

component carriers (downlink cells). In other words, the base station device 3 and/or the terminal device 1 can simultaneously perform transmission and/or reception on multiple physical channels in up to 5 serving cells. Here, the number of uplink component carriers may be less than the number of downlink component carriers.

[0091]

FIG. 3A illustrates that a first PUCCH cell group and a second cell group are configured as a cell group (the PUCCH cell groups). For example, in FIG. 3A, the base station device 3 may transmit a downlink signal in the first cell group, and the terminal device 1 may transmit an uplink signal in the first cell group (may transmit uplink control information on the PUCCH in the first cell group). For example, in a case where 20 serving cells (downlink component carriers or downlink cells) are configured or activated in the first cell group, the base station device 3 and the terminal device 1 may transmit and receive uplink control information for the 20 downlink component carriers, respectively.

[0092]

To be more specific, the terminal device 1 may transmit HARQ-ACK for the 20 downlink component carriers (HARQ-ACK for PDSCH transmission and HARQ-ACK for transport blocks). The terminal device 1 may transmit CSI corresponding to each of the 20 downlink component carriers. The terminal device 1 may transmit SRs for each cell group. Similarly, the base station device 3 and the terminal device 1 may transmit and receive uplink control information in the second cell group, respectively.

[0093]

Similarly, the base station device 3 and the terminal device 1 may configure a cell group as illustrated in FIG. 3B, and transmit and receive uplink control information, respectively. Also, the base station device 3 and the terminal device 1 may configure a cell group as illustrated in FIG. 3C, and transmit and receive uplink control information respectively.

[0094]

Herein, one cell group (e.g., a PUCCH cell group) may include at least one serving cell (e.g., a PUCCH serving cell). Additionally, in certain embodiments, one cell group (e.g., a PUCCH cell group) may include only one serving cell (e.g.,

- Format 1a
- Format 1b
- Format 2
- Format 2a
- 5 · Format 2b
- Format 3
- Format 4

[0105]

PUCCH format 1 may be defined for positive SR. For example, the positive
 10 SR may be used to indicate that an UL-SCH resource is requested. Here, negative
 SR may be used to indicate that an UL-SCH resource is not requested. PUCCH
 format 1 is also referred to as a first PUCCH format below.

[0106]

PUCCH format 1a may be defined for 1-bit HARQ-ACK or 1-bit
 15 HARQ-ACK with positive SR. PUCCH format 1b may be defined for 2-bit
 HARQ-ACK or 2-bit HARQ-ACK with positive SR. PUCCH format 1b may be
 defined for transmission of up to 4-bit HARQ-ACK with channel selection.
 PUCCH format 1a and/or PUCCH format 1b is also referred to as a second
 PUCCH format below.

20 [0107]

PUCCH format 2 may be defined for a CSI report when not multiplexed
 with HARQ-ACK. PUCCH format 2a may be defined for a CSI report multiplexed
 with 1-bit HARQ-ACK. PUCCH format 2b may be defined for a CSI report
 multiplexed with 2-bit HARQ-ACK. Here, PUCCH format 2 may be defined for a
 25 CSI report multiplexed with HARQ-ACK for extended cyclic prefix. PUCCH
 format 2, PUCCH format 2a, and/or PUCCH format 2b is also referred to as a
 third PUCCH format below.

[0108]

PUCCH format 3 may be defined for up to 10-bit HARQ-ACK. For
 30 example, PUCCH format 3 may be defined for up to 10-bit HARQ-ACK for FDD
 or FDD-TDD primary cell frame structure type 1.

[0109]

Also, as illustrated in FIG. 5, for example, HARQ-ACK bits may be concatenated in ascending order of cell index value, and the second predetermined value may be the minimum value (e.g., “12”) of the cell index when the number of concatenated bits exceeds a third predetermined value (e.g., 10 bits). In other words, HARQ-ACK bits may be concatenated in ascending order of cell index value, and the second predetermined value may be the value of the cell index (e.g., “12”) when the number of concatenated HARQ-ACK bits is the minimum value (e.g., 11 bits) that exceeds the third predetermined value (e.g., 10 bits).

[0174]

Also, the second predetermined value may be a value that satisfies at least the following conditions (minimum value, minimum value of the cell index). Herein, the condition may specify that the HARQ-ACK bits are sequentially concatenated starting from a cell index of “0” up to the cell index of the second predetermined value, and the number of concatenated HARQ-ACK bits exceeds a third predetermined value (e.g., 10 bits).

[0175]

Herein, for example, the third predetermined value may be a value defined by the specification or the like and be known between the base station device 3 and the terminal device 1. For example, the third predetermined value may be “10”, “20”, or “21”. For example, for FDD or FDD-TDD primary cell frame structure type 1, the third predetermined value may be 10. Also, for TDD, the third predetermined value may be “20”. Also, for FDD or FDD-TDD primary cell frame structure type 2, the third predetermined value may be 21.

[0176]

In addition, the third predetermined value may be “11”, “21”, or “22”. For example, for FDD or FDD-TDD primary cell frame structure type 1, the third predetermined value may be “11”. Also, for TDD, the third predetermined value may be “21”. Also, for FDD or FDD-TDD primary cell frame structure type 2, the third predetermined value may be “22”.

[0177]

That is, the third predetermined value may be determined based on the number of HARQ-ACK bits supported by the PUCCH format 3 described above (defined for the PUCCH format 3). The third predetermined value may also be

composed by sequentially concatenating cell index values in ascending order. Herein, the HARQ-ACK bit sequence may be formed by comparing the number of serving cells configured by the higher layer and a fourth predetermined value, and concatenating up to the smaller value. For example, in a case where the number of
 5 serving cells configured by the higher layer is 24 and the fourth predetermined value is 5, the HARQ-ACK bit sequence may be concatenated up to 5. That is, in this case, the HARQ-ACK bit sequence is concatenated from the smallest (lowest) cell index value up to the fifth value.

[0187]

10 Here, the fourth predefined value may be a value defined by the specification or the like, and may be known between the base station device 3 and the terminal device 1. For example, the fourth predetermined value may be a value such as “5” or “10”. For the TDD, the fourth predetermined value may be “5”. For example, for the FDD, the fourth predetermined value may be “10”. For example,
 15 for the TDD and the FDD, the fourth predetermined value may be “5”.

[0188]

Furthermore, in the processing for each serving cell, the HARQ-ACK bit sequence may be concatenated based on the downlink transmission mode. For example, when a downlink transmission mode that supports one transport block is
 20 configured for a particular cell, a 1-bit HARQ-ACK bit may be concatenated. Also, when a downlink transmission mode that supports two transport blocks is configured for a particular cell, a 2-bit HARQ-ACK bits may be concatenated.

[0189]

That is, the terminal device 1 may use the fourth PUCCH format to transmit
 25 a HARQ-ACK bit sequence (or a HARQ-ACK) provided based on the processing illustrated in FIG. 7.

[0190]

FIG. 8 is a diagram illustrating a method to process uplink control information according to the present embodiment. Here, FIG. 8 illustrates a
 30 processing method to be used when the uplink control information (e.g., HARQ-ACK) is transmitted using the fourth PUCCH format.

[0191]

Herein, in a case where the terminal device 1 does not detect PDSCH or PDCCH instructing release of a downlink SPS (Semi-Persistent Scheduling) in a particular subframe for a particular serving cell (i.e., in a case that neither PDSCH nor PDCCH is detected), a NACK may be generated for the particular serving cell.

5 For example, the terminal device 1 may generate a single NACK for serving cells for which a downlink transmission mode supporting one transport block is configured, and two NACKs may be generated for serving cells for which a downlink transmission mode supporting up to two transport blocks is configured.
[0197]

10 That is, the terminal device 1 may use the fourth PUCCH format to transmit a HARQ-ACK bit sequence (or a HARQ-ACK) provided based on the processing illustrated in FIG. 8.

[0198]

FIG. 9 is a diagram illustrating a method for allocating PUCCH resources according to the present embodiment.

[0199]

Here, the base station device 3 may instruct (configure, allocate) a PUCCH resource for the terminal device 1. Here, the PUCCH resource may include a first PUCCH resource (also referred to as $n(1)$ PUCCH), a second PUCCH resource (also referred to as $n(2)$ PUCCH), a third PUCCH resource (also referred to as $n(3)$ PUCCH), and a fourth PUCCH resource (also referred to as $n(4)$ PUCCH).

[0200]

For example, the base station device 3 may transmit the higher layer signaling including first information to be used to configure the first PUCCH resource. For example, SR may be transmitted with the first PUCCH resource. The base station device 3 may transmit higher layer signaling including second information to be used to indicate periodicity and/or offset for transmission of SR. The terminal device 1 may transmit SR in accordance with a configuration made by the base station device 3. To be more specific, the terminal device 1 may
30 transmit SR using the first PUCCH resource and the first PUCCH format.

[0201]

The base station device 3 may indicate the first PUCCH resource through the higher layer signaling and the PDCCH. For example, the base station device 3