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I possess advanced knowledge of the Chinese and English languages and am qualified to translate documents from Chinese to English;

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CERTIFICATE

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Application type: Invention patent

Name of invention: Data transmission method and device

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CLAIMS

1. A data transmission method, comprising:
detecting, by user equipment (UE), a physical downlink control channel (PDCCH) on a configured control resource set;
determining, by the UE according to the detected PDCCH, methods for dividing code blocks (CB) and rate matching of a physical downlink shared channel (PDSCH), and receiving the PDSCH according to the detected PDCCH; and
generating, by the UE according to a PDSCH detection result, HARQ-ACK information, and transmitting the HARQ-ACK information.
2. The method according to claim 1, wherein the dividing the CBs comprises:
for a transmission block (TB), when a TB size (TBS) is greater than a second threshold, triggering CB division operation on the TB, and making the size of each CB not exceed a third threshold, the third threshold being less than or equal to the second threshold, wherein the second threshold and/or the third threshold are/is predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH; and/or when the TBS is less than or equal to the second threshold, the TB only comprises one CB.
3. The method according to claim 1, wherein the dividing the CBs comprises:
for one TB, dividing the TB into M CB groups (CBG), and further dividing each CBG into one or more CBs, wherein M is predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH.
4. The method according to claim 3, wherein
the TB is equally divided into M CBGs;
alternatively, a modulation symbol of one CBG is only mapped to one or more mini time units (MTUs), and modulation symbols of different CBGs are mapped to different MTUs, wherein a bit number of each CBG is in direct proportion to a number of REs for data transmission in the MTU mapped by the CBG, or the bit number of each CBG is in direct proportion to a number of orthogonal frequency division multiplexing (OFDM)



symbols of the MTU mapped by the CBG.

5. The method according to claim 3, wherein M is determined according to one or more of the following parameters:

- a service category;
- a DCI format;
- system parameters;
- a downlink control channel resource set; and
- a downlink control channel search space.

6. The method according to claim 1, wherein the HARQ-ACK information is divided into two situations of single-bit HARQ-ACK or multi-bit HARQ-ACK information of each transmission block, and whether or not the single-bit or multi-bit HARQ-ACK information is generated is determined according to one or more of the following parameters:

- a service category;
- a DCI format;
- system parameters;
- a downlink control channel resource set; and
- a downlink control channel search space.

7. The method according to claim 1, wherein before a multi-bit HARQ-ACK feedback method is configured, the HARQ-ACK information is that one-bit HARQ-ACK information is fed back to one TB; or DCI in a common search space (CSS) feeds back one-bit HARQ-ACK information to one TB;

or the DCI in a fallback mode feeds back one-bit HARQ-ACK information to one TB; and

for the later one, the DCI in at least one control resource set feeds back one-bit HARQ-ACK information to one TB.

8. The method according to claim 3, wherein

for each CBG, whether or not the CBG is transmitted is indicated by a bit;
whether or not the CBG is transmitted is indicated by a combination of part of
control parameters for each CBG;
and a number of currently scheduled CBGs is indicated by N bits.

9. The method according to claim 3, wherein

if at least one retransmitted CBG is scheduled in one DCI, the size of the
retransmitted CBG determined according to the DCI needs to be the same as the size of
the CBG determined by the DCI in which the same CBG is scheduled last time;

alternatively, if at least one retransmitted CBG is scheduled in one DCI, the TB size
indicated by the DCI needs to be the same as the TB size indicated by the DCI in which
the same CBG is scheduled last time.

10. The method according to claim 1, wherein the receiving the PDSCH comprises:

if the PDCCH schedules to retransmit data of a part of CB, CBG or OFDM symbols
of the TB, determining by the UE to retransmit the CB, CBG or OFDM symbols which
are affected, and decoding the PDSCH by the UE according to the retransmitted CB,
CBG or OFDM symbols;

alternatively, indicating, by the PDCCH, whether or not the data of the currently
retransmitted TB, CB, CBG or OFDM symbols is affected, and decoding the PDSCH by
the UE;

alternatively, indicating the UE by the PDCCH to determine whether or not to
execute HARQ combination on the data of the currently retransmitted TB, CB, CBG or
OFDM symbols, and decoding the PDSCH by the UE.

11. The method according to claim 1, wherein the receiving the PDSCH comprises:

receiving the retransmitted CB, CBG or OFDM symbols which are affected in a fast
retransmission time window, or receiving the whole retransmitted TB in the fast
retransmission time window.

12. The method according to claim 11, wherein

if the same retransmitted TB is received in the fast retransmission time window, the



UE determines that the TB is affected; otherwise, the UE determines that the TB is not affected;

or the UE determines whether or not the currently retransmitted CB, CBG or OFDM symbols or the whole TB is affected according to an instruction in the PDCCH.

13. The method according to claim 1, further comprising:

defining the processing capacity of the UE according to a reference value of a set of system parameters; and when the system parameters of the UE in actual work are different from the reference value, obtaining the processing capacity of the current UE in an actual work scene according to the reference UE processing capacity.

14. The method according to claim 13, wherein the determining processing capacity of the current UE in an actual work scene according to the reference UE processing capacity comprises:

determining the processing capacity of the current UE in the actual work scene according to the reference UE processing capacity and a change factor of the UE processing capacity, wherein the length of a reference TTI is T_{ref} , the length of a TTI of the UE in actual work is T , and the change factor of the UE processing capacity is T/T_{ref} ;

alternatively, the UE processing capacity is equal to the reference UE processing capacity.

15. The method according to claim 1, wherein the determining rate matching of the PDSCH comprises:

for one category of service, processing the rate matching of the PDSCH only according to the control resource set of the one category of service and a set of time-frequency resources which cannot be used for transmitting the PDSCH;

alternatively, for one category of service, when performing rate matching, considering the control resource set of the one category of service and the set of the time-frequency resources which cannot be used for transmitting the PDSCH, and also considering the control resource set of another category of service and the set of the time-frequency resources which cannot be used for transmitting the PDSCH.



16. A data transmission device, comprising a PDCCH detecting and analyzing module, a PDSCH receiving module, a HARQ-ACK information generating module and a HARQ-ACK transmitting module, wherein

the PDCCH detecting and analyzing module is configured to determine a PDCCH for scheduling the PDSCH on a configured control resource set and analyzing the detected PDCCH;

the PDSCH receiving module is configured to determine methods for dividing CBs and rate matching of a PDSCH according to the detected PDCCH, and receive the PDSCH according to the detected PDCCH;

the HARQ-ACK information generating module is configured to generate HARQ-ACK information according to the detected PDSCH; and

the HARQ-ACK transmitting module is configured to transmit the HARQ-ACK information.



SPECIFICATION

DATA TRANSMISSION METHOD AND DEVICE

TECHNICAL FIELD

The present disclosure relates to the technology of wireless communication systems, and in particular, to a method and device for enhancing data transmission performance when services with various TTI length requirements are supported at the same time.

BACKGROUND ART

In wireless communication systems, downlink transmission refers to transmitting of signals from a base station to user equipment (UE). Downlink signals include data signals, control signals, and reference signals (pilot frequency). Here, the base station transmits downlink data over a physical downlink shared channel (PDSCH), or transmits downlink control information over a downlink control channel. Uplink transmission refers to transmitting of signals from the UE to the base station. Uplink signals also include data signals, control signals, and reference signals. Here, the UE transmits uplink data over a physical uplink shared channel (PUSCH), or transmits uplink control information over a physical uplink control channel (PUCCH). The base station may dynamically schedule the PDSCH and PUSCH transmissions of the UE via a physical downlink control channel (PDCCH).

In a 3GPP LTE system, the downlink transmission technology is orthogonal frequency division multiple access (OFDMA), and the uplink transmission technology is single carrier frequency division multiple access (SCFDMA). As shown in FIG. 1, the length of each wireless frame is 10 ms, and each wireless frame is equally divided into 10 sub-frames. One downlink transmission time interval (TTI) is defined on one sub-frame. Each downlink sub-frame includes two slots, each including 7 OFDM symbols for

the general CP length. The granularity of resource allocation is the physical resource block (PRB), and one PRB includes 12 consecutive sub-carriers in frequency, which is corresponding to a slot in time. A resource unit (RE) is the smallest unit of a time-frequency resource, i.e., a sub-carrier in frequency, and a OFDM symbol in time.

The 3GPP standards organization is standardizing new access network technology (NR), which is still a OFDM-based system. For data transmission, the length of TTI for different services is different depending on the throughput and time delay requirements. For some services, such as those that pursue greater throughput, including eMBB services, the length of TTI may be relatively large, which is conducive to reducing the overhead of control signaling, hereinafter referred to as a first category of service, and the time period to which the longer TTI is mapped is called a time unit (TU), for example, slot. For another service, such as service with higher time delay requirements, including URLLC service, the length of the TTI is to be relatively small, so as to reduce the processing delay, hereinafter referred to as a second category of service, and the time period to which the shorter TTI is mapped is called a mini time unit (MTU), for example, mini-slot (min-slot). One MTU includes one or more OFDM symbols. One TU may be divided into multiple MTUs, and the number of symbols for each MTU may be the same or different. One MTU may be part of a certain TU, or one MTU may cross the boundary of two adjacent TUs.

By taking the downlink data transmission as an example, it is assumed that the first category of service has been scheduled in one TU, but when a second category of service is generated, in order to reduce the delay as much as possible, the base station needs to transmit the second category of service to one MTU within this TU. If the time-frequency resources have been allocated to the first category of service, the second category of service can only occupy part of the resources already allocated to the first category of service for transmission. On time-frequency resources where two categories of services overlap, only the data of the second category of service may be transmitted. As shown in FIG. 2, it is assumed that one TU is divided into two MTUs 201 and 202. It

is assumed that a time-frequency resource 211 has been scheduled on the TU for the first category of service, but a new second category of service is generated before MTU 202 and needs to be processed quickly, the base station may schedule the time-frequency resource 212 on the MTU 202 for the second category of service. On the basis of the scheduling of the base station, for example, when there are not enough time-frequency resources in the MTU 202, some or all of the time-frequency resources 212 may overlap with the time-frequency resources 211. In this case, only the second category of service is transmitted on the time-frequency resources where the two categories of services overlap. Alternatively, two categories of services may be transmitted at the same time on the time-frequency resources where the two categories of services overlap. For the latter method, the two categories of services may be distinguished by setting different transmission powers, so the UE may correctly receive the data transmission scheduled to it. According to the above discussion, in order to transmit the second category of service, it may be necessary to punch part of the time-frequency resources of the first category of service, or to transmit data transmissions of two services at the same time on a part of the time-frequency resources of the first category of service, which will have an impact on the transmission performance of the first category of service. How to ensure the performance of the first category of service is a problem urgently to be solved.

SUMMARY

The present application provides a data transmission method and device, and provides a mechanism for enhancing data transmission performance when the services with various TTI length requirements are supported at the same time.

According to the present application, in order to achieve the above purpose, the following technical solutions are adopted:

A data transmission method includes:

detecting, by user equipment (UE), a physical downlink control channel (PDCCH) on a configured control resource set;

determining, by the UE according to the detected PDCCH, methods for dividing code blocks (CB) and rate matching of a physical downlink shared channel (PDSCH), and receiving the PDSCH according to the detected PDCCH; and

generating, by the UE according to the detected PDCCH, HARQ-ACK information, and transmitting the HARQ-ACK information.

Preferably, the dividing the CBs includes:

for a transmission block (TB), when the TB size (TBS) is greater than a second threshold, triggering CB division operation on the TB, and making the size of each CB not exceed a third threshold, the third threshold being less than or equal to the second threshold, wherein the second threshold and/or the third threshold are/is predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH; and/or when the TBS is less than or equal to the second threshold, the TB only includes one CB.

Preferably, the dividing the CBs includes:

for one TB, dividing the TB into M CB groups (CBG), and further dividing each CBG into one or more CBs, wherein M is predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH.

Preferably, it is characterized in that,

the TB is equally divided into M CBGs;

alternatively, a modulation symbol of one CBG is only mapped to one or more mini time units (MTUs), and modulation symbols of different CBGs are mapped to different MTUs, wherein a bit number of each CBG is in direct proportion to a number of REs for data transmissions in the MTU mapped by the CBG, or the bit number of each CBG is in direct proportion to a number of orthogonal frequency division multiplexing (OFDM) symbols of the MTU mapped by the CBG.

Preferably, for transmission modes that support the simultaneous transmission of two TBs, the number of divided CBGs of two TBs is the same.

Preferably, for transmission modes that support the simultaneous transmission of



two TBs, the number of the divided CBGs of two TBs may be different.

Preferably, M is determined according to one or more of the following parameters:

- a service category;
- a DCI format;
- system parameters;
- a downlink control channel resource set; and
- a downlink control channel search space.

Preferably, the HARQ-ACK information is divided into two situations of single-bit HARQ-ACK or multi-bit HARQ-ACK information of each transmission block, and whether or not the single-bit or multi-bit HARQ-ACK information is generated is determined according to one or more of the following parameters:

- a service category;
- a DCI format;
- system parameters;
- a downlink control channel resource set; and
- a downlink control channel search space.

Preferably, before a multi-bit HARQ-ACK feedback method is configured, the HARQ-ACK information is that one-bit HARQ-ACK information is fed back to one TB;

or DCI in a common search space (CSS) feeds back one-bit HARQ-ACK information to one TB;

or the DCI in a fallback mode feeds back one-bit HARQ-ACK information to one TB; and

for the later one, the DCI in at least one control resource set feeds back one-bit HARQ-ACK information to one TB.

Preferably, for each CBG, whether or not the CBG is transmitted is indicated by a bit; the predefined bit value is used for indicating whether or not the CBG is transmitted; alternatively, the predefined relative bit state is used for indicating whether or not the

CBG is transmitted.

Preferably, the predefined relative bit state is that, if the bit is reversed relative to the initial transmission of scheduling the same TB, it means that this CBG is not scheduled; and if the bit is unchanged relative to the initial transmission of scheduling the same TB, it means that the CBG is scheduled.

Preferably, the bit is used for indicating only on retransmission, and for the initial transmission, this bit is not used for indicating whether or not the corresponding CB/CBG is scheduled.

Preferably, if and only if this bit of all CBGs is reversed relative to the initial transmission of the previous TB of scheduling the same HARQ process, it represents the initial transmission of a new TB, otherwise retransmission is defined.

Preferably, whether or not the CBG is transmitted is indicated by a combination of part of control parameters for each CBG; and

preferably, a number of currently scheduled CBGs is indicated by N bits.

Preferably, if at least one retransmitted CBG is scheduled in one DCI, the size of the retransmitted CBG determined according to the DCI needs to be the same as the size of the CBG determined by the DCI in which the same CBG is scheduled last time;

alternatively, if at least one retransmitted CBG is scheduled in one DCI, the TB size indicated by the DCI needs to be the same as the TB size indicated by the DCI in which the same CBG is scheduled last time.

Preferably, the receiving the PDSCH includes:

if the PDCCH schedules to retransmit data of a part of CB, CBG or OFDM symbols of the TB, determining by the UE to retransmit the CB, CBG or OFDM symbols which are affected, and decoding the PDSCH by the UE according to the retransmitted CB, CBG or OFDM symbols;

alternatively, indicating, by the PDCCH, whether or not the data of the currently retransmitted TB, CB, CBG or OFDM symbols is affected, and decoding the PDSCH by

the UE;

alternatively, indicating the UE by the PDCCH to determine whether or not to execute HARQ combination on the data of the currently retransmitted TB, CB, CBG or OFDM symbols, and decoding the PDSCH by the UE.

Preferably, the receiving the PDSCH includes:

receiving the retransmitted CB, CBG or OFDM symbols which are affected in a fast retransmission time window, or receiving the whole retransmitted TB in the fast retransmission time window.

Preferably, if the same retransmitted TB is received in the fast retransmission time window, the UE determines that the TB is affected; otherwise, the UE determines that the TB is not affected;

or the UE determines whether or not the currently retransmitted CB, CBG or OFDM symbols or the whole TB is affected according to an instruction in the PDCCH.

Preferably, the method further includes:

defining the processing capacity of the UE according to a reference value of a set of system parameters; and when the system parameters of the UE in actual work are different from the reference value, obtaining the processing capacity of the current UE in an actual work scene according to the reference UE processing capacity.

Preferably, the determining processing capacity of the current UE in an actual work scene according to the reference UE processing capacity includes:

determining the processing capacity of the current UE in the actual work scene according to the reference UE processing capacity and a change factor of the UE processing capacity, wherein the length of a reference TTI is T_{ref} , the length of a TTI of the UE in actual work is T , and the change factor of the UE processing capacity is T/T_{ref} ;

alternatively, the UE processing capacity is equal to the reference UE processing capacity.

Preferably, the determining rate matching of the PDSCH includes:

for one category of service, processing the rate matching of the PDSCH only

according to the control resource set of the one category of service and a set of time-frequency resources which cannot be used for transmitting the PDSCH;

alternatively, for one category of service, when performing rate matching, considering the control resource set of the one category of service and the set of the time-frequency resources which cannot be used for transmitting the PDSCH, and also considering the control resource set of another category of service and the set of the time-frequency resources which cannot be used for transmitting the PDSCH.

A data transmission device includes a PDCCH detecting and analyzing module, a PDSCH receiving module, a HARQ-ACK information generating module and a HARQ-ACK transmitting module, wherein

the PDCCH detecting and analyzing module is configured to determine a PDCCH for scheduling the PDSCH on a configured control resource set and analyzing the detected PDCCH;

the PDSCH receiving module is configured to determine methods for dividing CBs and rate matching of a PDSCH according to the detected PDCCH, and receive the PDSCH according to the detected PDCCH;

the HARQ-ACK information generating module is configured to generate HARQ-ACK information according to the detected PDSCH; and

the HARQ-ACK transmitting module is configured to transmit the HARQ-ACK information.

With adoption of the method according to the present disclosure, when the service with low delay demand punches the time-frequency resource of other services, the performances of other services are improved as much as possible, thus improving the resource utilization rate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a frame structure of a LTE FDD system;

FIG. 2 is a schematic diagram of punching a time-frequency resource of a first

category of service by a second category of service.

FIG. 3 is a flowchart according to the present disclosure;

FIG. 4 is a schematic diagram of dividing CBGs according to a MTU according to the present disclosure;

FIG. 5 is a schematic diagram of fast HARQ retransmission according to the present disclosure;

FIG. 6 is a schematic diagram 1 of RE mapping of a PDSCH according to the present disclosure;

FIG. 7 is a schematic diagram 2 of RE mapping of a PDSCH according to the present disclosure;

FIG. 8 is a diagram of a device according to the present disclosure; and

FIG. 9 is a schematic diagram of CB/CBG mapping of a PDSCH of two TBs according to the present disclosure.

DETAILED DESCRIPTION

In order to make the purpose, the technical scheme and the advantages of the present disclosure more clearly understood, the present disclosure is further described in detail with reference to the accompanying drawings and embodiments below.

FIG. 3 is a flowchart according to the present disclosure.

Step 301: Detect, by a UE, a PDCCH on a configured control resource set.

In a downlink TU or MTU, a base station may configure Q Control Resource sets for the UE, and Q is more than or equal to 1. One control resource set corresponds to one or more OFDM symbols in time and corresponds to one or more PRBs in frequency. One PDCCH is mapped to one control resource set. The UE detects the PDCCH on the control resource set configured by the base station.

Step 302: Analyze, by the UE, the detected PDCCH, determine a method for dividing code blocks (CB) and a method for PDSCH RE mapping, and receive the PDSCH accordingly.

According to features of services, for some services, such as those that pursue greater throughput, including eMBB services, the length of TTI may be relatively large, which is conducive to reducing the overhead of control signaling, hereinafter referred to as a first category of service. For example, one TB of the first category of service may be mapped to one TU for transmission. For another services, such as services with higher time delay requirements, including URLLC services, a relatively short TTI may be adopted, hereinafter referred to as a second category of service. For example, one TB of the second category of service may be mapped to one MTU for transmission.

The UE may determine TBS according to received DCI carried by the PDCCH, and correspondingly divide the CB and/or CB groups (CBG), so that operations such as decoding may be performed on a data channel. In this case, the TB may be divided into multiple CBs, and then the multiple CBs are grouped into multiple CBGs; or the TB may be divided into multiple CBGs, and then each CBG is further divided into one or more CBs. Particularly, during data retransmission, the base station may retransmit the whole TB, or may only retransmit part of CBs or CBGs of the current TB or modulation symbols on part of OFDM symbols. Correspondingly, after receiving the DCI, the UE may execute HARQ combination to receive data; or the UE may cover related soft bits in a soft cache with the received retransmission soft bits.

Step 303: Generate, by the UE, HARQ-ACK information according to the received PDSCH, and transmit the HARQ-ACK information.

The data transmission processing method according to the present disclosure is described below in conjunction with embodiments.

Embodiment 1

For a second category of service, in order to reduce the time delay as much as possible, a part of time-frequency resources already used for a first category of service may be occupied, which causes interference to the first category of service. For example,



in FIG. 2, the first category of service occupies the whole TU for transmission, but a part of time-frequency resources of a second MTU are interfered by the second category of service. When the TB of the first category of service only includes one CB, the CB is certainly affected by the second category of service, which may cause the receiving failure of the TB, resulting in that a base station has to retransmit the whole TB. When the TB of the first category of service is actually divided into multiple CBs for transmission, the interference from the second category of service is possibly mainly concentrated on a part of CBs. At a UE side, the CBs not subjected to interference may be correctly received, while the CBs subjected to interference may make an error. Especially when the transmission of the second category of service causes the punching of overlapping time-frequency resources of the first category of service, the affected CBs of the first category of service may not be correctly decoded. In FIG. 2, it is assumed that the TB of the first category of service is divided into two CBs, so the two CBs are basically mapped to the front half part and the rear half part of the TU for transmission, which is consistent with the division of the MTU. In this way, since a MTU 202 transmits the second category of service, the second CB is affected, which may make an error or certainly make an error, while the first CB may still be successfully transmitted with a great probability. Therefore, the base station may only need to retransmit the second CB, thus saving downlink resources.

It is assumed that the influence of the second category of service is not considered, from the perspective of reducing the CRC overhead of the CB and increasing the channel coding gain, it is needed to increase the size of the CB as much as possible. Therefore, it may be that when the TBS is greater than a first threshold K_1 , the operation of dividing the TB into CBs is triggered, and the size of each CB does not exceed K_1 ; and when the TBS is less than or equal to K_1 , the TB only includes one CB. The above reference K_1 may be predefined or configured by high layer signaling in a semi-static mode, for example, K_1 is equal to 6144 in a LTE system. According to the above analysis, the influence of the second category of service on the TB transmission of the first category

of service is favorably reduced by dividing the TB into the multiple CBs. However, when the TB size (TBS) is relatively small, the excessive CB division brings negative effects. On one hand, each CB needs to be independently added with CRC, so whether or not each CB is received correctly may be judged, which brings certain overhead; and on the other hand, when the size of the CB is reduced, the channel coding gain is correspondingly reduced, which is also not beneficial to improving the link performance. Therefore, according to the present disclosure, the operation of dividing the TB into CBs is triggered only when the TBS is greater than a second threshold K_2 , and the size of each CB does not exceed a third threshold K_3 ; and when the TBS is less than or equal to K_2 , the TB only includes one CB. The K_3 may be equal to K_2 , thus the same parameter may be used for setting. Alternatively K_3 may also be less than K_2 . At this time, once the CB division is needed, more CBs may be divided. K_2 is less than or equal to K_1 . K_2 and/or K_3 may be predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH.

When K_2 is configured to be less than K_1 , on one hand, the TB is limited to be very small, namely, when the TBS is less than or equal to K_2 , CB division is not performed, thus reducing the overhead of CRC and ensuring the channel coding gain; on the other hand, in order to consider the possible influence of the second category of service, the TBS does not need to exceed K_1 , and as long as the TBS exceeds K_2 , CB division will be triggered, therefore, the second category of service may only affect part of the CB of this TB, and the resource utilization rate may be increased. The value of the above K_2 and/or K_3 may also be related to the TBS. For example, when TBS is less than or equal to $c \cdot K_1$, the value of K_2 is $K_{2,1}$; otherwise, the value of K_2 is $K_{2,2}$, $K_{2,1} < K_{2,2} \leq K_1$. c is a predefined constant, or a value configured by high layer signaling in a semi-static mode. $K_{2,1}$ and/or $K_{2,2}$ may be predefined, and configured by high layer signaling in a semi-static mode. When the TBS does not exceed $c \cdot K_1$, K_2 is set to be smaller $K_{2,1}$, thus increasing the number of the CBs in division; when TBS is larger, K_2 is increased to be $K_{2,2}$, thus increasing the size of the CB, and therefore, the channel coding gain is

increased under the condition that the TB is still divided into enough CBs.

With adoption of the above method, the number of the CBs divided from the TB may be increased, and the influence of overlapping time-frequency resources occupied by the second category of service may be reduced. However, because the CB division operation is not directly associated with a structure of dividing the TU into the MTU, there is still a phenomenon that the time-frequency resources mapped by one CB cross two adjacent MTUs. When there is only one MTU used for the second category of service, although only a part of modulation symbols of the CB are affected by the second category of service, the CB is possibly still not correctly received.

According to the present disclosure, the TB may be divided into M CBGs, and each CBG includes one or more CBs. A method for dividing the TB into the CBGs is that the TB is divided into M1 CBs firstly, the bit numbers of the respective CBs may be equal as much as possible, for example, in a LTE system, a method for determining the total number of the CBs and the bit numbers of the respective CBs according to the TB size and the maximum bit number 6144 of the CBs is adopted; then, the M1 CBs are mapped into the M CBGs, $M1 \geq M$. For example, one TB only includes two CBs, then, the number of the CBGs is certainly less than or equal to 2. When $M1 > M$, the number of the CBs in each CBG is determined according to the principle that the M1 CBs are evenly distributed to the M CBGs as much as possible. When M cannot be divided by M1 exactly, the number of the CBs in the respective CBGs is not completely equal. Alternatively, another method for dividing the TB into the CBGs is that the TB is divided into M small blocks firstly, each small block is further divided into one or more CBs, namely, one small block corresponds to one CBG, each CBG includes one or more CBs, and M is the number of the CBGs. M may be predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH. M may be less than or equal to the number of MTUs in one TU. In order to control the CRC overhead of the CBs and guarantee the channel coding gain, the method for dividing the TB into the M CBGs may be executed only when the TBS is greater than a fourth threshold K_4 . K_4

may be predefined, configured by high layer signaling in a semi-static mode, or dynamically indicated in the PDCCH.

The TB may be equally divided into M CBGs, namely, the bit number of each CBG is equal to $\lceil TBS/M \rceil$ or $\lfloor TBS/M \rfloor$; or the bit number of each CBG is approximately equal to $\lceil TBS/M \rceil$ or $\lfloor TBS/M \rfloor$, but the bit number of one CBG may be adjusted according to other criteria.

For M CBGs divided from one TB, the modulation symbol of one CBG may be only mapped to one or more MTUs, and the modulation symbols of different CBGs are mapped to different MTUs. As shown in FIG. 4, it is assumed that one TU is divided into two MTUs 401 and 402. It is assumed that time-frequency resources 411 and 412 are scheduled on the TU for the first category of service, the time-frequency resource 411 is at the MTU 401, and the time-frequency resource 412 is at the MTU 402. In this case, it is assumed that the TB of the first category of service is divided into two CBGs which are respectively mapped to the time-frequency resources 411 and 412. A new second category of service is generated before the MTU 402 and needs to be quickly processed, and the base station may schedule the time-frequency resource 421 on the MTU 402 for the second category of service. Based on the scheduling of the base station, for example, if there are not enough time-frequency resources in the MTU 402, one part or all of the time-frequency resource 421 possibly overlaps with the time-frequency resource 412. Because the first CBG is only mapped to the time-frequency resource 411, the first CBG may not be affected by the second category of service, and the CB of the first CBG may still be successfully transmitted with a larger probability.

The bit number of each CBG may be the number, in direct proportion to the MTUs mapped by the CBG, of REs which are used for data transmission. For example, it is assumed that one TU is divided into two MTUs, the TB is divided into two CBGs, the total number of REs used for data transmission of the PDSCH in the TU is recorded as N , the number of the REs used for data transmission of the PDSCH in the first MTU is recorded as N_1 , and the allocated bit number of the first CBG is about $\lceil TBS \cdot N_1/N \rceil$.

Alternatively, the bit number of each CBG may be the OFDM symbol number that is in direct proportion to the MTUs mapped by the CBG. For example, it is assumed that one TU is divided into two MTUs, the TB is divided into two CBGs, the OFDM symbol number of this TU is recorded as S ; the OFDM symbol number of the first MTU is S_1 , and the allocated bit number of the first CBG is about $\lceil TBS \cdot S_1 / S \rceil$. With adoption of this method, because the number of the REs which cannot be used for data transmission in each MTU may be different, the coding rates of the two CBGs may be different. If the OFDM symbol number of the MTU may be variable, namely, the number of the MTUs in one TU may be variable, and the positions of the MTUs in the TU may also be variable; and in this case, the bit of one CBG may be mapped to two adjacent MTUs. However, by adopting the method for dividing the TB into M CBGs, one CBG is mapped to the whole OFDM symbol, which is favorable for reducing the influence on second category of service.

For a transmission mode that supports simultaneous transmission of two TBs, such as MIMO transmission, multiple layers are transmitted in parallel on the same time-frequency resource, and the two TBs are carried; because signal to noise ratios on different layers are generally different, and correspondingly, TBSs of the two TBs are generally different. Because the TBSs are different, if the same maximum CB size is adopted during CB division, the number of CBs divided from the two TBs will be different. In this case, the influence of transmission of the second category of service on the two TBs is different. For example, it is assumed that the first TB is relatively large, it is divided into two CBs; and the second TB is relatively small, and it is only processed as one CB. The second category of service may only affect one CB of the first TB, but the whole second TB will be affected. For downlink transmission, the base station may need to transmit the affected CB of the first TB and the whole second TB, which increases the overhead on PDCCH indicating data transmission. Based on the above method for dividing the TBs into M CBGs, although the TBSs of the two TBs may be different, it is always ensured or ensured as much as possible that the number of the CBGs divided



from the two TBs is equal, and thus data retransmission may be processed by the consistent method.

Under different conditions, the number M of the CBGs divided from one TB may be determined separately, namely, the values of the M under different conditions may be the same or different. $M=1$ is a special condition, namely, it is the same as the LTE system, and if no CBG is divided from one TB, one TB is considered as one CBG. The above different conditions may refer to distinguishing different categories of services, for example, the values of the M for the TBs of the first category of service and the second category of service are different. The different conditions may refer to distinguishing DCI formats, namely, the values of the M for the TBs scheduled under different DCI formats are different. For example, different DCI formats may be adopted to schedule services of different categories, so that the values of the M may be determined according to the DCI formats. Alternatively the values of the M are determined by combining cell public/user special search space. The different conditions may refer to distinguishing multiple sets of downlink control channel resources, namely, the values of the M for the TBs transmitted under different downlink control channel resource sets are different. The different conditions may refer to distinguishing system parameters (Numerology), namely, the values of the M for the TBs transmitted under different system parameters are different. The system parameters may refer to sub-carrier spacing (SCS) and/or TTI length, for example, the TTI length may depend on whether or not the TBs are mapped to one TU or MTU and the like. For example, data of the services of different categories may be transmitted with different system parameters, so that the values of the M may be determined according to the system parameters. Actually, the values of the M may also be determined according to multiple combinations of the parameters. The values of the M under different conditions may be predefined, or may be determined by high layer signaling configuring. The method for dividing the TBs into the multiple CBGs may be applied to all TUs and/or MTUs; or it may be only applied to a part of the TUs and/or MTUs. This part of the TUs and/or MTUs may be predefined and are configured by high

layer signaling in a semi-static mode.

For data transmission based on HARQ, the UE may feed back N bits to one TB, and N is greater than 1. Correspondingly, after the base station receives HARQ-ACK information of each CBG, the CBG that is not properly received by the UE may be only retransmitted, and therefore, the downlink resource utilization rate is increased. For example, the method for dividing the TB into M CBGs may be adopted, and correspondingly, the UE may feed back the HARQ-ACK information to each CBG. The present disclosure does not limit the use of other methods for generating multi-bit HARQ-ACK information for one TB. These methods are collectively called as a multi-bit HARQ-ACK feedback method. Another HARQ-ACK feedback method is to only feed back one HARQ-ACK bit to one TB, namely a single-bit HARQ-ACK feedback method. Under different conditions, the methods for feeding back the HARQ-ACK information to one TB may be different. As mentioned above, the HARQ-ACK feedback methods may be independently configured for the services of different categories, or DCI formats and/or cell public/user special search spaces or downlink control channel resource sets, or system parameters.

Before the multi-bit HARQ-ACK feedback method is configured, the UE may determine to adopt the single-bit HARQ-ACK feedback method on all scheduled TUs and/or MTUs, namely, feeding back one bit of HARQ-ACK information to one TB is a default operation. The multi-bit HARQ-ACK feedback method may be applied to all the scheduled TUs and/or MTUs; alternatively, HARQ-ACK processing methods adopted on different TUs and/or MTUs may be different. That is, the multi-bit HARQ-ACK feedback method is performed on a part of TUs and/or MTUs, and the single-bit HARQ-ACK feedback method is performed on the other part of TUs and/or MTUs.

When the multi-bit HARQ-ACK feedback method is configured/reconfigured, in order to solve the possible confusion of the base station and the UE on the current HARQ-ACK feedback method, the following method may be adopted. The first method is to define that some DCIs are fixedly subjected to the single-bit HARQ-ACK feedback

method. For example, the DCI in the common search space (CSS) is fixedly subjected to the single-bit HARQ-ACK feedback method, or the HARQ-ACK feedback method of the DCI in the USS is configured by high layer signaling. Particularly, the DCI in the CSS may also be fixedly subjected to the single-bit HARQ-ACK feedback method, and the DCI in a user specific search space (USS) is fixedly subjected to the multi-bit HARQ-ACK feedback method.

Generally, the base station may be that the UE is configured to simultaneously adopt two transmission modes; one is a normal transmission mode which may fully utilizes the channel conditions and the capacity of the UE to improve the downlink transmission performance; and the other is a fallback DCI which is generally used for improving the receiving reliability of the DCI and the data transmission. Therefore, the second method is that the fallback DCI only supports the single-bit HARQ-ACK feedback method, and the HARQ-ACK feedback method of the DCI in the normal transmission mode is configured by high layer signaling. Particularly, the fallback DCI is fixedly subjected to the single-bit HARQ-ACK feedback method, and the HARQ-ACK feedback of the DCI in the normal transmission mode is fixedly subjected to the multi-bit HARQ-ACK feedback method.

In addition, the base station may be that the UE is configured to detect the PDCCHs on multiple control resource sets. The different control resource sets may be subjected to different PDCCH transmission methods, such as local transmission and distributed transmission; and the multiple control resource sets are configured, which is beneficial to providing the flexibility of multiplexing the PDCCHs of the respective UEs and ensuring the transmission performance of the PDCCHs of the respective UEs. The third method is that on the multiple control resource sets of the configured UE, it may be that the DCI of at least one control resource set is fixedly subjected to the single-bit HARQ-ACK feedback method, and the HARQ-ACK feedback methods for DCI of other control resource sets are configured by high layer signaling. Particularly, it may be that the DCI of the at least one control resource set is fixedly subjected to the single-bit HARQ-ACK



feedback method, and the DCI of other control resource sets is fixedly subjected to the multi-bit HARQ-ACK feedback method.

Embodiment 2

For downlink data transmission, it is assumed that one-time transmission of a TB of a first category of service partially overlaps with a time-frequency resource of a second category of service, for example, a base station only transmits data of the second category of service on the overlapping time-frequency resource; when the first category of service is retransmitted, the base station may only retransmit the data of the first category of service carried by the time-frequency resource, affected by the second category of service, of the TB, for example, only an affected CB or CBG is retransmitted, or the whole TB is retransmitted; alternatively, only retransmitting the data of the affected time-frequency resources may refer to only retransmitting the data of the affected PRB and/or OFDM symbol, or only retransmitting the data on the affected MTU.

The retransmitting the affected CB, CBG or time-frequency resources may be implicitly indicated. For example, it is assumed that DCI schedules to retransmit a part of CBs or CBGs, or the DCI schedules to retransmit the data of a part of time-frequency resources in previous transmission, the UE may determine to retransmit the data on the affected CB and CBG or the affected time-frequency resources. For the situation of scheduling to retransmit the whole TB, it is needed to indicate in the DCI whether or not the TB is affected by the second category of service, or it is needed to indicate that the UE may perform HARQ combination and decoding on this TB, or may not perform HARQ combination and may only perform decoding according to the retransmitted TB. It is assumed that scheduling to retransmit the DCI indicates the affected CB or CBG, the UE may clear the cached soft bits corresponding to these CBs or CBGs and perform decoding according to received retransmitted soft bit information of the CBs or CBGs, and therefore, whether or not the TB, the CB and/or the CBG are/is successfully received

or not can be determined. Alternatively, it is assumed that scheduling to retransmit the DCI indicates that the TB is affected by the second category of service, the UE may clear the cached soft bits of the TB and perform decoding according to received retransmitted soft bit information of the TB, and therefore, whether or not the TB is successfully received can be determined. Alternatively, it is assumed that scheduling to retransmit the DCI indicates the affected time-frequency resources, the UE may clear the cached soft bits corresponding to the affected time-frequency resources and perform decoding according to received retransmitted soft bit information of the affected time-frequency resources, and therefore, whether or not the TB, the CB and/or the CBG are/is successfully received can be determined.

During retransmission, it may also indicate in the DCI whether or not the currently retransmitted TB, CB, CBG, or the data of time-frequency resources is affected by the second category of service. When the base station retransmits one CB or CBG of the TB, it may further indicate in the DCI whether or not the currently transmitted CB or CBG is affected by second category of service in previous transmission. It is assumed that according to the received DCI, for the CBs or CBGs that are affected by the second category of service, the UE may clear the cached soft bits corresponding to these CBs or CBGs, and perform decoding according to the received retransmitted soft bit information of these CBs or CBGs; and for the CBs or CBGs that are not affected by the second category of service, the UE may perform HARQ combination on the soft bits of these CBs or CBGs and then perform decoding. Alternatively, when the base station retransmits the TB, it may further indicate in the DCI whether or not the currently retransmitted TB is affected by the second category of service in the previous transmission. It is assumed that according to the received DCI, for the TB that is affected by the second category of service, the UE may clear the cached soft bits of the TB and perform decoding according to the received retransmitted soft bit information of the TB; and for the TB that is not affected by the second category of service, the UE may perform HARQ combination on the these soft bits of the TB and then perform decoding.



Alternatively, the base station may indicate in the DCI that the currently retransmitted data are the data of which one or which time-frequency resource in the previous transmission, and further indicate in the DCI whether or not the data of the currently retransmitted time-frequency resources is affected by the second category of service. According to the received DCI, for the time-frequency resources that are affected by the second category of service, the UE may clear the cached soft bits corresponding to the affected time-frequency resources and perform decoding according to received retransmitted soft bit information corresponding to the affected time-frequency resources; and for the time-frequency resources which are not affected by the second category of service, the UE perform HARQ combination on the soft bits of these time-frequency resources and then perform decoding.

During retransmission, it may also directly indicate in the DCI the operation of the UE performing on the currently retransmitted TB, CB, CBG, or the data of time-frequency resource. That is, it may indicate that the UE may perform HARQ combination and decoding on the data of the TB, CB, CBG, or time-frequency sources; alternatively, it indicates that the UE may not perform HARQ combination, but may perform decoding according to the data of retransmitted TB, CB, CBG, or time-frequency resources. Specifically, not performing HARQ combination means that if the data of a part of the CB, CBG, or a part of the time-frequency resources in the previous transmission is retransmitted, the UE may clear the cached soft bits corresponding to this part of the CB, CBG, or time-frequency resources, and perform decoding according to the retransmitted soft bit information of this part of the CB, CBG, or time-frequency resources; and if the whole TB is retransmitted, the UE may clear the cached soft bits of this TB and perform decoding according to the received retransmitted soft bit information of this TB.

It is assumed that the UE still feeds back the HARQ-ACK information to one TB; for one-time transmission of the TB of the first category of service, because of the influence of the second category of service, the affected CB or CBG may make an error,

resulting in the UE feeding back a NACK to the TB; in this case, the feedback of HARQ-ACK does not have much reference value for the base station, and the base station may indicate and retransmit the affected CB or CBG according to the above method. After the UE re-receives and decodes the affected part of the CB or CBG, the HARQ-ACK information of the TB fed back by the UE reflects whether or not the current TB is successfully transmitted. If the UE feeds back a ACK, it means that the TB is received correctly. If the UE feeds back the NACK, which may be caused by a sudden error or an improper link adaptation, the base station may retransmit the TB based on this HARQ-ACK information and adjust the data transmission parameters to the UE accordingly.

Alternatively, it is assumed that the HARQ-ACK feedback of the UE is enhanced so that the UE feeds back multi-bit HARQ-ACK information to one TB, for example, the HARQ-ACK information is correspondingly fed back for different CBs or CBGs. At this time, the CB or CBG affected by the second category of service may not be received correctly with a relatively high probability or may not be received correctly at all; the HARQ-ACK information fed back by the UE is generally a NACK, and the base station may indicate and retransmit the affected CB or CBG according to the above method; for the CBs or CBGs that are not affected by the second category of service, the HARQ-ACK information fed back by the UE indicates whether or not these CBs or CBGs are successfully received, so as to assist in the retransmission of the base station.

It is assumed that in the TU n , if the transmission of the second category of service affects the transmission of the first category of service, the base station may finish retransmitting the affected CB, CBG or the data of the affected time frequency resource or retransmitting the whole TB in the fast retransmission time window, such as $[n+1, n+g]$. The retransmission may be performed through the same HARQ process ID as the previous transmission of the TB. The value of a parameter g may enable the base station to retransmit the affected CB, CBG, the data of the affected time frequency resource or the whole TB before the UE feeds back the HARQ-ACK information; alternatively, it may enable the base station to retransmit the affected CB, CBG, the data

of the affected time frequency resource or the whole TB before receiving the HARQ-ACK information fed back by the UE; or the current round trip time (RTT) of the HARQ is recorded as r , g is less than r , that is, the affected CB, CBG, the data of the affected time frequency resource or the whole TB is retransmitted before the fixed time limited by the RTT for the base station to retransmit the TB. The UE may respectively feed back the HARQ-ACK information of the PDSCH of the TU n and the retransmitted HARQ-ACK information in the fast retransmission time window. Alternatively, the UE may only feed back the retransmitted HARQ-ACK information in the fast retransmission time window. The UE may determine whether or not the first category of service is affected by the second category of service according to whether or not retransmission of the TB is received in the fast retransmission time window. Specifically, if the UE receives the retransmission of the same TB in the fast retransmission, the UE may determine that the TB of the first category of service is affected by the second category of service, and therefore the UE may clear the cached soft bits corresponding to the affected CB or CBG or affected time frequency resources or the whole TB, and perform decoding according to received retransmitted soft bit information corresponding to the affected CB or CBG or affected time frequency resources or the whole TB, and thus whether or not the TB, CB and/or CBG is successfully received can be determined. In addition, if the UE receives retransmission of the same TB outside the fast retransmission time window, the UE may determine that the TB of the first category of service is not affected by the second category of service, and the UE may perform HARQ combination and then perform decoding. Alternatively, no matter whether or not retransmission is carried out in the fast retransmission time window or outside the fast retransmission time window, whether or not currently retransmitted the CB or CBG or data of time frequency resources or the whole TB is affected by the second category of service may be further indicated in DCI for scheduling retransmission.

As shown in FIG. 5, it is assumed that the base station schedules the TB of the first category of service at a downlink TU 501, the UE may feed back the HARQ-ACK



information at an uplink TU 521, so that the base station may retransmit the TB at a downlink TU 502 under the condition that ID confusion is not generated in the HARQ process. It is assumed that the second category of service interferes with the transmission of the first category of service at the downlink TU 501, the base station may determine or almost determine that the TB cannot be successfully transmitted. When the TB is divided into multiple CBs or CBGs, the CBs or CBGs interfered by the second category of service are likely to make an error or certainly make an error, and other CBs or CBGs are successfully transmitted at a relatively high probability. At the moment, the base station may retransmit the TB in one fast retransmission window, and as shown in FIG. 5, the base station is assumed to retransmit the TB at a downlink TU 511 or only retransmit the affected CBs or CBGs or data of affected time-frequency resources. Corresponding to the retransmission at the downlink TU 511, the UE feeds back the HARQ-ACK information at an uplink TU 522; and according to the HARQ-ACK information, the base station may determine that the TB needs to be continuously retransmitted at the downlink TU 512, or a new TB may be transmitted.

Embodiment 3

For a system supporting variable sub-carrier space (SCS) and/or TTI length, such as a 3GPP NR system, the SCS and TTI length in actual operation of the UE are not fixed according to actual network configuration. Accordingly, the processing capacity of the UE within one TTI is also varied depending on the current processing time requirement according to the SCS and TTI length in actual operation, including the maximum TBS that can be modulated and the total number of TBSs that can be modulated of multiple TBs.

When defining the UE Category, the reference processing capacity of the UE may be defined according to the reference values of a set of system parameters, including the bit number of soft cache, the maximum TBS that may be demodulated within one TTI, the sum of the TBSs that can be modulated of the multiple TBs within one TTI, and the

like. The system parameters used for defining the reference processing capacity of the UE may include SCS, TTI length, bandwidth and/or processing delay requirement, and the like. For example, the reference values of the system parameters may be SCS of 15 kHz and TTI length of 1 ms. When the SCS and/or TTI length of the UE in actual operation are/is different from the reference values, the processing capacity of the current UE in the actual operation scene is obtained according to the reference processing capacity of the UE. The factor of capacity change may be equal to the value obtained by dividing the metric calculated according to the actual values of the system parameters by the metric calculated according to the reference values of the system parameters. For example, if the reference TTI length is recorded as T_{ref} , and the TTI length of the UE in actual operation is T , the factor of capacity change may be T/T_{ref} , and if the maximum TBS that may be calculated of the UE in the reference TTI is recorded as TBS_{max} , the maximum TBS that can be modulated of the UE in actual operation is $[TBS_{max} \cdot T/T_{ref}]$. Alternatively, when the SCS and/or TTI length of the UE in actual operation are/is different from the reference values, it may be determined that the processing capacity of the UE in the current actual operation scene is still equal to the reference processing capacity of the UE. For example, it is assumed that the reference UE processing capacity is defined according to bandwidth of 20 MHz and TTI length of 1 ms, and it is assumed that the UE can support bandwidth of 40 MHz, the base station may configure the UE to operate over the bandwidth of 40 MHz when the TTI length is 0.5 ms; and it is assumed that the processing delay requirement is not changed, the sum of the maximum TBS that can be processed by the UE and the TBSs of the respective TBs may be unchanged. In this example, if the reference TTI length is 1 ms, the reference bandwidth is 20 MHz, the actual TTI length is 0.5 ms, and the actual bandwidth is 40 MHz, it may be determined that capability change factor = (actual TTI length $\times$ actual bandwidth) / (reference TTI length $\times$ reference bandwidth) = 1, so that the processing capacity of the UE is unchanged.

Alternatively, when defining the UE Category, the processing capacity of the UE



may be separately defined according to different values of system parameters. The system parameters for defining the processing capacity of the UE may include SCS and/TTI length and the like. The processing capacity includes the bit number of soft cache, the maximum TBS that can be demodulated within one TTI under a certain processing delay requirement, the sum of the TBSs that can be modulated of the multiple TBs, and the like. According to different system parameters, the defined UE processing capacity is generally different. For example, when the TTI is shortened and the requirement of the processing delay is increased, the maximum TBS supported by the UE in the TTI is reduced.

Embodiment 4

For downlink transmission, control information is transmitted in some time-frequency resources within a TU or MTU, including a PDCCH, and a PDSCH is transmitted in other time-frequency resources. When rate matching is carried out on the PDSCH, the influence of the time-frequency resources allocated for the PDCCH needs to be considered. The method for processing PDSCH rate matching related to a control channel according to the present disclosure is described below.

On one hand, part or all of multiple control resource sets detected by a configured UE cannot be used for transmitting the PDSCH. The first processing method is that: it is assumed that the UE detects a PDCCH for scheduling the PDSCH of the UE on one control resource set, the UE determines that all time-frequency resources of the control resource set cannot be used for transmitting the PDSCH of the UE; and for other control resource sets that the PDCCH for scheduling the PDSCH of the UE is not detected, if it overlaps with the PDSCH of the UE in current scheduling, the control resource sets can be used for data transmission of the UE when other limiting conditions are not violated. The second processing method is that: if the configured UE detects all the control resource sets with the PDCCH, the UE determines that all time-frequency resources of each control resource set do not transmit the PDSCH.

On the other hand, a set of time-frequency resources which cannot be used for transmitting the PDSCH may be configured by high layer signaling. A typical configuration is that the set of time-frequency resources which cannot be used for transmitting the PDSCH includes a control resource set which can be used for transmitting this UE or other UEs. However, the present disclosure does not limit the inclusion relation, and a specific method for configuring the set of time-frequency resources which cannot be used for transmitting the PDSCH and the control resource set may be determined by the base station. Except for the set of time-frequency resources which cannot be used for transmitting the PDSCH, if the time-frequency resources of one control resource set overlap with the PDSCH of the UE in current scheduling, the set of time-frequency resources can be used for data transmission of this UE when other limiting conditions are not violated. Here, the set of time-frequency resources which cannot be used for transmitting the PDSCH can be configured only by the high layer signaling; alternatively, N sets of time-frequency resources which cannot be used for transmitting the PDSCH may be configured by the high layer signaling, and the set of time-frequency resources which cannot be used for transmitting the PDSCH and is required to be avoided in RE mapping of the current PDSCH is dynamically indicated in the current PDCCH.

When the first category of service and the second category of service coexist, a control resource set may be configured for each category of service, and a set of time-frequency resources which cannot be used for transmitting the PDSCH is configured for each category of service. A first method for processing rate matching is that: for one category of service, during rate matching, the rate matching of the PDSCH may only be processed according to the control resource set of the category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH. As shown in FIG. 6, by taking the first category of service as an example, during rate matching, the rate matching of the PDSCH is processed according to the control resource set of the first category of service and the set of time-frequency resources which cannot be used for

transmitting the PDSCH, and other time-frequency resources can be used for PDSCH transmission if other limitations do not exist. A second method for processing rate matching is that: for one category of service, during processing of rate matching of the PDSCH, the control resource set of the category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH are considered, and the control resource set of the other category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH are also considered. As shown in FIG. 7, by taking the first category of service as an example, during processing of rate matching of the PDSCH, on one hand, the control resource set of the first category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH are considered, and on the other hand, the control resource set of the second category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH are also considered, and other time-frequency resources can be used for PDSCH transmission if other limitations do not exist. A third method for processing rate matching is that: for one category of service, during processing of rate matching of the PDSCH, the control resource set of the category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH are considered, and the control resource set of the other category of service is also considered. A fourth method for processing rate matching is that: for one category of service, during processing of rate matching of the PDSCH, the control resource set of the category of service and the set of time-frequency resources which cannot be used for transmitting the PDSCH are considered, and on the other hand, the set of time-frequency resources which cannot be used for transmitting the PDSCH for the other category of service is also considered.

Based on four methods for processing rate matching, rate matching of the two categories of services above may be processed by the same methods for processing rate matching; alternatively, rate matching may be processed by different methods for processing rate matching. For example, for the first category of service, the UE may



adopt the first method during rate matching. Therefore, on one hand, when the second category of service is not actually scheduled in one TU, or the PDCCH of the second category of service not overlaps with the PDSCH of the first category of service, the number of valid REs of the PDSCH of the first category of service is increased, so that the utilization rate of downlink resources is improved; and on the other hand, when the PDCCH of the second category of service overlaps with the PDSCH of the first category of service, the base station may punch the first category of service, namely the PDCCH of the second category of service is transmitted on overlapping time-frequency resources, so that the transmission of the second category of service is not affected. For example, for the second category of service, the UE may adopt the second rate matching method during rate matching. By this method, the transmission of the PDCCH of the first category of service may not be affected under the condition that the PDSCH of the second category of service is transmitted. Otherwise, when the PDSCH of the second category of service overlaps with the PDCCH of the first category of service, the PDSCH of the second category of service possibly influences the reception of the PDCCH of the first category of service because the base station needs to preferentially ensure the performance of the second category of service, and as a result, the normal transmission of the first category of service is seriously affected. For example, even if the scheduled PDSCH of the first category of service is not conflicted with the second category of service, the UE still cannot successfully receive the PDSCH of the first category of service because the second category of service interferes with the receiving of the PDCCH.

Embodiment 5

For a downlink data transmission, it is assumed that one transmission of a TB of the first category of service overlaps with time-frequency resources of the second category of service partially. For example, if the base station only transmits data of the second category of service on the overlapping time-frequency resources, when retransmitting the



first category of service, the base station may only retransmit CBs/CBGs on the time-frequency resources, affected by the second category of service, of the TB. Alternatively, when there is a large amount of data for downlink data transmission, that is, when the TB is large, the transmission result (successful or unsuccessful) of each CB/CBG within a TB may be different. For example, among M CBGs in a TB, only M_3 CBGs are transmitted incorrectly, while the UE receives $(M-M_3)$ CBGs correctly, and then the base station may only retransmit the M_3 CBGs of the TB.

Retransmissions in the present disclosure are divided into two types. One is that the UE needs to flush a HARQ buffer of the CBs/CBGs scheduled to be retransmitted, and the other is that the UE does not need to flush the HARQ buffer of the CBs/CBGs scheduled to be retransmitted, but to combine the received data with the HARQ buffer of the CBs/CBGs. For the UE, in an implementation method, the base station may instruct the UE so that the UE can distinguish (x) a new transmission, (y) a retransmission without needing the UE to flush the HARQ buffer of the CBs/CBGs scheduled to be retransmitted and (z) a retransmission with needing the UE to flush the HARQ buffer of the CBs/CBGs scheduled to be retransmitted. In another implementation method, the base station may instruct the UE so that the UE can distinguish the retransmission without needing the UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted from the new transmission or the retransmission with needing the UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted, but the UE cannot distinguish the new transmission from the retransmission with needing the UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted.

Preferably, the base station can only schedule CBGs that need retransmission (including y and z) in one transmission. That is, CBGs from different TBs are not allowed to be scheduled by the same DCI.

Alternatively, the base station may schedule both a retransmitted CBG and a newly transmitted CBG in one transmission.

In order to support scheduling the retransmission/the new transmission of the CBGs

flexibly, the downlink scheduling signaling DCI includes at least one of the following:

(1) Indications of a number of CB/CBGs scheduled to be transmitted

In an implementation method, (1.1) each CB/CBG has a separate bit field used for indicating whether or not the CB/CBG is transmitted. For example, it is assumed that the DCI may support a transmission of a maximum of 4 CBGs. Then, for the 4 CBGs, there is 1 bit in each CBG to indicate whether or not the base station schedules the CBG. For example, 1 represents scheduling, and 0 represents not scheduling. Alternatively, for the 4 CBGs, there is 1 bit in each CBG, if the 1 bit is toggled with respect to an initial transmission scheduling the same TB, it indicates that the CBG is not scheduled, and if the 1 bit is untoggled with respect to the initial transmission scheduling the same TB, it indicates that the CBG is scheduled. However, for the initial transmission, the bit may not be used to indicate whether or not the corresponding CB/CBG is scheduled, instead, the number of the CBs/CBGs scheduled at the initial transmission is determined by the TBS and a predefined CBs/CBG grouping rule.

In another implementation method, (1.2) whether or not the base station has scheduled the CB/CBG is indicated by a combination of part of control parameters for each CB/CBG. For example, the part of control parameters for each CB/CBG may refer to a NDI and a RV. It is assumed that the NDI is 1 bit, and the RV is 2 bits. Then, there are 8 types of combinations of the NDI and the RV. The system pre-defines one or more combinations of them, which indicates the CB/CBG is unscheduled to be transmitted. Preferably, the NDI indicating a new transmission is combined with a RV most unlikely to be used for a new transmission, for example, a combination of the NDI=1 and RV=1, indicating a new transmission or a combination of NDI=X1 and RV=Y1.

In another implementation method, (1.3) the number of CBs/CBGs scheduled by the base station is indicated by N bits. For example, the DCI may support a transmission of a maximum of 4 CBGs, N=2. Then, the base station may be instructed to schedule k CBs/CBGs, wherein k=1, 2, 3, or 4. When k<4, the CBs/CBGs from the 1st to the kth in the DCI are scheduled by default, then bit fields of the scheduled CBs/CBGs, such as



RV/NDI information, are valid, while the CBs/CBGs from the $(k+1)^{\text{th}}$ to the 4^{th} are not scheduled, the indication information of the bit fields of the unscheduled CBs/CBGs is invalid and may be used as redundant bits.

In another implementation method, (1.4) the number of CBs/CBGs of a TB (or multiple TBs, for example, 2 TBs that MIMO may support) scheduled by the base station is indicated by N bits, and in combination with (1.1), which CBs/CBGs are scheduled is determined and which CBs/CBGs are not scheduled is determined. Preferably, for a DCI scheduling an initial transmission of the TB, the number of CBs/CBGs indicated by the N bits is the number of CBs/CBGs scheduled by the DCI; for the DCI scheduling a retransmission of the TB, the number of CBs/CBGs indicated by the N bits is not the number of CB/CBGs scheduled by the DCI but the number of CBs/CBGs corresponding to the TB corresponding to the CBs/CBGs scheduled by the DCI. For example, it is assumed that one DCI may schedule up to 4 CBGs, then $N=2$ bits. The base station schedules one TB initially, which is divided into three CBGs, and the indication in the DCI scheduling the initial transmission is 10, and 1 bits in the CBGs are 1, 1, 1, 0 respectively. If the second CBG is affected by the URLLC service, the base station schedules the TB for the second time and only schedules the second CBG of the TB. Then, the indication in the DCI is still 10, which does not indicate that the three CBGs are scheduled this time, but indicates that the TB corresponding to the CBG has 3 CBGs. And the 1 bits in the CBGs are 0, 1, 0, 0, respectively. This is good because, when the UE receives a DCI again after missing the DCI scheduling the data transmission, the UE may determine the number of CBGs corresponding to the TB size in the DCI through the 2 bits so as to determine the CBG size, and determine whether or not the CBG is transmitted by the 1 bit of each CBG. In order to make the UE to determine which CBG in the last retransmission is combined with the CBG of the received retransmission, it is necessary to ensure that an index of the CBG used for the retransmission is the same as an index of the CBG to be combined in the last transmission.

For example, it is assumed that the DCI may support a transmission of a maximum

of 4 CBGs. In the downlink TU i1, the base station schedules 4 CBGs, all of which are new transmissions. The UE does not decode the third CBG transmission correctly, and feeds back a NACK, and the other three CBGs are decoded correctly, an ACK is fed back. In downlink TU i2, the base station schedules two CBGs, which are the first and third CBGs respectively, of which the first CBG is a new transmission and the third CBG is a retransmission. According to (1.1), the base station may set the 1-bit indication of the first CBG and the third CBG to be 1 to indicate being transmitted, and set the 1-bit indication of the second and fourth CBGs to be 0 to indicate being not transmitted. Alternatively, according to (1.2), the base station may set the NDI of the first CBG as a new transmission indication, and may set the RV to indicate a redundancy version, but the RV may not be equal to Y1 ($Y1=1$). The NDI of the third CBG is set as the retransmission indication, and RV indicates the redundancy version. And the NDIs of the second and the fourth CBGs are set as the new transmission, $RV=1$, indicating not transmitted. Alternatively, according to (1.3), the base station may set N to be 3 to indicate to retransmit 3 CBGs, CBGs from the first to the third. The fourth CBG is not transmitted. The method cannot support the CBGs of the new transmission to be transmitted together.

When the UE operates in a MIMO work mode, multiple TBs may be scheduled for one transmission. For the multiple TBs, each TB has a separate indication of a number of the CBs/CBGs scheduled to be transmitted. For example, for 2 TBs, each TB may have up to 4 CBGs that can be scheduled, and then each TB has 4 bits.

(2) HARQ relevant indications for each CB/CBG

In one implementation method, (2.1) includes an NDI indicating a retransmission or new transmission of each CB/CBG, as well as a RV indicating a redundancy version of each CB/CBG, and includes the NDI indicating a retransmission or new transmission of the TB; alternatively, (2.2) includes the NDI indicating the retransmission or new transmission of each CB/CBG, and the RV indicating the redundancy version of each CB/CBG.

In the context, the redundancy version corresponding to the RV bits may be predefined by the standard or configured by the high layer signaling.

In another implementation method, (2.3) includes only the NDI indicating the retransmission or new transmission of each CB/CBG and the TB-level redundancy version information and includes an NDI indicating the retransmission or new transmission of the TB; alternatively, (2.4) includes only the NDI indicating the retransmission or new transmission of each CB/CBG, as well as the TB-level redundancy version information.

For the redundancy version information, specifically, the redundancy version is used for all CBGs except the CBGs of (z). The redundancy version of the CBGs of (z) is predefined, for example $RV=0$.

Preferably, for the initial scheduling, the TB-level redundancy version information is applicable to all the CBs/CBGs.

Preferably, when all the retransmitted CBs/CBGs are (z), the TB-level redundancy version information is applicable to all the CBs/CBGs.

For example, a 2-bit RV in a DCI. The base station transmits a TB, which is divided into 4 CBGs. Because time-frequency resources of the third CBG overlaps with a URLLC, the base station transmits only the first, second, and fourth CBGs completely, and the third CBG is not transmitted completely, in the initial transmission. It is assumed that the UE decodes the first CBG correctly and the second and fourth CBGs are not decoded correctly. Therefore, the base station retransmits the second, third and fourth CBGs again. The 2-bit RV in the DCI is suitable for the second and fourth CBGs, while the RV of the third CBG is predefined as $RV=0$.

Preferably, the redundancy version information is indicated in a unit of a transmission block. In the context, if all the data blocks in the same scheduling are data blocks that are not scheduled initially for transmission and need the UE to flush the buffer, the redundancy version of the data blocks is determined according to the indicated redundancy version information. If data blocks in the same scheduling include data

blocks that are not scheduled initially for transmission and need the UE to flush the buffer and also include data blocks of other transmission states, the former is determined according to the predefined RV and the latter is determined according to the indicated RV information.

There is another implementation method, (2.5) includes an NDI that indicates a retransmission or new transmission of each CB/CBG and an NDI that indicates a retransmission or new transmission of the TB, and TB-level redundancy version information; alternatively, (2.6) includes an NDI that indicates a retransmission or new transmission of each CB/CBG and TB-level redundancy version information. The redundancy version information in the DCI is applicable to all the CBGs scheduled by the DCI, that is, it is applicable to the CBGs in all three states (x), (y) and (z). NDIs of all the methods stated above adopt toggled/untoggled forms to distinguish (x)/(z) from (y). In an implementation method, the toggled/untoggled forms are both relative to the latest transmission of the same TB scheduled. In another implementation method, the toggled/untoggled forms are both relative to the initial transmission of the same TB scheduled.

When the UE operates in a MIMO work mode, multiple TBs may be scheduled for one transmission. For multiple TBs, in an implementation method, each TB has a separate HARQ relevant indication of each CB/CBG. For example, for 2 TBs, each TB may have up to 4 CBGs that can be scheduled, and then each TB has 4 bits. In another implementation method, the multiple TBs share the HARQ relevant indication of each CB/CBG. By (1) indicating the HARQ information of the CB/CBG of the TB having a large number of CBs/CBGs at an initial transmission explicitly, or (2) by indicating the HARQ information of the CB/CBG of the TB having a large number of scheduled CBs/CBGs at each scheduling, the HARQ information of the CB/CBG of other TBs overlapping with the CB/CBG in time-frequency resources is indicated indirectly. When

all the TBs have the same number of CBs/CBGs, the HARQ information of the CB/CBG of the TBs with smaller TB indexes is indicated explicitly, for example, the first TB.

Preferably, when a CB/CBG of a TB_i overlaps with multiple CBs/CBGs of another TB_j , whether or not the CB/CBG of the TB_j is based on an indication of the corresponding CB/CBG of the TB_i to determine the state of the CB/CBG is determined according to a size of the overlapping resources. The size of the overlapping resources is a predefined RE number of the time-frequency resources or a proportion of a number of the overlapping REs and the total number of REs containing the CBs/CBGs of the REs. For example, if a CBG of the first TB indicates state (z), a RE of a CBG of the second TB overlaps with a RE of the CBG of the first TB, then if the CBG of the second TB is scheduled, then the state of the CBG is (y), and it does not need to flush the buffer.

Preferably, when a CB/CBG of a TB overlaps with multiple CBs/CBGs of another TB, and HARQ information indicated by the multiple CBs/CBGs is different, it is determined as (z). It should be noted that the HARQ indication information is only valid to the scheduled CBs/CBGs. For example, the base station schedules 2 TBs, wherein TB1 may be divided into 4 CBGs, and TB2 may be divided into 3 CBGs. A relationship of the time-frequency resources occupied by each CBG of the two TBs is shown in FIG. 9. Assuming that a downlink slot has 7 symbols, of which the third symbol is used for transmitting an URLLC, that is, the base station transmits eMBB services of the two TBs on symbols 1, 2, and 4 to 7, and transmits the URLLC on the third symbol. Then, when scheduling an eMBB retransmission, the base station instructs, in the DCI, to schedule the second CBG of TB1, and the HARQ state of the CBG is (z), i.e., a retransmission needing the UE to flush the HARQ buffer of the CBs/CBGs scheduled to be retransmitted. Then, if the first CBG and second CBG of TB2 are also scheduled in the DCI, the HARQ states of the two CBGs are both (z), because the first CBG and second CBG of TB2 overlap with the second CBG of TB1 on the time-frequency resources.

(3) Indications of a bit number of each CB/CBG.

The bit number refers to the bit number before channel coding.

The bit number refers to the bit number before CRC encoding.

Preferably, an implementation method (3.1): a number of CBGs is determined according to the method (1), and a size of each CBG is determined according to a TB size indicated in the DCI. For example, the CBG size may be determined by the number of CBs/CBGs corresponding to a TB indicated by the DCI in (1.4) and the TB size indicated by the DCI.

Preferably, another implementation method (3.2) may be that the bit number of each CB/CBG is indicated explicitly and separately, or the bit number of the CB/CBG of a reference is indicated explicitly, and an offset of a size of each CBG group, relative to the reference, is indicated. When the size of a CBG is indicated, the size of the CBG may be determined by a number of the RBs of the downlink TU, a MCS index, and a number of CBGs transmitted at the same time. For example, a size of the CBG, CBGS1, is determined by the number of RBs and the MCS index in the same way as the LTE, or the size of the CBG is determined as $\lceil \text{CBGS1}/M \rceil$ by the number of the RBs and the MCS index, as well as the number M of the CBGs.

Preferably, another implementation method (3.3) may be that the bit number of a CB/CBG is indicated explicitly and the bit number of each CB/CBG is equal.

Preferably, the indication of the bit number of each CB/CBG may also indicate jointly modulation coding information.

Preferably, it is not required to indicate the bit number of each CB/CBG explicitly. The bit number of each CB/CBG is determined by a TBS, a predefined CB/CBG grouping rule.

(4) Indications of a transmission state of each CB/CBG.

The transmission state of the CB/CBG may be one of the following:

(4.1) The transmission state of the CB/CBG is (x)/(z) or (y) for the transmission block.

(4.2) The transmission state includes (x) a new transmission (initial scheduling transmission), (y) a retransmission without needing the UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted, (z) a retransmission with needing the UE to flush the HARQ buffer of the CBs/CBGs scheduled to be retransmitted, and (w) being untransmitted/unscheduled. For example, the four states may be represented by 2 bits: 00 means (x), 01 means (y), 10 means (z), and 11 means (w).

For example, the number of CBGs that may be scheduled by the base station is up to 4. The base station transmits a TB, which is divided into 3 CBGs. For an initial transmission, the transmission state of the first, second and third CBGs is (x) a new transmission, the transmission state of the fourth CBG is (w) being untransmitted/unscheduled. Since the time-frequency resources of the third CBG overlaps with the URLLC, the base station transmits only the first and second CBGs completely, and the third CBG is not transmitted completely. It is assumed that the UE decodes the first CBG correctly and does not decode the second CBG and third CBG correctly. The base station schedules to transmit the second CBG and third CBG again, where the transmission state of the second CBG is (y) and the transmission state of the third CBG is (z).

(4.3): The transmission state includes (y) a retransmission, (x) a new transmission / (z) a retransmission with needing the UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted, (w) being untransmitted/unscheduled, (u) having been scheduled to transmit previously but being unscheduled/untransmitted in the current scheduling. For example, the 4 states may be represented by 2 bits.

Preferably, one or more of indications (1) to (4) stated above may be used in combination. Only a few examples are given below, but the present disclosure is not limited thereto. For example, the implementation methods (1.4), (2.1), (3.1) are adopted. That is,

- a TB-level indication:



- 2 bits, indicating the number of CB/CBGs corresponding to a TB
- 1-bit NDI of the TB, representing, by being toggled, that the TB is a new TB and representing, by being untoggled, that the TB is a retransmitted TB.
- TB size
- a CB/CBG-level indication:
 - 1 bit, indicating whether or not each CB/CBG is scheduled/transmitted.
 - 1-bit NDI of each CB/CBG, representing, by being toggled, that (x) the CB/CBG is a new CBG or (z) the CBGs needing the buffer to be flushed and representing, by being untoggled, that the CB/CBG is (y) with no needing to flush the buffer.
 - 1-bit RV of a redundancy version of each CB/CBG.

It is easy to see that if a TB is a new transmission, the 1-bit NDI of the TB should be toggled and the NDI of each scheduled CB/CBG should also be toggled. If a TB is a retransmission, the 1-bit NDI of the TB should be untoggled, but the NDI of part of CBGs, CB/CBG of the TB, may be toggled. For example, if a CBG of eMBB is affected by the URLLC service, the CBG needs the UE to flush the buffer to be re-received, that is, it is in the state of (z). Alternatively, the NDI of the CB/CBG may be untoggled for part of the CBGs of the TB, for example, since the SINR is lower, although the base station transmits the CB/CBG, but the UE does not demodulate it correctly, the base station transmits the CB/CBG again, the UE may combine the received signal with the data in the buffer, that is, it is in the state of (y). In the subsequent retransmission, the number of CBs/CBGs scheduled by the base station may be smaller than the number of CBs/CBGs scheduled in the initial transmission, but the CB/CBG size is determined according to the number of CBs/CBGs in the initial transmission and the TB size indicated in the DCI.

Alternatively, the implementation methods (1.1), (2.2), (3.1) are adopted. That is,

- a TB-level indication:
 - TB size
- a CB/CBG-level indication:

- 1 bit, indicating whether or not each CB/CBG is scheduled/transmitted.
- 1-bit NDI of each CB/CBG, representing, by being toggled, that (x) the CB/CBG is a new CBG or (z) the CBGs needing the buffer to be flushed and representing, by being untoggled, that the CB/CBG is (y) with no needing to flush the buffer.
- 1-bit RV of a redundancy version of each CB/CBG.

It is easy to see that if a TB is a new transmission, the NDI of each CB/CBG should be toggled. If a TB is a retransmission, the NDI of part of CBGs, CB/CBG of the TB, may be toggled. For example, if a CBG of eMBB is affected by the URLLC service, the CBG needs the UE to flush the buffer to be re-received, that is, it is in the state of (z). Alternatively, the NDI of the CB/CBG may be untoggled for part of the CBGs of the TB, for example, since the SINR is lower, although the base station transmits the CB/CBG, but the UE does not demodulate it correctly, the base station transmits the CB/CBG again, the UE may combine the received signal with the data in the buffer, that is, it is in the state of (y). In the subsequent retransmission, the number of CBs/CBGs scheduled by the base station may be smaller than the number of CBs/CBGs scheduled in the initial transmission, but the CB/CBG size is determined according to the number of CBs/CBGs in the initial transmission and the TB size indicated in the DCI.

Alternatively, the implementation methods (2.5), (3.1), (4.3) are adopted. That is,

- a TB- a TB-level indication:
 - TB size
 - 1-bit NDI of the TB, representing, by being toggled, that the TB is a new TB and representing, by being untoggled, that the TB is a retransmitted TB.
 - 2-bit RV of the redundant version, which is applicable to all CBs/CBGs.
- a CB/CBG-level indication:
 - 2 bits, indicating 4 transmission states, 00: (y) a retransmission, 01: (x) a new transmission/(z) a retransmission with needing the UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted, 10: (w) being untransmitted/unscheduled, 11: (u) having been scheduled to transmit previously but being unscheduled/untransmitted in the current schedule.

It is easy to see that if a TB is a new transmission, the 1-bit NDI of the TB should be toggled, and each scheduled CB/CBG should be (x) a new transmission. If a TB is a retransmission, then the 1-bit NDI of the TB should be untoggled, and then for each CBG of the TB, it may be either (y), or (z), or (w), or (u). Obviously, (x) the new transmission may be represented by toggling the NDI of the TB and 01, and the untoggling of the NDI of the TB and 01 indicate (z) a retransmission with needing UE to flush the HARQ buffer of the CB/CBG scheduled to be retransmitted. When calculating the CB/CBG, (x), (y), (z) and (u) all indicate that one TB corresponds to the CBG, wherein, (x), (y) and (z) indicate that the CB/CBG is scheduled currently, (u) indicates that the CB/CBG is not scheduled currently, but the CB/CBG belongs to the TB, and (w) indicates that the TB does not include the CB/CBG.

The CBGs of (x) and (y) all adopt the indicated TB-level redundancy version, the redundancy version of the CBGs of (z) is predefined, for example, RV=0.

Alternatively, the implementation methods (1.1) and (2.4) are adopted. That is,

- a TB-level indication:
 - TB size
 - 2 bits RV of the redundant version
- a CB/CBG-level indication:
 - 1 bit, indicating whether or not each CB/CBG is scheduled/transmitted. For a retransmission, being toggled with respect to the initial transmission scheduling the same TB indicates no transmission, and being untoggled indicates transmission. If it is an initial transmission, all bits are toggled with respect to the initial transmission of the previous TB scheduling the same HARQ process.
 - 1-bit NDI of each CB/CBG, representing, by being toggled with respect to the last transmission scheduling the same TB, that (x) the CB/CBG is a new CBG or (z) the CBGs needing the buffer to be flushed by being toggled and representing by being untoggled, that the CB/CBG is (y) with no needing to flush the buffer.

If and only if the bits of “whether or not each CB/CBG is scheduled/transmitted” in the DCI of the current transmission are all toggled with respect to the bits of “whether or not each CB/CBG is scheduled/transmitted” in the DCI of the initial transmission of the previous TB scheduling the same HARQ process, it means that the current transmission is a new transmission (x), otherwise the current transmission is not a new transmission. For example, for a first transmission of a TB, NDIs of all CBGs are the same value certainly, and all of the NDIs are toggled with respect to the initial transmission of the previous TB scheduling the same HARQ process. If it is a new transmission, the number of CBGs scheduled actually is determined according to the TBS and the predefined CB/CBG grouping rule, that is, it is not necessary to determine, according to the value of the bit field, whether or not the corresponding CB/CBG is scheduled.

If DCI formats of the new transmission and the retransmission are different, for example, the DCI of the initial transmission does not include any indication related to the CB/CBG according to the existing scheduling based on the TB in LTE and the retransmitted DCI is indicated according to the method described above. If the bits of “whether or not each CB/CBG is scheduled/transmitted” in the DCI of the current transmission are all toggled with respect to the TB-level NDI of the last initial transmission, it indicates that the current transmission is a retransmission of a new TB. For example, it is assumed that the DCI can support transmission of a maximum of 4 CBGs, in the downlink TU i1, the base station schedules a TB, which is divided into 4 CBGs, and the base station transmits the DCI of TB-level scheduling, wherein the TB-level NDI is 1. The UE detects the DCI successfully and feeds back an ACK. In downlink TU i2, the base station schedules a new TB, which is divided into 4 CBGs, and the base station transmits the DCI of the TB-level scheduling, wherein the TB-level NDI is 0. The UE does not detect the DCI. In downlink TU i3, the base station schedules the retransmission of the TB and transmits the DCI of a CBG-level scheduling, wherein, the bit of “whether or not each CB/CBG is scheduled/transmitted” of the 4 CBGs is 0. The UE detects the DCI and determines that it is a retransmission. However, since the bit of



“whether or not each CB/CBG is scheduled/transmitted” is toggled with respect to the TB-level NDI of the DCI of the downlink TU i1, the UE determines that the UE itself has missed the DCI of the current TB and that the DCI received this time is a retransmission of the undetected TB. The UE determines that the 4 CBGs are transmitted by the base station in the current retransmission according to the indication of the bit of “whether or not each CB/CBG is scheduled/transmitted” of the received DCI.

If it is not a new transmission, whether or not each CB/CBG is scheduled is determined separately according to whether or not the bit of “whether or not each CB/CBG is scheduled/transmitted” is toggled with respect to the bit of “whether or not each CB/CBG is scheduled/transmitted” in the DCI scheduling the initial transmission of the same TB. If being toggled, it indicates no scheduling, if being untoggled, it means scheduling. And, for the scheduled CB/CBG, according to the situation whether or not “NDI bit indication information indicating an initial transmission or retransmission of each CB/CBG” is toggled with respect to “the NDI bit indication information indicating an initial transmission or retransmission of each CB/CBG” in the DCI scheduled in the latest scheduling, scheduling the same TB, the state of each scheduled CB/CBG is determined as (z) or (y) respectively. If being toggled, it means the state of the CB/CBG is (z), if not, it means (y). For the unscheduled CB/CBG, the state of the bit is not limited by the present disclosure.

For example, it is assumed that the DCI may support a transmission up to 4 CBGs, in the downlink TU i1, the base station schedules 4 CBGs, all of which are new transmissions, the TB-level RV indicates 0, and the 4 CBGs has 2 bits respectively. Assuming that initial states are 11, 11, 11, 11. Assuming that the first CBG was pre-empted by the URLLC, the other several CBGs are transmitted normally. The UE fails to decode the first and third CBG correctly for transmission, feeds back the NACK, and the other two CBGs are all decoded correctly and the ACK is fed back. In downlink TU i2, the base station schedules the first and third CBGs for retransmissions, the TB-level RV indicates 2, and the 2 bits of the 4 CBGs indicate 10, 00, 11, 00, respectively. Wherein,

the 2 bits “10” of the first CBG indicates that the CBG is scheduled and the state of the CBG is (z), the 2 bits “11” of the third CBG indicates that the CBG is scheduled and the state of the CBG is (y). The other two CBGs represent no scheduling. The first CBG adopts RV=0, the third CBG adopts the indicated RV=2. It is assumed that the first and third CBGs are transmitted normally. The UE decodes the first CBG transmission correctly this time, feeds back the ACK, but does not decode the third CBG correctly and feeds back the NACK. In downlink TU i3, the base station schedules the third CBG for retransmission, the TB-level RV indicates 3, and the 2 bits of the 4 CBGs indicate 00, 00, 11, 00, respectively. Wherein, the 2 bits “11” of the third CBG indicates that the CBG is scheduled and the CBG state is (y). It is assumed that the UE decodes the third CBG correctly and feeds back the ACK. In downlink TU i4, the base station schedules a new TB, and the base station schedules 4 CBGs, all of which are new transmissions, the TB-level RV indicates 0, and the 4 CBGs have 2 bits respectively, assuming that the initial states are 00, 00, 00, 00.

The description above mainly for the DCI scheduling a PDSCH is also suitable for the DCI scheduling a PUSCH. For example, in the DCI scheduling a PUSCH,

- a TB-level indication:
 - TB size
 - 2 bits RV of the redundant version
- a CB/CBG-level indication:
 - 1 bit, indicating whether or not each CB/CBG is scheduled/transmitted. For a retransmission, being toggled with respect to the initial transmission scheduling the same TB indicates no transmission, and being untoggled indicates transmission. If it is an initial transmission, all bits are toggled with respect to the initial transmission of the previous TB scheduling the same HARQ process.

Embodiment 6

For the downlink data transmission, when the base station schedules part of CBG

retransmissions in the M CBGs scheduling a TB, the base station may notify the UE whether the CBG is a retransmission or a new transmission through the bit field of the corresponding CBG in the downlink scheduling signaling DCI. For the specific indication manner, Embodiment 5 of the present disclosure is referred to. In order to allow the UE to combine the received retransmitted CBG with the previously received bit of the CBG, the base station may control the retransmission in a granularity of CBG in the following three manners, including the implementation of the numbers of bits of the retransmitted CBG scheduled currently and the CBG scheduled previously being the same,

(1) If at least one retransmitted CBG is scheduled in the DCI of the current downlink TU, the size of the retransmitted CBG determined according to the DCI needs to be the same as the size of the CBG determined by the DCI scheduling the same CBG last time.

The UE side behavior: if the size of the retransmitted CBG determined by the DCI, received by the UE, is the same as the size of the CBG determined by the DCI scheduling the same CBG last time, the UE may combine the retransmitted CBGs. If the size of the retransmitted CBG determined by the DCI, received by the UE, is different from the size of the CBG determined by the DCI scheduling the same CBG last time, it may be considered as an error condition, and the processing of the CBG by the UE may be reserved for the UE, or the UE discards the CBG received currently or the UE discards the CBG received previously so as to decode only according to the CBG received currently.

If the DCI only indicates the TB size explicitly, the size of the retransmitted CBG needs to be determined by the method of the present disclosure or by other methods. The TB size indicated by the DCI scheduling the retransmitted CBG currently may be the same as or different from the TB size indicated by the DCI scheduling the CBG last time. For example, it is assumed that the DCI may support the transmission of a maximum of 4

CBGs. In downlink TU i1, the base station schedules 4 CBGs, and all 4 CBGs are transmitted for the first time, and the TB size is TBS_1 . It is assumed that the TB may be divided into 4 CBGs equally, that is, the number of bits of each CBG is equal to $TBS_1/4$. Wherein, the third CBG is transmitted unsuccessfully. In the downlink TU i2, the base station schedules 4 CBGs, of which the third CBG is indicated to be a retransmission, i.e., the retransmission of the third CBG of the downlink TU i1, and the other three CBGs are the newly transmitted CBGs. From the perspective of the physical layer, it may be understood that multiple CBGs transmitted simultaneously in a scheduling are from the same TB, and the CBGs constitute a new TB, regardless of whether the CBGs are retransmitted or newly transmitted. Alternatively, it may be understood that the retransmitted and newly transmitted CBGs, transmitted simultaneously in a scheduling, are from different TBs. For the latter manner, there are two methods to achieve it. (1) The DCI of the downlink TU i2 in this example indicates to schedule 4 CBGs, which illustrates that the new TB is divided into 4 CBGs, that is, the TB size is equal to the total number of bits of the 4 CBGs, and only the data of 3 CBGs of the new TB is transmitted in the current TU, and the other one CBG of the new TB may be transmitted next time. As long as the TB sizes indicated by the DCIs of the downlink TU i1 and the downlink TU i2 are the same, the number of bits of the retransmitted third CBG calculated by the UE according to the TB size is untoggled. (2) In this example, the DCI of the downlink TU i2 indicates to schedule 4 CBGs, which illustrates that the new TB is divided into 4 CBGs, the new TB is completely transmitted in the current TU, that is, the TB size is equal to the total number of bits of 3 CBGs indicated to be a new transmission. In this case, it is still required to ensure that the size of the retransmitted CBG determined according to the DCI in the downlink TU i2 is the same as the size of the CBG determined by the DCI scheduling the same CBG last time.

Alternatively, in the downlink TU i2, the base station schedules 3 CBGs, the CBGs from the second to the fourth, wherein the third CBG is indicated to be a retransmission, i.e., the retransmission of the third CBG of the downlink TU i1, and the first CBG and

the fourth CBG are the newly transmitted CBGs. The TB size indicated by the DCI of the downlink TU i2 is TBS_2 . It's easy to see, TBS_2 is different from TBS_1 . The TB with the TB size TBS_2 may be divided into 3 CBGs equally, and the size of the 3 CBGs is $TBS_2/3$. Then, TBS_2 and TBS_1 are required to satisfy that $TBS_1/4 = TBS_2/3$. Alternatively, TBS_2 may also be the total number of bits of 2 CBGs indicated as the new transmissions, then TBS_2 and TBS_1 are required to satisfy that $TBS_1/4 = TBS_2/2$.

Alternatively, in the downlink TU i2, the base station schedules a CBG, the third CBG, and other CBGs are all indicated to be untransmitted. In the context, the third CBG is indicated to be a retransmission, i.e., the retransmission of the third CBG of the downlink TU i1. The TB size is TBS_3 . It is easy to see that $TBS_3 = TBS_1/4$.

It should be noted that for determining manners of different CB/CBG sizes, the TB sizes indicated by the DCI in downlink TU i2 may be different in order to make the size of the retransmission of the same CBGs the same as that of the CBG in the last transmission. However, finally the size of the retransmission of the same CBG obtained by the DCI should be the same as that of the CBG in the last transmission.

If the size of each CBG is indicated by the DCI explicitly, as the method described in embodiment five, the DCI may indicate the size of a CBG explicitly and the sizes of all the scheduled CBGs are the same, or the DCI indicates the size of a reference CBG explicitly, the sizes of all scheduled CBGs are determined according to the size of the reference CBG, and then the size of the retransmitted CBGs may be directly determined by a value indicated by the DCI explicitly. For example, it is assumed that the DCI may support the transmission of a maximum of 4 CBGs. In the downlink TU i1, the base station schedules 4 CBGs, which are all transmitted for the first time, and the indicated size of the CBG is $CBGS_1$, representing that the sizes of the 4CBGs are all $CBGS_1$. Wherein, the third CBG is transmitted unsuccessfully. In the downlink TU i2, the base station schedules 3 CBGs, the CBGs from the second to the fourth, wherein the third CBG is indicated to be a retransmission, i.e., the retransmission of the third CBG of the downlink TU i1, and the first CBG and the fourth CBG are newly transmitted CBGs. The

size of the CBG indicated by the base station is still CBGS_1 , representing that the sizes of the 3 CBGs are all CBGS_1 regardless of the newly transmitted CBGs or retransmitted CBGs.

(2) If at least one retransmitted CBG is scheduled in the DCI of the current downlink TU, the TB size indicated by the DCI needs to be the same as the TB size indicated by the DCI scheduling the same CBG last time.

The UE side behavior: If the TB size indicated by the DCI, received by the UE, is the same as the TB size indicated by the DCI scheduling the same CBG last time, then the UE may combine the retransmitted CBGs. If the TB size indicated by the DCI, received by the UE, is different from the TB size indicated by the DCI scheduling the same CBG last time, it may be considered as an error condition, and the processing of the CBG by the UE may be reserved for the UE, or the UE discards the CBG received currently or the CBG received previously.

For example, it is assumed that the DCI may support the transmission of a maximum of 4 CBGs. In downlink TU i1, the base station schedules 4 CBGs, and all 4 CBGs are transmitted for the first time. Wherein, the third CBG is transmitted unsuccessfully. In the downlink TU i2, the base station schedules 4 CBGs, of which the third CBG is indicated to be a retransmission, i.e., the retransmission of the third CBG of the downlink TU i1, and the other three CBGs are the newly transmitted CBGs. The TB sizes indicated by the DCIs of the downlink TU i1 and the downlink TU i2 are the same, so that the number of bits of the retransmitted third CBG calculated by the UE according to the TB size is untoggled.

Alternatively, in the downlink TU i2, the base station schedules the third CBG indicated as a retransmission and the other three CBGs are all indicated to be untransmitted. Then, the UE assumes that as long as at least one CBG is indicated as a retransmission, the indicated TB size should be the same as the TB size indicated in the DCI scheduling the retransmitted CBG last time. The UE determines the size of the retransmitted CBG according to the number of scheduled CBGs indicated in the DCI

scheduling the first transmission. Here, it is assumed that the base station does not combine the CBGs, of which the initial transmission is from different TBs, into a new TB for transmission. Therefore, in this example, in the downlink TU i2, the base station may only schedule the retransmission of the third CBG or may schedule a new TB but not to schedule the retransmission of the third CBG, and the CBGs included in the new TB are all transmitted for the first time.

It is easy to see that when the DCI may only indicate the TB size, the size of the newly transmitted CBG scheduled together with the retransmitted CBG is limited by the size of the retransmitted CBG, for either (1) or (2). In order to support more flexible scheduling, the size of each CBG may be indicated by the DCI explicitly according to the method in embodiment five.

(3) If at least one retransmitted CBG is scheduled in the DCI of the current downlink TU, the TB size indicated by the DCI needs to be the same as the TB size indicated by the DCI scheduling the same CBG last time.

The base station may indicate the modulation mode of retransmission through $MCS \geq Thr_mcs1$, without indicating the TBS index. The TB size is considered to be the same as the TB size indicated by the DCI scheduling the same CBG last time. For example, $Thr_mcs1=29$.

The base station may also indicate the modulation mode of a retransmission and a TBS index through $MCS < Thr_mcs1$. The advantage is that when the UE misses the DCI scheduling the initial transmission but detects the DCI scheduling the retransmission, the UE may adopt the TBS of the initial transmission directly. If the retransmission is scheduled only according to $MCS \geq Thr_mcs1$, when the UE does not receive the DCI scheduling the initial transmission, the data cannot be received.

The modulation mode adopted by a retransmission and an initial transmission may belong to different modulation mode sets. For example, in the MCS table, the same MCS index may correspond to two modulation mode sets (corresponding to two columns of modulation modes in the table 1 respectively). The base station may indicate explicitly,

by the DCI, which column modulation mode is used.

For a DCI scheduling the uplink transmission, the same method as the downlink scheduling may be adopted. That is, different from the DCI of the uplink scheduling of LTE, the RV and the MCS in the DCI are indicated respectively, and MCS=29-31 indicates the modulation mode.

Similarly, the DCI scheduling the uplink transmission, the base station may indicate explicitly, by the DCI, which column modulation mode is used. The modulation mode and values of the TBS index in the MCS table may be different from those for downlink transmission.

TABLE 1 MCS table

MCS Index I_{MCS}	Modulation Order Q_m	Modulation Order Q'_m	TBS Index I_{TBS}
0	2	2	0
1	2	2	1
2	2	2	2
3	2	2	3
4	2	2	4
5	2	2	5
6	2	2	6
7	2	2	7
8	2	2	8
9	2	2	9
10	4	2	9
11	4	2	10
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21	6	4	19
22	6	4	20
23	6	4	21
24	6	4	22
25	6	4	23
26	6	4	24
27	6	4	25
28	6	4	26/26A
29	2	2	reserved
30	4	4	
31	6	6	

When the base station indicates a retransmitted TBS through $MCS < Thr_mcs1$, the base station may also indicate an adjustment factor β for determining the TBS, wherein β is determined according to N_{PRB} , when looking up the TBS according to a PRB number N'_{PRB} occupied by the PDSCH, according to Table 7.1.7.2.1-1 in TS 36.213, wherein,

$$N_{PRB} = \lfloor N'_{PRB} \times \beta \rfloor, \text{ and } N_{PRB} = \min\{\lfloor N'_{PRB} \times \beta \rfloor, N_{PRB_max}\}, N_{PRB_max} \text{ is the}$$

maximum value of the PRB number available for transmitting data, β is a number greater than or equal to 1. For example, in an initial transmission, a TB includes 4 CBGs, wherein, one CBG needs to be retransmitted. A length of the time resources occupied by the PDSCH of the initial transmission and the retransmission is untoggled, but the frequency resources (PRB number) occupied by the retransmitted PDSCH is 1/4 of that of the initial transmission. The base station may determine N_{PRB} by indicating $\beta=4$, and may determine the TBS. At this time, the determined TBS should be the same as the TBS transmitted last time.

Preferably, the base station does not need extra bit field to indicate the adjustment factor β used for determining the TBS, and β is determined by the relationship between the number of CBGs scheduled in the retransmission and the total number of CBGs corresponding to the TB. For example, $\beta = [\text{the number of CBGs in the present scheduling} / \text{the total number of CBGs of a TB}]$. Alternatively, N β s are pre-defined, and β is determined according to the relationship between the number of CBGs scheduled in the retransmission and the total number of CBGs corresponding to the TB.

Preferably, when the base station indicates the modulation mode of a retransmission and the TBS index by $MCS < Thr_mcs1$, the bits indicating which modulation mode is used, or which TBS determining method is used exist in the DCIs used for scheduling the initial transmission and the retransmission. Alternatively, when the bits only exist in the DCI used for scheduling the initial transmission, the initial transmission (for example, the TB-based scheduling of LTE) determines the corresponding modulation mode and/or TBS according to a predefined rule.

For example, it is assumed that the DCI may support transmission of a maximum of

4 CBGs. In the downlink TU i1, the base station schedules a transmission of the PDSCH, the transmission is a new transmission of a TB, which may be divided into 4 CBGs. The PDSCH occupies 7 OFDM symbols. Assuming that, when determining the TBS, N_{PRB} is expressed as $N_{\text{PRB}} = \max\{N'_{\text{PRB}} \times \beta, 1\}$, where N'_{PRB} is a size of the PRB indicated by the DCI, $\beta=1/2$. The base station schedules the transmission of the PDSCH in downlink TU i2 for the retransmissions of the first CBG and the third CBG. The PDSCH occupies 3 OFDM symbols. The DCI transmitted by the base station is a DCI based on CBG scheduling, which contains 2 bits indicating a β value, for example, $\beta=1, 0.75, 0.5$ and 0.375 . Based on the indicated β value, the TBS is determined.

Corresponding to the method above, the present application further discloses a device, which may be used to implement the method above. As shown in FIG. 8, the device comprises a PDCCH detecting and analyzing module, a PDSCH receiving module, a HARQ-ACK information generating module and an HARQ-ACK transmitting module.

The PDCCH detecting and analyzing module is configured to detect a PDCCH of a scheduled PDSCH on a configured control resource set and analyze the detected PDCCH.

The PDSCH receiving module is configured to determine a method for dividing CBs and a method for rate matching of the PDSCH according to the detected PDCCH and to receive the PDSCH according to the detected PDCCH.

The HARQ-ACK information generating module is configured to generate HARQ-ACK information according to the detected PDSCH.

The HARQ-ACK transmitting module is configured to transmit the HARQ-ACK information.

Those skilled in the art may understand achieving all or part of the steps carried by the method embodiments described above may be accomplished through commanding



the associated hardware by a program, the program may be stored in a computer-readable storage medium, and when the program is executed, one of the steps of the method embodiments or a combination thereof is included.

In addition, the functional units in the various embodiments of the present application may be integrated in a processing module, or various units may be physically present individually, or two or more units may be integrated in one module. The integrated module described above may be implemented in the form of hardware, and may also be achieved in the form of software function modules. The integrated module may also be stored in a computer-readable storage medium if it is implemented in the form of a software function module and is sold or used as a standalone product.

The storage medium mentioned above may be a read-only memory, a magnetic disk or an optical disk, etc.

The foregoing is only preferred embodiments of the present application and is not used to limit the scope of the present application. Any modification, equivalent substitution and improvement without departing from the spirit and principle of the present application are within the scope of the present application.

DRAWINGS

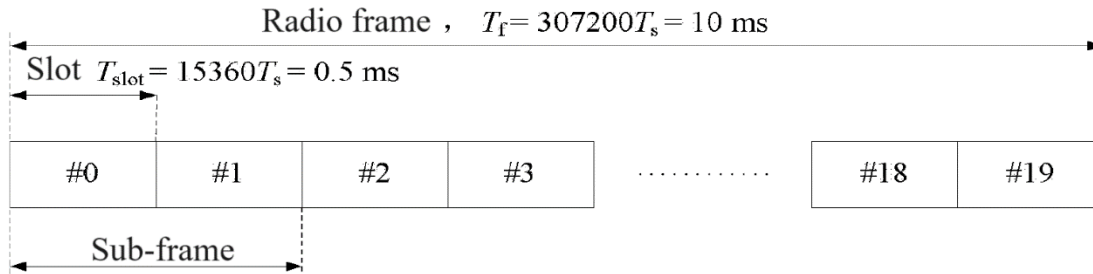


FIG. 1

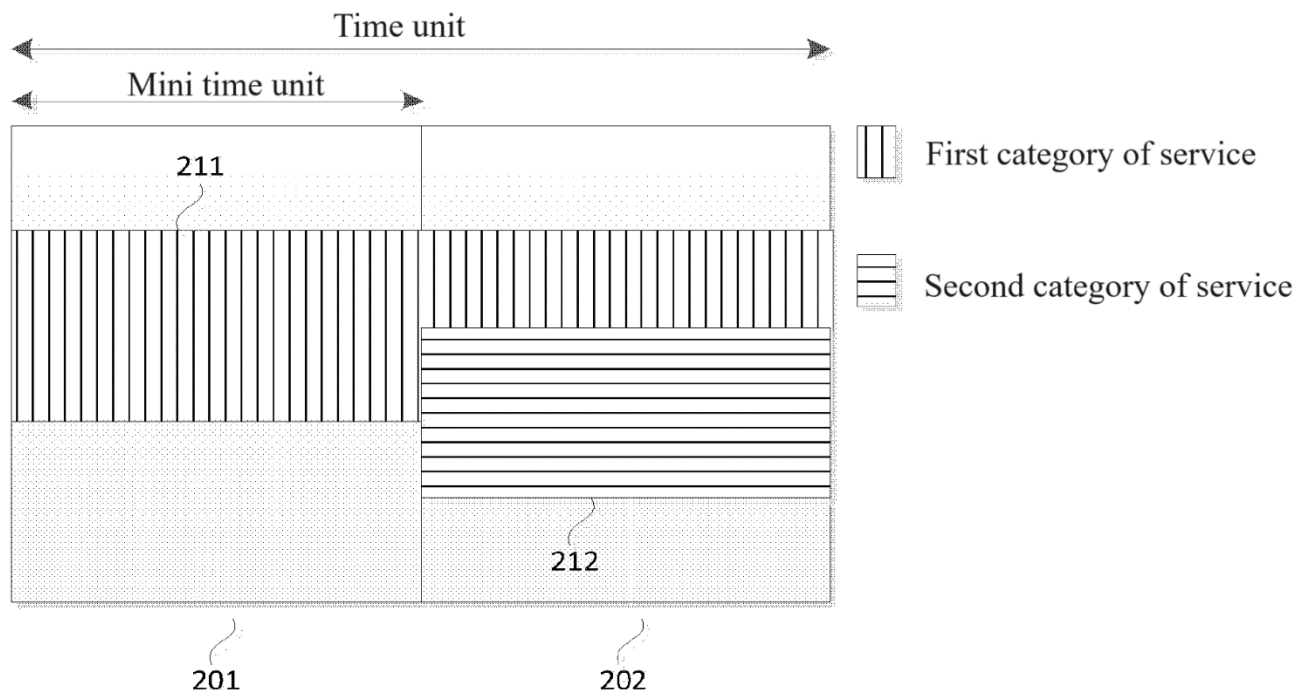


FIG. 2

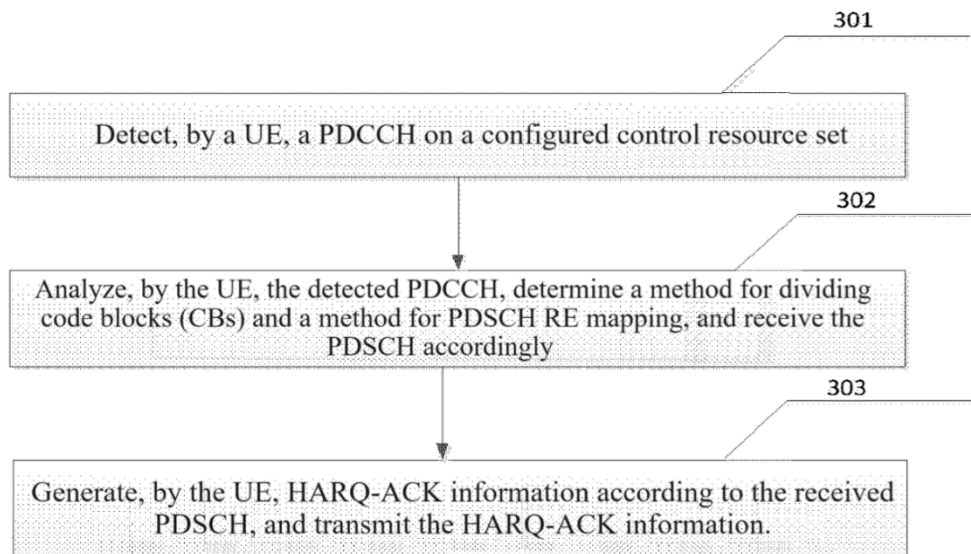


FIG. 3

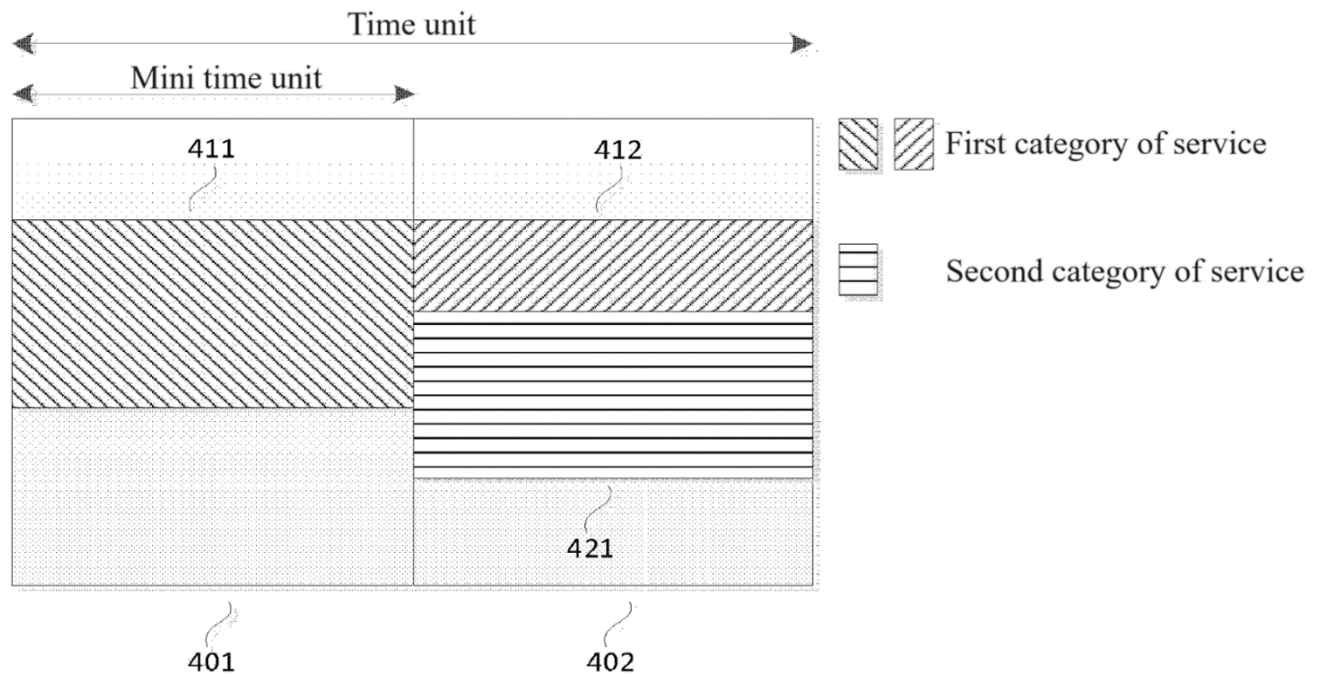


FIG. 4

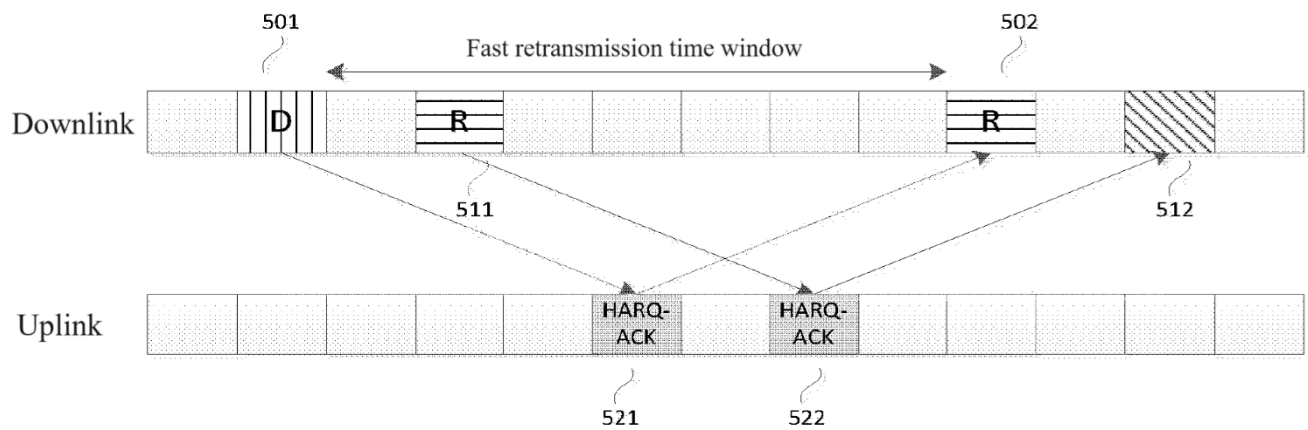


FIG. 5

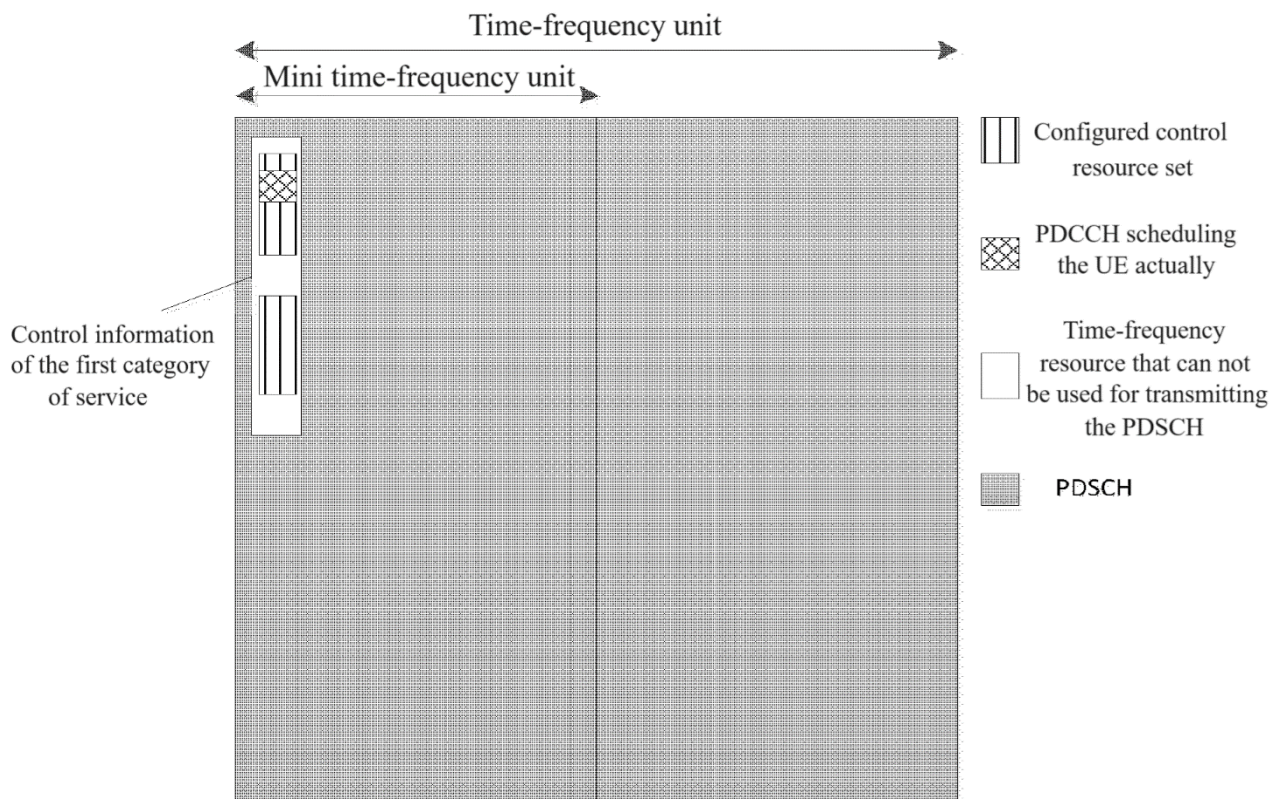


FIG. 6

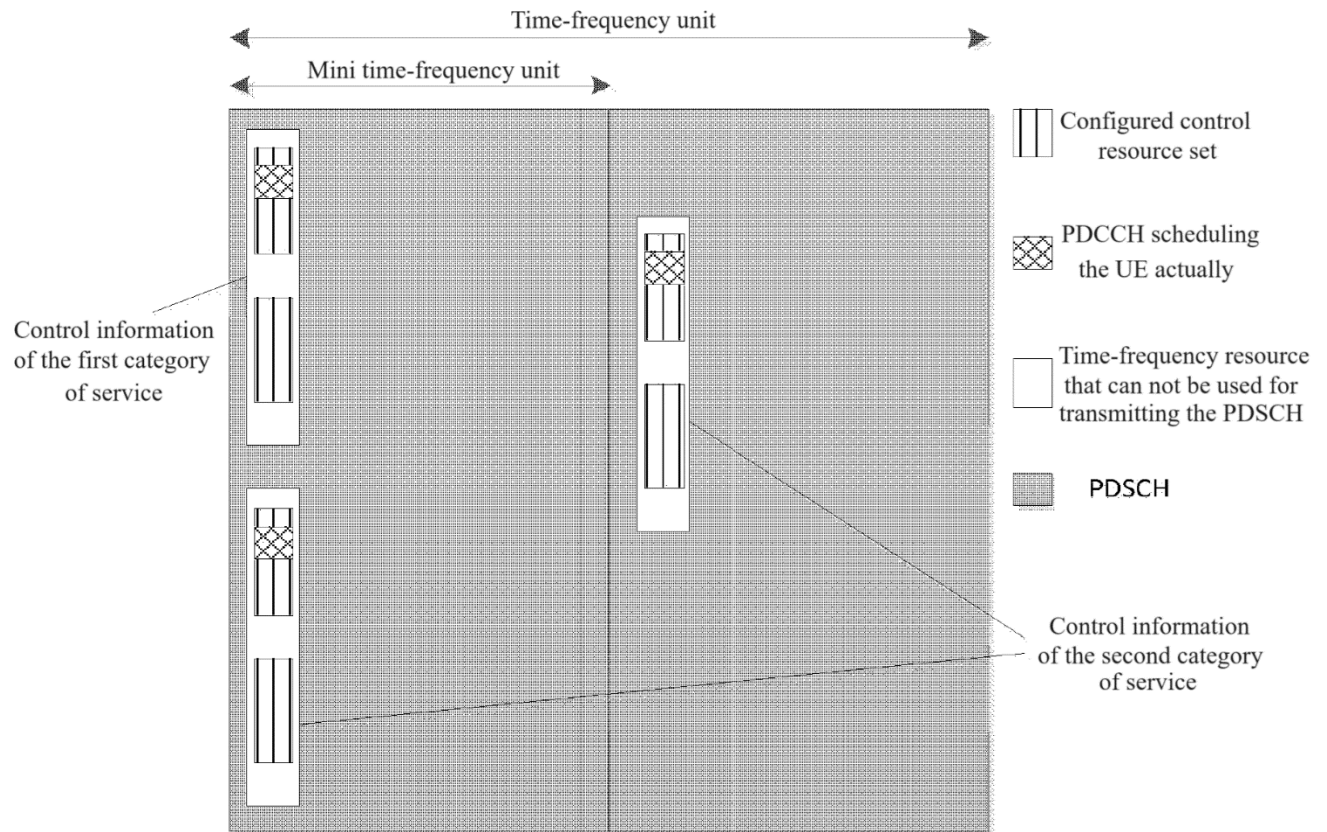


FIG. 7

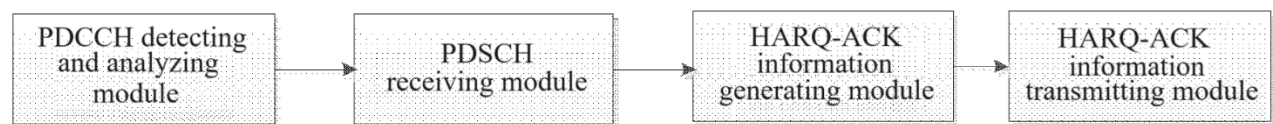


FIG. 8

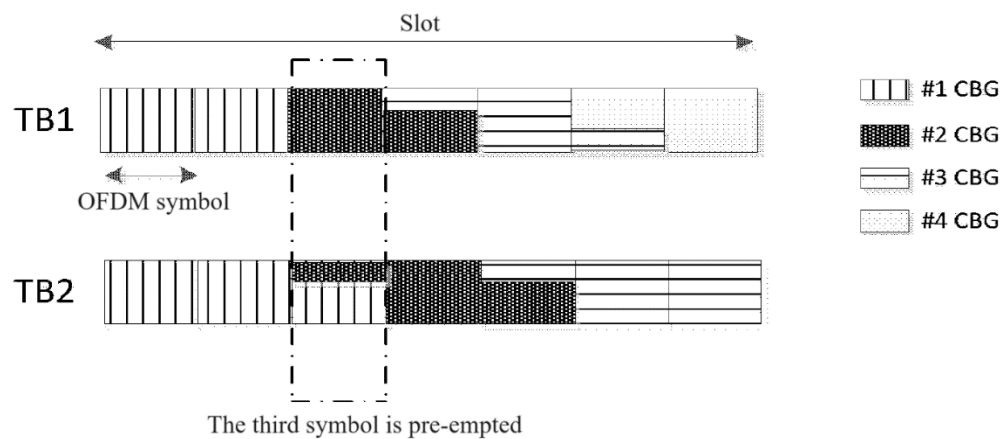


FIG. 9



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