCCH format if the options mentioned above are adopted.

5

SUMMARY OF THE INVENTION

According to one aspect of the present invention, methods of resource allocation and fallback operation for the new PUCCH format in Rel-13 are proposed.

The resource allocation and fallback solutions in the present invention enable the compatibility with existing PUCCH format. It is beneficial not only from HARQ-ACK performance perspective but also useful for UEs during the transition period.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates an example for the principle according to the present invention;

Figure 2 illustrates one example for multiple segments according to the present invention; and

Figure 3 illustrates one example for the feedbacks which are not covered by one segment, but multiple segments.

DETAILED DESCRIPTION

For better illustration, the new PUCCH format is named as PUCCH format 4 in the present invention.

1. Resource allocation

The proposed solutions on resource allocations are described based on different PUCCH format design options.

1.1 Resource allocation for PUCCH format design option 1

Option 1 for PUCCH format 4 is to use legacy PUCCH format 3 or modified PUCCH format 3 (e.g., PUCCH format 3 with tail-biting convolutional code (TBCC)) on multiple PRBs to carry more HARQ-ACK bits than today's PUCCH format 3 capacity.

Alternative 1: Legacy PUCCH format 3 is used.

The number of PRBs needed for PUCCH format 4 is denoted as N_{PUCCH4} and calculated by

$$N_{PUCCH4} = \left\lceil \frac{Q_{ACK}}{q} \right\rceil$$

where Q_{ACK} is the number of HARQ-ACK bits in total and q is the maximum number

5 of HARQ-ACK bits that can be carried by one PRB using PUCCH format 3, i.e., q is

equal to 22. Q_{ACK} can be determined based on the number of scheduled carriers, the number of activated carriers or the number of configured carriers. Moreover, the number of transport blocks on each carrier and whether HARQ-ACK bundling is applied also need to be taken into account.

10 Similarly as PUCCH format 3, the PUCCH resource for PUCCH format 4 is determined according to higher layer configuration and a dynamic indication from the downlink assignment. Denote the PUCCH format 4 resource as $n_{PUCCH}^{(4)}$, the resource block numbers of the PUCCH format 4 resource m is determined by the following

$$m = \left\lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \right\rfloor, \left\lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \right\rfloor + 1, \dots, \left\lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \right\rfloor + N_{PUCCH4} - 1$$

15 where, as mentioned previously, $N_{SF,0}^{PUCCH}$ denotes the length of the orthogonal sequence in the first slot.

Another example is that the resource allocation of the new PUCCH format is defined directly based on the first configured PUCCH format 4 resource and the length of the orthogonal sequence for the first slots. The UE would determine when

20 transmitting how many resource it should allocate depending on the number of PUCCH

format 4 resources required denoted by N_{PUCCH4} . Each resource is defined as follows

$$m = \left\lfloor n_{PUCCH(z)}^{(4)} / N_{SF,0}^{PUCCH} \right\rfloor \quad z = 0, 1, \dots, N_{PUCCH4} - 1$$

The orthogonal sequence applied for the two slots is similar to the approach for PUCCH format 3. In one example, the same OCC applies for multiple PRBs. In another example, different OCCs apply for different PRBs following a predefined rule. A principle is that the OCC used for resource block number with lowest index should follow exactly same approach for PUCCH format 3. This is to enable fallback operation.

In another example, the UE is configured by the eNB with a set of PUCCH format 4 resources. Each resource is then individually determined, which could for example be as follows:

$$m = \left\lfloor n_{\text{PUCCH}(0)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \right\rfloor, \left\lfloor n_{\text{PUCCH}(1)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \right\rfloor, \dots, \left\lfloor n_{\text{PUCCH}(N_{\text{PUCCH}4}-1)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \right\rfloor$$

The UE would only use up to $N_{\text{PUCCH}4}$ number of resources, although it is possible to configure the UE with the maximum number of resources.

Alternative 2: Modified PUCCH format 3 is used.

In one embodiment, the number of PRBs needed for PUCCH format 4 is denoted

as $N_{\text{PUCCH}4}$ and calculated by

$$N_{\text{PUCCH}4} = \left\lceil \frac{Q_{\text{ACK}} - 22}{q} \right\rceil + 1$$

where Q_{ACK} is the number of HARQ-ACK bits in total and q is the maximum number of HARQ-ACK bits that can be carried by one PRB using modified PUCCH format 3 (e.g., PUCCH format 3 with TBCC). In the formula above, 22 reflects the maximum number of HARQ-ACK bits already supported by legacy PUCCH format 3.

In another embodiment, the number of PRBs needed for PUCCH format 4 is denoted as $N_{\text{PUCCH}4}$ and calculated by

$$N_{\text{PUCCH}4} = \left\lceil \frac{Q_{\text{ACK}} - 9}{q} \right\rceil + 1$$

where C_{PUCCH} is the number of HARQ-ACK bits in total and q is the maximum number of HARQ-ACK bits that can be carried by one PRB using modified PUCCH format 3 (e.g., PUCCH format 3 with TBCC).

Similarly as PUCCH format 3, the PUCCH resource for PUCCH format 4 is

5 determined according to higher layer configuration and a dynamic indication from the downlink assignment. Denote the PUCCH format 4 resource as $n_{PUCCH}^{(4)}$, the resource block numbers of the PUCCH format 4 resource m is determined by the following

$$m = \lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \rfloor + 1, \dots, \lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \rfloor + N_{PUCCH4} - 1$$

The orthogonal sequence applied for the two slots is similar to the approach
 10 for PUCCH format 3. In one example, the same OCC apply for multiple PRBs. In another example, different OCCs apply for different PRBs following a predefined rule. A principle is that the OCC used for resource block number with lowest index should follow exactly same approach for PUCCH format 3. This is to enable fallback operation.

15 1.2 Resource allocation for PUCCH format design option 2

Option 2 for PUCCH format 4 is to use legacy PUCCH format 3 or modified PUCCH format 3 (e.g., PUCCH format 3 with TBCC) with multiple OCCs to carry more HARQ-ACK bits than today's PUCCH format 3 capacity.

Alternative 1: Legacy PUCCH format 3 is used.

20 The number of OCCs needed for PUCCH format 4 is denoted as C_{PUCCH4} and calculated by

$$C_{PUCCH4} = \left\lceil \frac{C_{PUCCH}}{q} \right\rceil$$

where C_{PUCCH} is the number of HARQ-ACK bits in total and q is the maximum number of HARQ-ACK bits that can be carried by one PRB and one OCC using PUCCH

25 format 3, i.e., q is equal to 22. C_{PUCCH4} shall be equal or less than $N_{SF,1}^{PUCCH}$.

The orthogonal sequences applied for the two slots are $n_{oc,0}, n_{oc,0} + 1, \dots, n_{oc,0} + C_{PUCCH4} - 1$ and $n_{oc,1}, n_{oc,1} + 1, \dots, n_{oc,1} + C_{PUCCH4} - 1$ derived by the following

$$n_{oc,0} = n_{PUCCH}^{(3)} \bmod N_{SF,1}^{PUCCH},$$

$$n_{oc,1} = \begin{cases} (3n_{oc,0}) \bmod N_{SF,1}^{PUCCH} & \text{if } N_{SF,1}^{PUCCH} = 5 \\ n_{oc,0} \bmod N_{SF,1}^{PUCCH} & \text{otherwise} \end{cases}$$

where $N_{SF,0}^{PUCCH}$ and $N_{SF,1}^{PUCCH}$ are the length of the orthogonal sequence for the two

5 slots respectively. $N_{SF,0}^{PUCCH} = N_{SF,1}^{PUCCH} = 5$ for both slots in a subframe using normal PUCCH format 4 and $N_{SF,0}^{PUCCH} = 5, N_{SF,1}^{PUCCH} = 4$ holds for the first and second slot, respectively, in a subframe using shortened PUCCH format 4.

Similarly as PUCCH format 3, the PUCCH resource for PUCCH format 4 is determined according to higher layer configuration and a dynamic indication from the
10 downlink assignment. Denote the PUCCH format 4 resource as $n_{PUCCH}^{(4)}$, the resource block number of the PUCCH format 4 resource m is determined by the following

$$m = \lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \rfloor$$

Alternative 2: Modified PUCCH format 3 is used.

In one embodiment, the number of PRBs needed for PUCCH format 4 is

15 denoted as C_{PUCCH4} and calculated by

$$C_{PUCCH4} = \left\lceil \frac{Q_{ACK} - 22}{q} \right\rceil + 1$$

where Q_{ACK} is the number of HARQ-ACK bits in total and q is the maximum number of HARQ-ACK bits that can be carried by one PRB one OCC using modified PUCCH

format 3 (e.g., PUCCH format 3 with TBCC). C_{PUCCH4} shall be equal or less than

20 $N_{SF,1}^{PUCCH}$.

In another embodiment, the number of PRBs needed for PUCCH format 4 is

denoted as C_{PUCCH4} and calculated by

$$C_{PUCCH4} = \left\lfloor \frac{Q_{ACK} - q}{q} \right\rfloor + 1$$

where Q_{ACK} is the number of HARQ-ACK bits in total and q is the maximum number of HARQ-ACK bits that can be carried by one PRB one OCC using modified PUCCH format 3 (e.g., PUCCH format 3 with TBCC). C_{PUCCH4} shall be equal or less than

5 $N_{SF,1}^{PUCCH}$.

The orthogonal sequences applied for the two slots are

$n_{oc,0}, n_{oc,0} + 1, \dots, n_{oc,0} + C_{PUCCH4} - 1$ and $n_{oc,1}, n_{oc,1} + 1, \dots, n_{oc,1} + C_{PUCCH4} - 1$ derived by the following

$$n_{oc,0} = n_{PUCCH}^{(3)} \bmod N_{SF,1}^{PUCCH},$$

$$n_{oc,1} = \begin{cases} (3n_{oc,0}) \bmod N_{SF,1}^{PUCCH} & \text{if } N_{SF,1}^{PUCCH} = 5 \\ n_{oc,0} \bmod N_{SF,1}^{PUCCH} & \text{otherwise} \end{cases}$$

10 where $N_{SF,0}^{PUCCH}$ and $N_{SF,1}^{PUCCH}$ are the length of the orthogonal sequence for the two slots respectively. $N_{SF,0}^{PUCCH} = N_{SF,1}^{PUCCH} = 5$ for both slots in a subframe using normal PUCCH format 4 and $N_{SF,0}^{PUCCH} = 5, N_{SF,1}^{PUCCH} = 4$ holds for the first and second slot, respectively, in a subframe using shortened PUCCH format 4.

15 Similarly as PUCCH format 3, the PUCCH resource for PUCCH format 4 is determined according to higher layer configuration and a dynamic indication from the downlink assignment. Denote the PUCCH format 4 resource as $n_{PUCCH}^{(4)}$, the resource block number of the PUCCH format 4 resource m is determined by the following

$$m = \left\lfloor n_{PUCCH}^{(4)} / N_{SF,0}^{PUCCH} \right\rfloor$$

20 1.3 Resource allocation for PUCCH format design option 3

Option 3 for PUCCH format 4 is to use legacy PUCCH format 3 or modified PUCCH format 3 (e.g., PUCCH format 3 with TBCC) with multiple PRBs and multiple OCCs to carry more HARQ-ACK bits than today's PUCCH format 3 capacity.

The total number of OCCs needed for PUCCH format 4 is denoted as C_{PUCCH4} and calculated by

$$C_{PUCCH4} = \left\lceil \frac{Q_{ACK}}{q} \right\rceil$$

where Q_{ACK} is the number of HARQ-ACK bits in total and q is the maximum number of HARQ-ACK bits that can be carried by one PRB and one OCC using PUCCH format 3, i.e., q is equal to 22. C_{PUCCH4} shall be larger than $N_{SF,1}^{PUCCH}$ in this case.

The number of PRBs needed for PUCCH format 4 is denoted as N_{PUCCH4} and calculated by

$$N_{PUCCH4} = \left\lceil \frac{C_{PUCCH4}}{N_{PUCCH3}} \right\rceil$$

10 1.4 Resource allocation for PUCCH format design option 4

Option 4 for PUCCH format 4 is to use PUSCH structure for PUCCH new format, i.e., one DMRS per slot and remaining REs are used for transmitting the UCI information. The coding of UCI information bits could be Turbo code or convolutional code. The resource allocation for this option could be a high layer signaling or added in the DCI message for DL assignment.

2. Fallback operation

As a general principle of PUCCH Format fall back:

- If the required feedback bits in a subframe are included in the predefined segmentation with length N_1 bits, named as the first predefined segmentation, format 1a/1b is used. For example, in Rel-10, the predefined segmentation is corresponding to the first 2 bits. As an example, $N_1 = 2$.

- Otherwise, if the required feedback bits in a subframe are included in the predefined segmentation with length M_2 bits, named as the second predefined segmentation, format 3 is used.

- As one example, the second predefined segmentation is corresponding to the first $M_2 = 22$ bits

- Otherwise, new format such as format 4 is used. One example is shown in figure 1. Assuming the feedback bits are $a_n (n = 0, \dots, N - 1)$, the first segmentation includes feedback bits a_0, a_1 , the second segment includes feedback bits $a_2, a_3, \dots, a_{21}, a_{22}$.

- In case only a_0 , or a_1 or a_2, a_1 are required for feedback, format 1a/1b is used.

- In case some of a_2, \dots, a_{21} are required for feedback but not only a_0 , or a_1 or a_2, a_1 , and no other feedback is required, format 3 is used.

- Otherwise, new format such as format 4 is used.
- 15 In the following section, we provide detailed conditions on the fallback operation.

2.1 In case PUCCH on PCell

2.1.1 Fall back to PUCCH format 1a/1b

20 The fallback of PUCCH format 4 is PUCCH format 1a/1b for some specific conditions listed below:

- For FDD PCell, if no (E)PDCCH corresponding to PDSCH on SCells is received and PDSCH is received on PCell, fallback to PUCCH format 1a/1b.

- In this case, only a_0, a_1, a_2, a_1 is required.

- For TDD PCell, if no (E)PDCCH corresponding to PDSCH on SCells is received and PDSCH is received on PCell in only one DL subframe where the DAI value is set to '1', fallback to PUCCH format 1a/1b.

Otherwise, PUCCH format 4 will fall back to format 3 when some other specific
5 conditions are satisfied, which are described in section 2.1.2

2.1.2 Fall back to PUCCH format 3

If the condition of falling back to PUCCH format 1a/1b is not satisfied, PUCCH format 4 may fall back to format 3. The conditions to fall back to format 3 are included in the following embodiments.

10 In some embodiments, if PDSCH is received on one or more SCells with predefined cell indices and no (E)PDCCH corresponding to PDSCH on other SCells is received, fallback to PUCCH format 3.

As one example of the predefined cell indices, the cell index 1-4 may be set as the predefined cell indices. Given this condition, if all the component carriers are FDD
15 carriers, the second segmentation includes HARQ-ACK feedback bits $\{b_{n-1}, b_n, \dots, b_{n+N-1}\}$ without appending of SR. If all the component carriers are TDD carrier, the second segmentation includes HARQ-ACK feedback bits may be $\{b_{n-1}, b_n, \dots, b_{n+N-1}\}$ without appending of SR. If the component carriers are mixture of FDD and TDD, the second segmentation includes HARQ-ACK feedback bits $\{b_{n-1}, b_n, \dots, b_{n+N-1}\}$. N is determined by the
20 carrier configuration of cell index 1-4. Note that 1 bit SR can be appended on HARQ-ACK feedback and sent on the same PUCCH format.

In some embodiments, the following steps could be used to determine the condition for the format 3 fallback:

- Obtaining each component carrier configuration and the
25 capacity of PUCCH format 3 which can be used for the HARQ-ACK feedback.
- Selecting the feedback bits to form the segmentation, the size of the segmentation is based on the obtained capacity.

- Deciding the component carrier and subframes associated with the formed segmentation based on the information of the component carrier configurations and PUCCH configuration.

If PDSCH is received only on the cells associated with the formed segmentation and no (E)PDCCH corresponding to PDSCH on other cells is received, fallback to PUCCH format 3.

In this embodiment, the associated cell indices may be different on different uplink subframes to determine the fallback to PUCCH format 3. As one example in case of TDD CA, assuming there are 6 component carriers and the TDD configuration for the 6 component carriers are:

- CC0: Uplink-downlink configuration 1 (Primary carrier)
- CC1: Uplink-downlink configuration 0
- CC2: Uplink-downlink configuration 1
- CC3: Uplink-downlink configuration 1
- CC4: Uplink-downlink configuration 1
- CC5: Uplink-downlink configuration 1

The uplink-downlink configuration is defined in 36.211. In this case, the cell indices associated with the formed segmentation for different subframes are:

- In case the PUCCH is transmitted on subframe 7 or subframe 2, the cell indices associated with the PUCCH on these subframes are 0, 1, 2, 3, 4, 5
- In case the PUCCH is transmitted on subframe 8 or subframe 3, the cell indices associated with the PUCCH on these subframes are 0, 2, 3, 4, 5, 6

In some embodiments, a plurality of segmentations may be formed. Each segmentation is allocated on one PUCCH format 3 resource. The PUCCH format-3 resource may be overlapped with the format 4. It may be derived from the resource allocation for PUCCH format 4. If all the PDSCHs are received only on the cells

corresponding to one segmentation, the PUCCH format will fall back to format 3, and the resource for the fallback is given by the allocated PUCCH format 3 resource associated with the segmentation. As one example shown in figure 2, assuming there are 20 FDD carriers, the second segment including the feedback bits corresponding to CC 0~9, and the third segment including the feedback bits corresponding to CC 10~19, assume the PUCCH resource $m = \lfloor n_{\text{PUCCH}(0)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \rfloor \lfloor n_{\text{PUCCH}(1)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \rfloor$ is allocated for PUCCH format 4. In this case:

- If PDSCH is received only on the cells with cell indices 0~9 and no (E)PDCCH corresponding to PDSCH on other cells is received, Format 4 will fall back to PUCCH format 3, the resource $n_{\text{PUCCH}(0)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}}$ will be used for the PUCCH format 3.

- If PDSCH is received only on the cells on cell indices 10~19 and no (E)PDCCH corresponding to PDSCH on other cells is received, Format 4 will fall back to PUCCH format 3, the resource $n_{\text{PUCCH}(1)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}}$ will be used for the PUCCH format 3.

- Otherwise, PUCCH format 4 will be used.

In some embodiments, a plurality of segmentations may be formed. Each segmentation is allocated one PUCCH format 3 resource. If the PDSCHs are received on the cells associated with multiple segmentations, the PUCCH format may fall back to multiple format 3, and the resources for the fallback are given by the allocated PUCCH format 3 resources associated with these segmentations. As one example shown in figure 3, assuming there are 20 FDD carriers, the second segment including the feedback bits corresponding to CC 0~9, and the third segment including the feedback bits corresponding to CC 10~19, assume the PUCCH resource $m = \lfloor n_{\text{PUCCH}(0)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \rfloor \lfloor n_{\text{PUCCH}(1)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}} \rfloor$ is allocated for PUCCH format 4. In this case:

- If PDSCH is received only on the cells with cell indices 0~9 and no (E)PDCCH corresponding to PDSCH on other cells is received, Format 4 will fall back to PUCCH format 3, the resource $n_{\text{PUCCH}(0)}^{(4)} / N_{\text{SF},0}^{\text{PUCCH}}$ will be used for the PUCCH format 3.

- If PDSCH is received only on the cells on cell indices 10~19 and no (E)PDCCH corresponding to PDSCH on other cells is received, Format 4 will fall back to PUCCH format 3, the resource $n_{\text{PUCCH}(1)}^{(4)}/N_{\text{SF},0}^{\text{PUCCH}}$ will be used for the PUCCH format 3.
- 5 ● If PDSCH is received on the some cells with cell indices 0~9 and some cells with cell indices 10~19, and no (E)PDCCH corresponding to PDSCH on other cells is received, Format 4 will fall back to *two* PUCCH format 3, *the resource* $n_{\text{PUCCH}(0)}^{(4)}/N_{\text{SF},0}^{\text{PUCCH}}$ *and* $n_{\text{PUCCH}(1)}^{(4)}/N_{\text{SF},0}^{\text{PUCCH}}$ *will be used for the PUCCH format 3.*
- 10 ● Otherwise, PUCCH format 4 will be used.

2.2 In case PUCCH on Scell

In case there is a PUCCH on Scell, there may exist a plurality of PUCCH cell groups. In each PUCCH cell group, there may exist a plurality of downlink carriers. For PUCCH on SCells, there are multiple realization methods for PUCCH transmission:

- PUCCH is transmitted on one SCell configured by higher-layer signaling to carry PUCCH for SCells in the PUCCH cell group.
- PUCCH is transmitted on the PCell for SCells in the PUCCH cell group.
- 20 ● PUCCH on SCell-only (i.e., no PUCCH on PCell) (Note: based on current agreements, PUCCH on SCell-only (i.e., no PUCCH on PCell) is not supported in Rel.13, but it may be re-discussed in the future release.)

For the first two realizations, PUCCH is transmitted on both PCell and SCell. For the third realization, there is no PUCCH on PCell. For the first two realizations, the fall back condition is similar. For the third realization, the fall back condition for format 1a/1b has slightly difference. In the following section, section 2.2.1 give details on the fallback solution for the first two realizations, and section 2.2.2 give details on the feedback solution for the third realizations.

2.2.1 PUCCH is transmitted on both PCell and SCell

In this section, we use pSCell to denote the cell which transmits PUCCH in the PUCCH cell group. If PUCCH is transmitted on the PCell for SCells in the PUCCH cell group, the pSCell is the PCell. Otherwise, pSCell is one SCell.

5 In some embodiments, all the description in section 2.1 can be applied for each PUCCH cell group. The fall back operation may be independent between cell groups.

As one example, for PUCCH format 1a/1b fall back, the specific conditions listed below:

- For FDD pSCell, if no (E)PDCCH corresponding to PDSCH
10 on SCells in the PUCCH cell group is received and PDSCH is received on pSCell, fallback to PUCCH format 1a/1b.
- For TDD pSCell, if no (E)PDCCH corresponding to PDSCH
on SCells in the PUCCH cell group is received and PDSCH is received on pSCell in only one DL subframe where the DAI value is set to '1', fallback to
15 PUCCH format 1a/1b.

For fallback to PUCCH format 3, the embodiments may be updated into:

Embodiments#1: If PDSCH is received on one or more SCells in the PUCCH cell group with predefined cell indices and no (E)PDCCH corresponding to PDSCH on other SCells in the PUCCH cell group is received, fallback to PUCCH format 3.

20 **Embodiments#2:** In some embodiments, the following steps could be used to determine the condition for the format 3 fallback:

- Obtaining each component carrier configuration in the PUCCH cell group and the capacity of PUCCH format 3 which can be used for the HARQ-ACK feedbacks.
- 25 ● Selecting the HARQ-ACK feedback bits to form the segmentation, the size of the segmentation is based on the obtained capacity.
- Deciding the component carrier and subframes associated with the formed segmentation based on the information for the component carrier configurations and PUCCH configuration.

If PDSCH is received only on the cells associated with the formed segmentation *in the PUCCH cell group* and no (E)PDCCH corresponding to PDSCH on other cells *in the PUCCH cell group* is received, fallback to PUCCH format 3.

Embodiments#3: In some embodiments, a plurality of segmentations may be formed *in each PUCCH cell group*.

Not all the embodiments in Section 2.1 are elaborated in this section. Similar principle can be applied to the embodiments which are not repeated here.

2.2.2 PUCCH on SCell-only (i.e., no PUCCH on PCell)

For this case, the fallback to format 1a/1b described in Section 2.2.1 need to be modified into:

- For FDD PCell, if no (E)PDCCH corresponding to PDSCH on SCells is received and PDSCH is received on PCell, fallback to PUCCH format 1a/1b. *The PUCCH format 1a/1b is transmitted on PCell uplink carrier*
- For TDD PCell, if no (E)PDCCH corresponding to PDSCH on SCells is received and PDSCH is received on PCell in only one DL subframe where the DAI value is set to '1', fallback to PUCCH format 1a/1b. *The PUCCH format 1a/1b is transmitted on PCell uplink carrier.*
- For FDD pSCell, if no (E)PDCCH corresponding to PDSCH on other cells in the PUCCH cell group is received and PDSCH is received on pSCell, fallback to PUCCH format 1a/1b. *The PUCCH format 1a/1b is transmitted on SCell uplink carrier.*
- For TDD pSCell, if no (E)PDCCH corresponding to PDSCH on other cells in the PUCCH cell group is received and PDSCH is received on pSCell in only one DL subframe where the DAI value is set to '1', fallback to PUCCH format 1a/1b. *The PUCCH format 1a/1b is transmitted on the SCell uplink carrier.*

Otherwise, the PUCCH may fall back to PUCCH format 3 according to Section 2.2.1.

Abbreviations

	<u>Abbreviation</u>	<u>Explanation</u>
	CA	Carrier aggregation
5	UCI	Uplink control information
	PUCCH	Physical uplink control channel
	LTE	Long term evolution
	TDD	Time domain duplex
	FDD	Frequency domain duplex
10	UL	Uplink
	DL	Downlink
	UE	User equipment
	LAA	Licensed-Assisted Acces
	TPC	Transmit power control
15	DCI	Downlink control information
	PDCCH	Physical downlink control channel
	ePDCCH	Enhanced physical downlink control channel
	DAI	Downlink Assignment index
	HARQ	Hybrid Automatic Repeat request
20	Ack	Acknowledgement
	NACK	Negative-ACK
	eNB	Evolved Node B

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What is claimed is:

1. A method of resource allocation for new PUCCH format, including:

allocating resources based on different PUCCH format, wherein a new PUCCH
format is to use legacy PUCCH format 3 or modified PUCCH format 3 on
5 multiple PRBs.

2. The method according to claim 1, wherein the PUCCH format 3 is for example
PUCCH format 3 with tail-biting convolutional code.

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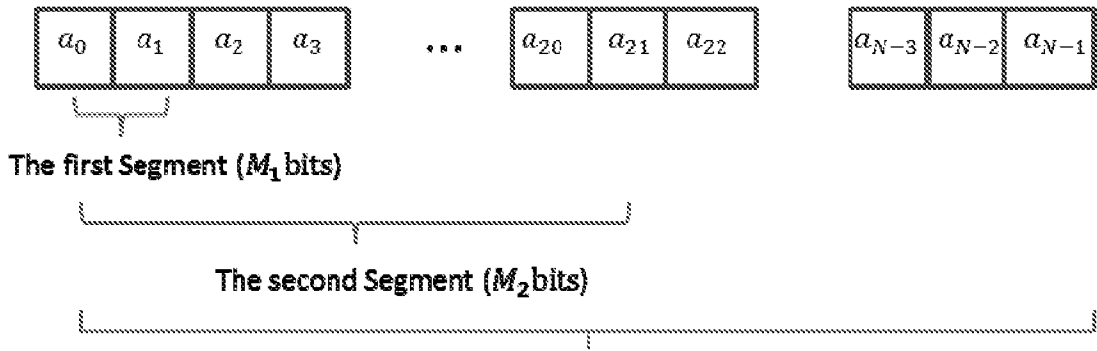


Fig. 1

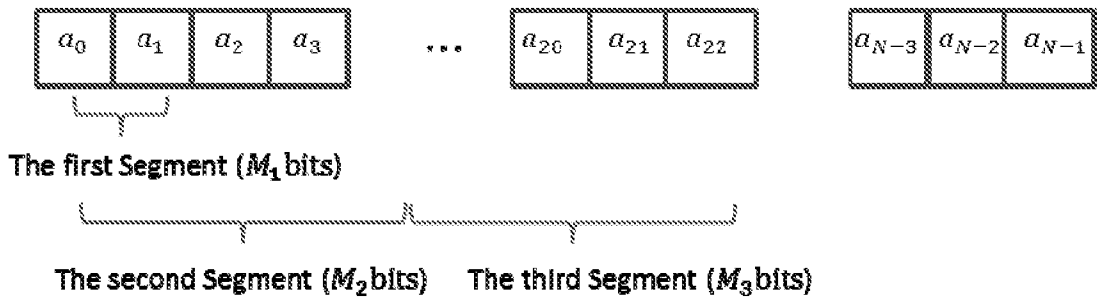


Fig. 2

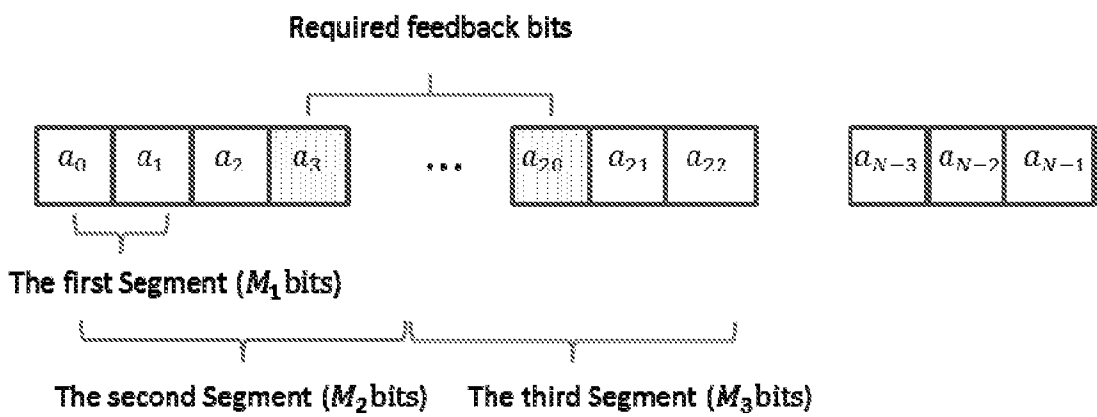


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/076176

A. CLASSIFICATION OF SUBJECT MATTER

H04W 72/08(2009.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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)

WPI; EPODOC; CNKI; CNPAT:PUCCH, format, modified, legacy, aggregation, PRB, DL, UL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014233419 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 21 August 2014 (2014-08-21) description, paragraphs [0082]-[0085]	1-2
A	CN 102315910 A (ZTE CORPORATION) 11 January 2012 (2012-01-11) the whole document	1-2
A	US 2013195063 A1 (LG ELECTRONICS INC.) 01 August 2013 (2013-08-01) the whole document	1-2

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

* Special categories of cited documents:

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

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

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

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

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

“&” document member of the same patent family

Date of the actual completion of the international search

23 December 2015

Date of mailing of the international search report

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Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/076176

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				CN	103095398	A	08 May 2013
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