

SPECIFICATION

TITLE OF THE INVENTION

USER DEVICE, BASE STATION DEVICE, AND
METHOD IN MOBILE COMMUNICATION SYSTEM

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TECHNICAL FIELD

The present invention relates to the next
generation mobile communication scheme. More
particularly, the present invention relates to a
10 user apparatus, a base station apparatus, and a
method in the mobile communication system of the
next generation mobile communication scheme.

BACKGROUND ART

15 In this kind of technical field, research
and development on the next generation communication
system is rapidly progressing. In the communication
system considered as of now, from the view point of
widening coverage while reducing PAPR (Peak - to -
20 Average Power Ratio), it is proposed to use a
single carrier scheme for uplink. In addition, in
this communication system, for both of uplink and
downlink, radio resources are properly assigned, as
a form of a shared channel which is shared by a
25 plurality of users, according to communication
states of each user and the like. More particularly,
a data signal of a user in the uplink is transmitted
by a physical uplink shared channel (PUSCH). The
terms "channel" and "signal" may be used
30 synonymously as long as there is no fear of
confusion. A data signal of a user in the downlink
is transmitted by a physical downlink shared channel
(PDSCH).

Processing for determining assignment is
35 called scheduling. In order to properly perform
scheduling in the uplink, each user apparatus
transmits a reference signal (also called as a pilot

channel) to a base station, and the base station evaluates the channel state of the uplink based on the reception quality. In addition, in order to perform scheduling in the downlink, the base station
5 transmits a reference signal to the user apparatus, and the user apparatus reports to the base station information indicating channel state (CQI: Channel Quality Indicator) based on the reception quality of the reference signal. Based on the CQI reported
10 from each user apparatus, the base station evaluates the channel state of the downlink to perform scheduling of downlink. The contents of scheduling are transmitted to each user apparatus by a downlink control signal. This control signal is called a
15 downlink L1/L2 control channel or a downlink L1/L2 control signal.

As uplink control signals, there are control information (called first control information, for the sake of convenience) that
20 should be transmitted by accompanying an uplink data signal, and control information (called second control information, for the sake of convenience) that is transmitted irrespective of the presence or absence of the uplink data signal. The first
25 control information includes information necessary for demodulation of a data signal, such as modulation scheme, channel coding rate and the like of the data signal. The second control information includes CQI information of downlink channel,
30 acknowledgement information (ACK/NACK) of downlink data signal, and information of resource assignment request, and the like. Therefore, there is a possibility that the user apparatus transmits only the first control information, only the second
35 control information, or both of the first and the second control information by using the uplink control signal.

When a resource block (radio resource) is assigned for transmitting an uplink data channel, the first control information (and second control information as necessary) is transmitted by the resource block. On the other hand, when the uplink data signal is not transmitted, it is considered to transmit the second control signal by using dedicated resources (dedicated band). In the following, an outline of an example is described in which a band is used in such a way.

Fig.1 shows a band use example of uplink. Fig.1 shows resources (a plurality of resource blocks) for transmitting the physical uplink shared channel (PUSCH) that is the uplink data signal, and shows resources (corresponding to the dedicated band) for a user to which the resources for the PUSCH are not assigned to transmit the uplink control signal. The latter is called a physical uplink control channel (PUCCH). In the example shown in the figure, one or more of four resource blocks are assigned to users, and a first hopping control signal and a second hopping control signal are prepared in a transmission time interval (TTI), and a third hopping control signal and a fourth hopping control signal are prepared in the following TTI. Each hopping control signal corresponds to PUCCH. By performing hopping with respect to time and frequency in TTIs or subframes, diversity effect can be obtained. Each of the first to fourth hopping control signals may be occupied by one user or may be multiplexed by a plurality of users. This type of transmission scheme of the uplink control signals is described in the non-patent document 1.

[Non-patent document 1] 3GPP, R1-071245

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

In the above-mentioned proposed methods, it is necessary to report, to the user apparatus, which resource should be used for the uplink control signal by using the downlink L1/L2 control signal.

5 As to the uplink control signal for a user to which resources are not assigned for transmission of the uplink data signal, it is necessary to report, to each user apparatus, which slot in the dedicated resources should be used for transmission of the
10 uplink control signal. The uplink control signal may only include acknowledgment information (ACK/NACK), for example. Essentially, only one bit is necessary for the acknowledgment information. But, the acknowledgment information plays a central
15 role in retransmission control, and, true or false of the acknowledgment information largely affects throughput of data transmission. However, in the conventional method, for transmitting the acknowledgment information, which is merely one bit,
20 using the uplink, it is necessary to report, to the user apparatus, which resource should be used for transmission of the acknowledgment information by using the downlink L1/L2 control signal each time. Thus, there is a problem that such processing is
25 inefficient. In addition, there is a problem in that it is difficult to enhance quality of the acknowledgment information since it is hard to obtain coding gain for the acknowledgment information having merely one bit.

30 An object of the present invention is to efficiently report, to the user apparatus, which resource should be used for transmitting, in the uplink, control information that has a small number of bits, but that requires high quality.

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MEANS FOR SOLVING THE PROBLEM

In the present invention, a user apparatus

which transmits an uplink control signal to a base station apparatus using a single carrier scheme is used. The user apparatus includes: a unit configured to receive a downlink control signal and
5 a downlink data signal; a unit configured to prepare acknowledgement information indicating positive acknowledgement or negative acknowledgement for the downlink data signal; a unit configured to prepare the uplink control signal including the
10 acknowledgement information; a unit configured to transmit the uplink control signal using different resources which are different from resources that can be used for an uplink data signal; and a storage unit configured to store predetermined
15 correspondence relationship which uniquely associates resources of the downlink control signal or the downlink data signal with resources used for the uplink control signal.

20 EFFECT OF THE PRESENT INVENTION

According to the present invention, it becomes possible to efficiently report, to the user apparatus, information indicating which resource should be used in uplink for transmitting control
25 information that has a small number of bits, but that requires high quality.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a diagram showing a band use
30 example used in a mobile communication system;

Fig.2 shows a block diagram of a user apparatus according to a first embodiment of the present invention;

Fig.3 is a diagram showing examples of TTI,
35 subframe and block;

Fig.4 is a diagram for explaining properties of CAZAC code;

Fig.5 is a diagram showing a situation in which each long block LB is multiplied by a factor (modulating data);

5 Fig.6 is a diagram showing a situation in which each long block LB is multiplied by factors (modulating data and block spread code);

Fig.7 shows a block diagram of a base station apparatus according to a first embodiment of the present invention;

10 Fig.8 is a flowchart showing an operation example of the present invention;

Fig.9 is a flowchart for specifying code information from broadcast information and assigned number;

15 Fig.10 is a diagram showing setting examples of CAZAC codes, cyclic shift amounts and bands realized by executing the flow shown in Fig.9;

20 Fig.11 is a diagram showing an example of correspondence relationship between resources of downlink control signal addressed to the user apparatus and resources of the uplink control signal;

25 Fig.12 is a diagram showing a situation in which specific resources are reserved for a user performing persistent scheduling;

Fig.13 shows a block diagram of the user apparatus according to a second embodiment of the present invention;

30 Fig.14 shows a block diagram of the base station apparatus according to the second embodiment of the present invention; and

35 Fig.15 is a diagram showing an example of correspondence relationship between resource blocks addressed to the user apparatus and resources of the uplink control signal.

Description of reference signs

304 ACK/NACK determination unit
306 block-by-block modulation pattern generation
308 block-by-block modulation unit
310 discrete Fourier transform unit (DFT)
5 312 subcarrier mapping
314 inverse fast Fourier transform unit
316 cyclic prefix (cp) adding unit
318 multiplexing unit
320 RF transmission circuit
10 322 power amplifier
324 duplexer
331 CAZAC sequence number setting unit
332 CAZAC code generation unit
333 cyclic shift number setting unit
15 334 cyclic shift unit
335 block spread code setting unit
336 block spreading unit
337 frequency setting unit
338 reference signal generation unit
20 340, 340' determination unit
342, 342' code information and resource information
unit
702 duplexer
704 RF reception circuit
25 706 reception timing estimation unit
708 fast Fourier transform unit (FFT)
710 channel estimation unit
712 subcarrier demapping unit
714 frequency domain equalizing unit
30 716 inverse discrete Fourier transform unit (IDFT)
718 demodulation unit
722 scheduler
742, 742' code information and resource information
unit

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PREFERRED EMBODIMENTS FOR CARRYING OUT THE INVENTION

For the sake of convenience of explanation,

although the present invention is described by being
classified into some embodiments, classification
into each embodiment is not essential in the present
invention, and equal to or more than two embodiments
5 may be used as necessary. Although specific
numerical values are in explanation, such numerical
values are merely examples, so that any appropriate
value may be used unless specified otherwise.

[Embodiment 1]

10 Fig.2 shows a block diagram of a user
apparatus according to an embodiment of the present
invention. Fig.2 shows an ACK/NACK determination
unit 304, a block-by-block modulation pattern
generation unit 306, a block-by-block modulation
15 unit 308, a discrete Fourier transform (DFT) unit
310, a subcarrier mapping unit 312, an inverse fast
Fourier transform unit (IFFT) 314, a cyclic prefix
(CP) adding unit 31, a multiplexing unit 318, a RF
transmission circuit 320, a power amplifier 322, a
20 duplexer 324, a CAZAC sequence number setting unit
331, a CAZAC code generation unit 332, a cyclic
shift number setting unit 333, a cyclic shift unit
334, a block spread code setting unit 335, a block
spreading unit 336, a frequency setting unit 337, a
25 reference signal generation unit 338, a
determination unit 340 for L1/L2 control information
number and the number of times of retransmission,
and a code information and resource information unit
342.

30 The ACK/NACK determination unit 304
determines whether there is an error in each of
packets that form the received downlink data signal,
and outputs a determination result as
acknowledgement information. The acknowledgement
35 information may be represented as positive
acknowledgement (ACK) indicating there is no error
or negative acknowledgement (NACK) indicating there

is an error. Since it is only necessary that the acknowledgement information can represent presence or absence of an error in the received packet, the acknowledgement information can be represented essentially by one bit. But, the acknowledgement information may be represented by a larger number of bits.

The block-by-block modulation pattern generation unit 306 shapes each of channel state information (CQI) and acknowledgment information (ACK/NACK) into a block-by-block modulation pattern. A predetermined number of blocks are included in a subframe, and the subframe forms a transmission time interval (TTI) which is an assignment unit of resources.

Fig.3 shows examples of the subframe and the TTI. In the examples shown in the figure, TTI of 1.0 ms includes two subframes each being 0.5 ms, and each subframe includes six long blocks (LB) and two short blocks (SB). The long block is $66.7\mu s$, for example. The short block is $33.3\mu s$, for example. The numerical values are merely examples, and can be changes as necessary. Generally, the long block is used for transmitting data (control signal, data signal and the like) which is unknown for the receiving side, and the short block is used for transmitting data (pilot channel and the like) which is known to the receiving side. In the example shown in the figure, one TTI includes 12 long blocks (LB1 - LB12) and 4 short blocks (SB1 - SB4).

The block-by-block modulation pattern generation unit 306 shown in Fig.2 determines correspondence relationship between one or more of the 12 blocks (LB1 - LB12) and bits representing channel state information (CQI), and determines correspondence relationship between one or more of

the 12 blocks (LB1 - LB12) and bits representing
acknowledgement information (ACK/NACK). The user
apparatus transmits only channel state information,
transmits only acknowledgement information, or
5 transmits both of them, by using an uplink control
signal. Therefore, (A) all of the 12 blocks may be
associated with channel state information, (B) all
of the 12 blocks may be associated with
acknowledgement information, or (C) a part of 12
10 blocks may be associated with the channel state
information and the remaining part may be associated
with the acknowledgement information. In any way,
based on the correspondence relationship, one factor
is prepared for each of the 12 blocks, so that 12
15 factors (first factor - twelfth factor) are prepared
in total per one TTI.

The block-by-block modulation unit 308
forms a first long block by multiplying, by the
first factor, all chips of a CAZAC code sequence
20 (the length of the sequence can be associated with
one long block) assigned to the user apparatus, and
forms a second long block by multiplying all chips
of the same CAZAC code sequence by the second factor,
and after that, similarly, the block-by-block
25 modulation unit 308 forms a twelfth long block by
multiplying all chips of the same CAZAC code
sequence by the twelfth factor, so that the block-
by-block modulation unit 308 derives an information
sequence to be transmitted in one TTI. The CAZAC
30 code sequence used commonly for all blocks is an
orthogonal code sequence assigned in the residing
cell for identifying the user apparatus. Properties
of the CAZAC code sequence are described later.

The discrete Fourier transform unit (DFT)
35 310 performs discrete Fourier transform to transfer
time series information into information of the
frequency domain.

The subcarrier mapping unit 312 performs mapping in the frequency domain. Especially when the frequency division multiple access (FDM) scheme is used for multiplexing a plurality of user apparatuses, the subcarrier mapping unit 312 performs mapping of signals based on bands set in the frequency setting unit 336. There are two types of FDM schemes which are a localized FDM scheme and a distributed FDM scheme. In the localized FDM scheme, a continuous band is assigned for each individual user on the frequency axis. In the distributed FDM scheme, a downlink signal is generated such that the signal includes discontinuous frequency components over a wide band (over the whole of the specific band F_{RB2} for uplink control signal).

The inverse fast Fourier transform unit (IFFT) 314 restores the signal of the frequency domain into a signal of the time domain by performing inverse Fourier transform.

The cyclic prefix (CP) adding unit 316 adds a cyclic prefix to information to be transmitted. The cyclic prefix (CP) functions as a guard interval for absorbing multipath propagation delay and for absorbing differences of reception timing among a plurality of users in the base station.

The multiplexing unit 318 multiplexes the reference signal into information to be transmitted so as to generate a transmission symbol. The reference signal is transmitted by the short block (SB1, SB2) shown in the frame configuration of Fig.3. The reference signal is a signal that includes a pattern which is known to the transmission side and the reception side, and can be also referred to as a pilot signal, a pilot channel, a training signal, and the like.

The RF transmission circuit 320 performs processing such as digital-analog conversion, frequency conversion, band limitation and the like for transmitting the transmission symbol by a radio
5 frequency.

The power amplifier 332 adjusts transmission power.

The duplexer 324 properly separates a transmission signal and a received signal such that
10 simultaneous communication is realized.

The CAZAC sequence number setting unit 331 sets a sequence number of CAZAC code sequence used by the user apparatus. The CAZAC code will be described later with reference to Fig.4.

15 The CAZAC code generation unit 332 generates the CAZAC code sequence according to the set sequence number.

The cyclic shift number setting unit 333 sets a cyclic shift amount of the CAZAC code
20 sequence to be used by the user apparatus according to code information.

The cyclic shift unit 334 derives another code by cyclically rearranging the CAZAC code sequence according to the set cyclic shift amount.

25 In the following, an outline of the CAZAC code is described.

As shown in Fig.4, it is assumed that a code length of a CAZAC code A is L. For the sake of convenience of explanation, although it is assumed
30 that the code length corresponds to a time duration of L samples or L chips, such assumption is not essential for the present invention. Another code B is generated by moving a series of Δ samples (shaded area in the figure) including the last sample (L-th
35 sample) of the CAZAC code A to the top of the CAZAC code A as shown in the lower side of Fig.4. In this case, the CAZAC codes A and B are orthogonal to each

other with respect to $\Delta = 0 \sim (L-1)$. That is, a CAZAC code is orthogonal to a code obtained by cyclically shifting the CAZAC code. Therefore, when one sequence of a CAZAC code of the code length L is prepared, L codes which are orthogonal to each other can be prepared theoretically. A CAZAC code A is not orthogonal to another CAZAC code C that cannot be obtained by cyclically shifting the CAZAC code A . However, a cross-correlation value between the CAZAC code A and a random code which is not a CAZAC code is remarkably greater than a cross-correlation value between the CAZAC code A and the CAZAC code C . Thus, CAZAC code is preferable also from the viewpoint of reducing cross-correlation amount (interference amount) between non-orthogonal codes.

In the present embodiment, each user apparatus uses a CAZAC code selected from among a group of CAZAC codes having such properties (a code sequence group derived by cyclically shifting a CAZAC code). In the present embodiment, among L codes that are orthogonal to each other, L/L_Δ codes obtained by cyclically shifting a basic CAZAC code by $\Delta=n \times L_\Delta$ are actually used as reference signals by mobile stations ($n=0,1,\dots,(L-1)/L_\Delta$). L_Δ is an amount determined based on a multipath propagation delay amount. In doing this way, orthogonal relationship can be maintained in uplink control signals transmitted from individual user apparatuses under a multipath propagation environment. Details of the CAZAC code are described in D.C.Chu, "Polyphase codes with good periodic correlation properties", IEEE Trans.Inform.Theory, vol.IT-18, pp.531-532, July 1972; 3GPP,R1-050822, Texas Instruments, "On allocation of uplink sub-channels in EUTRA SC-FDMA", for example.

The block spreading unit 336 shown in Fig.2 prepares a set of predetermined number of

factors (block spread codes) and multiplies each of long blocks (LB) by each factor. The block spread code is an orthogonal code sequence, and which orthogonal code sequence is used is specified by
5 information from a code information specifying unit 330.

Fig.5 shows subframes of a first user apparatus UE1 and a second user apparatus UE2 in which multiplication by the block spread code is not
10 performed. Both of the first and the second user apparatuses use a CAZAC code sequence (CAZAC1). But, the second user apparatus uses a cyclic shift amount Δ which is different from that used by the first user apparatus. Therefore, two subframes
15 transmitted by the user apparatuses are orthogonal to each other. "Mod.a" indicates data to modulate a first long block for the first user apparatus UE1, that is, "Mod.a" indicates a factor used for multiplication. "Mod.a" - "Mod.f" correspond to
20 first factor to sixth factors (or seventh to eighth factors) for the first user apparatus UE1. "Mod.u" - "Mod.z" correspond to first factor to sixth factors (or seventh to eighth factors) for the second user apparatus UE1. Each factor (modulating
25 data) may include any information.

Fig.6 shows a situation in which long blocks of each of the first and the second user apparatuses UE1 and UE2 are multiplied by block spread codes. In the example shown in the figure, a
30 factor (separately from modulating data) is prepared every two long blocks. This factor forms a block spread code (BLSC). As shown in the broken line frame, an orthogonal code (1,1) is prepared for the first user apparatus UE1, and an orthogonal code
35 (1,-1) is prepared for the second user apparatus UE2. As described in the first embodiment, as long as one or more resource blocks are multiplied by a same

factor (value), orthogonality of the CAZAC code that forms the long block is not lost.

Therefore, as shown in the figure, when a set of factors by which the blocks is multiplied is codes that are orthogonal among users, users can be made orthogonal to each other using the codes while maintaining orthogonality of the CAZAC code. However, the blocks which are multiplied by an orthogonal code should have the same contents. In the example shown in the figure, for the first user UE1, each of the first factor and the second factor is "Mod.a", each of the third factor and the fourth factor is "Mod.b", and each of the fifth factor and the sixth factor is "Mod.c". Similarly, for the second user UE2, each of the first factor and the second factor is "Mod.x", each of the third factor and the fourth factor is "Mod.y", and each of the fifth factor and the sixth factor is "Mod.z". Thus, contents of information carried by the first to twelfth factors are limited to some extent. But, the limitation is not critical since the number of bits necessary for representing ACK/NACK etc. is relatively small.

Since the first and the second user apparatuses UE1 and UE2 can be identified by the block spread codes (1,1) and (1,-1), the CAZAC code shift amount used for the first and the second user apparatuses may be the same (it is not essential to use different cyclic shift amounts Δ). For the sake of convenience of explanation, although factors by which long blocks are multiplied are described, the short blocks SB may be multiplied by factors.

In the case when the frequency division multiplexing (FDM) scheme is applied for an uplink control signal from a plurality of user apparatuses, the frequency setting unit 337 shown in Fig.2 specifies which frequency should be used by each

user apparatus.

The reference signal generation unit 338 prepares a reference signal to be included in the uplink control signal. As mentioned above, the reference signal is transmitted using the short block (SB1,SB2) in the frame configuration shown in Fig.3. The reference signal is also formed by a CAZAC code assigned to each user apparatus. The CAZAC code for the reference signal may be also specified by a sequence number and a cyclic shift amount.

Generally, the long block (LB) and the short block (SB) are different in length, in time duration, or in number of chips, a CAZAC code C_L included in the long block (LB) and a CAZAC code C_S included in the short block (SB) may be prepared separately. However, since both of them are used for a same user apparatus, there may be a relationship between the CAZAC codes C_L and C_S (for example, a part of C_L may form C_S).

The unit 340 for determining the L1/L2 control information number and determining a number of times of retransmission demodulates and decodes the downlink L1/L2 control signal to specify where control information addressed to the user apparatus is mapped. In other words, the determination unit 340 specifies a position number to which the control information addressed to the user apparatus is mapped from among multiple pieces of control information of one or more users multiplexed in the downlink L1/L2 control information. For the sake of convenience of explanation, it is assumed that control information of N users are multiplexed into the downlink L1/L2 control signal, and that control information to the particular user apparatus is mapped to a X-th position. The determination unit 340 specifies information indicating "X". In

addition, when the signal received by the user apparatus is a retransmission packet, the determination unit 340 also specifies how many times retransmission has been performed.

5 The code information and resource information unit 342 specifies code information which includes information of a CAZAC code sequence (sequence number), a cyclic shift amount of CAZAC code sequence, a transmission band and the like,
10 used by the user apparatus. The code information may be derived based on broadcast information of the broadcast channel, or may be reported from the base station individually. The individual reporting may be performed using signaling of the upper layer such
15 as a L3 control signal. The code information further specifies an orthogonal code sequence represented by a set of factors (block spread code sequence) by which each set of a plurality blocks is multiplied.

20 The code information and resource information unit 342 refers to a list indicating correspondence relationship between "X" which is the downlink L1/L2 control information number (number of times of retransmission, as necessary) and resources
25 of the uplink control signal in order to specify resources by which the uplink control signal including acknowledgement information should be transmitted.

Fig.7 shows a base station apparatus
30 according to an embodiment of the present invention. Fig.7 shows a duplexer 702, an RF reception circuit 704, a reception timing estimation unit 706, a fast Fourier transform unit (FFT) 708, a channel estimation unit 710, a subcarrier demapping unit 712,
35 a frequency domain equalizing unit 714, an inverse discrete Fourier transform unit (IDFT) 716, a demodulation unit 718, a scheduler 722, and a code

information and resource information unit 742.

The duplexer 702 properly separates between a transmission signal and a received signal such that simultaneous communication is realized.

5 The RF reception circuit 704 performs processing such as digital analog conversion, frequency conversion, band limitation and the like for processing the received symbol in baseband.

10 The reception timing estimation unit 706 specifies reception timing based on a synchronization channel or a reference signal in a received signal.

15 The fast Fourier transform unit (FFT) 708 performs Fourier transform to convert time series information to information in the frequency domain.

 The channel estimation unit 710 estimates a channel state in the uplink based on reception state of the uplink reference signal, and outputs information for performing channel compensation.

20 The subcarrier demapping unit 712 performs demapping in the frequency domain. This processing is performed in response to mapping in the frequency domain performed in the individual user apparatuses.

25 The frequency domain equalizing unit 714 performs equalization of the received signal based on the channel estimation value.

30 The inverse discrete Fourier transform unit (IDFT) 716 restores a frequency domain signal into a time domain signal by performing inverse discrete Fourier transform.

 The demodulation unit 718 demodulates the received signal. As to the present invention, an uplink control signal is demodulated, so that the demodulation unit 718 outputs channel state
35 information (CQI) of downlink channel and/or acknowledgement information (ACK/NACK) for downlink data signal.

The scheduler 722 determines assignment in the downlink based on quality of the channel state information (CQI) of the downlink channel and other criteria. In addition, the scheduler 722 determines
5 uplink resource assignment based on reception result of the reference signal transmitted from each user apparatus and other criteria. The determined information is output as scheduling information. The scheduling information specifies frequency, time,
10 transmission format (data modulation scheme and channel coding rate) and the like used for transmitting signals.

In addition, the scheduler 722 reports, to the code information and resource information unit
15 742, information indicating where the control information for each user apparatus is mapped in the downlink L1/L2 control signal. The information indicates a position number to which control information of each user is mapped from among
20 multiple pieces of control information of one or more users multiplexed in the downlink L1/L2 control signal. In the above-mentioned example, control information addressed to a user apparatus is mapped to an X-th position, and information of "X" is
25 reported to the code information and resource information unit 742 for the user apparatus.

Based on the assignment result by the scheduler, the code information and resource information unit 742 specifies code information
30 which includes a sequence number indicating a CAZAC code used by a user apparatus in the uplink, cyclic shift amount, usable frequency band, block spread code and the like. The code information may be commonly reported to each user using the broadcast
35 channel, or may be reported individually to individual users. In the former case, it is necessary that each user apparatus uniquely derives

specific code information for the user apparatus from broadcast information.

Like the code information and resource information unit 342 (Fig.2), the code information and resource information unit 742 refers to a list indicating correspondence relationship between X which is a downlink L1/L2 control information number (number of times of retransmission as necessary) and resources of the uplink control signal, and specifies resources to be used for transmitting the uplink control signal including the acknowledgement information in the future.

Fig.8 shows an operation procedure according to an embodiment of the present invention. In this operation example, general code information related to all user apparatuses are transmitted by the broadcast channel (BCH). Each user apparatus uniquely derives code information specific to the own apparatus from the broadcast information. The general code information may include information indicating that there are N CAZAC code sequences ($C\#1, C\#2, \dots, C\#N$) used in the cell, there are M cyclic shift amounts ($0, L_{\Delta}, \dots, (M-1) \times L_{\Delta}$) for each sequence, and that frequency division multiplexing (FDM) scheme is used and there are F available bandwidths ($Bw1, Bw2, \dots, BwF$), and the like. As necessary, the code information may include information on block spread code.

In step B1, the base station apparatus performs downlink scheduling, and the base station apparatus sends a downlink control signal (L1/L2 control signal), a downlink data signal and a reference signal to the user apparatus.

In step M1, the user apparatus specifies information (code information for the user apparatus) related to the code used for an uplink control signal based on information included in the

downlink control signal.

Fig.9 shows an example of a method for specifying code information that may be used in step M1. For the sake of simplicity, it is assumed that
5 two CAZAC code sequences (C#1, C#2) are prepared, three cyclic shift amounts (0, L_{Δ} , $2L_{\Delta}$) are prepared for each sequence, and that two available bands (Bw1, Bw2) are prepared. Therefore, $2 \times 3 \times 2 = 12$ user apparatuses can be identified. The numbers are
10 merely examples, and other proper numbers may be used.

In step S1, the user apparatus recognizes an assigned number $P(=1, 2, \dots, 12)$ of the user apparatus specified in the downlink L1/L2 control
15 signal.

In step S2, the user apparatus determines whether the assigned number p is greater than 3 or not. When the determination result is No (when $p=1, 2$ or 3), the sequence number is specified as C#1,
20 the shift amount is specified as $(P-1) \times L_{\Delta}$, and the band is specified as Bw1. When the assigned number is greater than 3, the process flow goes to step S3.

In step S3, the user apparatus determines whether the assigned number p is greater than 6 or not. When the determination result is No (when $p=4, 5$ or 6), the sequence number is specified as C#1,
25 the shift amount is specified as $(P-1) \times L_{\Delta}$, and the band is specified as Bw2. When the assigned number is greater than 6, the process flow goes to step S4.

In step S4, the user apparatus determines whether the assigned number p is greater than 9 or not. When the determination result is No (when $p=7, 8$ or 9), the sequence number is specified as C#2,
30 the shift amount is specified as $(P-7) \times L_{\Delta}$, and the band is specified as Bw1. When the assigned number is greater than 9 (when $p=10, 11$ or 12), the sequence number is specified as C#2, the shift

amount is specified as $(P-1) \times L_{\Delta}$, and the band is specified as Bw2.

Fig.10 shows examples of CAZAC codes, cyclic shift amounts and bands realized by executing the flow shown in Fig.9. As shown in the figure, users are multiplexed using a code division multiplexing (CDM) scheme using a CAZAC code of a same sequence, first. As the number of users increases, users are code-multiplexed using the same CAZAC code sequence in another band. After that, CDM is performed in each available band. In other words, although CDM and FDM are performed, CDM is given preference. In the case when multiplexing users the number of which is greater than the number of users that can be identified by code division multiplexing using a CAZAC code sequence and using frequency division multiplexing, another CAZAC code sequence is prepared, and users are multiplexed by CDM, and CDM and FDM.

Assuming that N CAZAC code sequences (C#1, C#2, ..., C#N) are prepared, M cyclic shift amounts $(0, L_{\Delta}, \dots, (M-1) \times L_{\Delta})$ are prepared, frequency division multiplexing scheme (FDM) is used, and that F available bands (Bw1, Bw2, ..., BwF) are prepared, the sequence number of CAZAC code is represented as a value of $(P/(M \times F))$ in which a fractional portion is round up, a $((P-(n-1) \times (M \times F))/M)$ -th band is used, and the cyclic shift amount is represented as $(P - ((n-1) \times (M \times F)) - (f-1) \times M = P \bmod M)$ times L_{Δ} .

In the example described with reference to Figs.9 and 10, the user apparatus starts to use another band Bw2 at the time when the assigned number or the number of multiplexed users exceeds three. However, even when the number of multiplexed users is greater than 3 and equal to or less than 6, it can be considered to use the same band Bw1, and instead, use another CAZAC code sequence C#2. The

CAZAC codes C#1 and C#2 are not orthogonal to each other in which one cannot be derived from another by cyclically shifting. However, the reason to use C#1 and C#2 is that the cross-correlation value is
5 relatively small.

As mentioned above, code information of each user apparatus can be specified from the broadcast information and the assignment information p. The specified code information is provided to
10 the CAZAC sequence number setting unit 331, the cyclic shift number setting unit 333, the block spread code setting unit 335, the frequency setting unit 337 and the reference signal setting unit 38 shown in Fig.2, so that various parameters are set.

15 In step M2 in Fig.8, the user apparatus determines presence or absence of an error for each packet of the downlink data signal. For example, the error detection may be performed using the cyclic redundancy check (CRC) method, or any other
20 proper error detection method known in this technical field may be used. The user apparatus determines positive acknowledgement ACK which indicates there is no error (or within a permissible range even if there is an error) or negative
25 acknowledgement NACK which indicates there is an error, for each packet. The ACK and the NACK form the acknowledgment information.

In step M3, the user apparatus measures reception quality of the downlink reference signal,
30 and converts the measurement value to a numerical value within a range to derive the channel state information (CQI). For example, in the case when the reception quality (SIR and the like) is represented as 32 levels, the user apparatus
35 converts the measurement result to a numerical value indicating what level the current reception quality is, so that CQI that can be represented by 5 bits is

derived.

It is not essential that the steps M2 and M3 are performed in this order. The determination of the acknowledgement information and the measurement of the channel state information may be performed at any proper time.

In step M4, the user apparatus generates an uplink control signal for reporting, to the base station, both or one of the acknowledgement information (ACK/NACK) or the channel state information (CQI). As mentioned above, the block-by-block modulation pattern generation unit shown in Fig.2 prepares one factor for each of 12 blocks, so that 12 factors (first factor - twelfth factor) are prepared for one TTI. One or more of the 12 factors may represent the acknowledgement information, the channel state information or other information. The uplink control signal has a frame structure shown in Figs.3 and 6.

For example, the first long block (LB1) is generated by multiplying the whole CAZAC code sequence (cyclically shifted) by the first factor. The second long block (LB2) is generated by multiplying the same CAZAC code sequence by the second factor. After that, in the same way, a K-th long block (LBK) is generated by multiplying the same CAZAC code by the K-th factor. Accordingly, a frame for the uplink control signal including 12 long blocks is generated. More properly, the frame includes a reference signal formed by a CAZAC code.

The uplink control signal generated in this way is transmitted from the user apparatus to the base station using a dedicated band. The user apparatus can uniquely determine which part in the dedicated band is used based on resource information. The resource information indicates predetermined correspondence relationship between a mapping

position in the downlink L1/L2 control signal and resources of the uplink control signal, and is specified by the code information and resource information units 342 and 742 shown in Figs.2 and 7.

5 For example, assuming that control information for a user apparatus is mapped to a X-th position in the downlink L1/L2 control signal which includes information of N users, the corresponding relationship uniquely associates X with slot (Fig.1),
10 CAZAC code (sequence number, cyclic shift amount), block spread code, frequency band and the like used for the uplink control signal. This correspondence relationship is known to the user apparatus and the base station apparatus. Accordingly, resources to
15 be used for the uplink control signal including acknowledgement information are uniquely derived based on information indicating that "control information (control information accompanying the downlink data signal) addressed to the user
20 apparatus is mapped to the X-th position", and the uplink control signal is transmitted using the resources.

Fig.11 schematically shows such a predetermined correspondence relationship. In the
25 example shown in the figure, when control information accompanying the downlink data signal addressed to a user apparatus (that is, control information including scheduling information) is mapped to an X-th position, ACK/NACK for the
30 downlink data signal is transmitted by the first hopping control signal (Fig.1). The downlink data signal may be a retransmission packet instead of a new packet. In the case when a resource block used for the retransmission packet is specifically
35 determined, the correspondence relationship is determined considering such information.

Fig.12 shows a situation in which

resources for the uplink control signal are reserved for a user performing persistent scheduling. When downlink communication based on persistent scheduling is performed, the downlink L1/L2 control
5 signal is not transmitted. In this case, an uplink control signal including ACK/NACK is transmitted by resources specifically prepared as shown in Fig.12.

In step B2 in Fig.8, the base station apparatus receives uplink control signals from a
10 plurality of user apparatuses, and demodulates the signals. Each user apparatus transmits a similar uplink control signal. But, the uplink control signals use the same CAZAC code sequence having different cyclic shift amounts, different bands,
15 CAZAC code of different sequences and/or different block spread codes. These are specified by the code information and resource information unit 742.

As mentioned above, since the whole CAZAC code is merely multiplied by one factor in each long
20 block, the base station apparatus can add uplink control signals received from each user apparatus in phase. Therefore, when the block spread code is used, orthogonality of the code is exerted. In addition to that, orthogonality among CAZAC codes of
25 the same sequence having different cyclic shift amounts is not collapsed. Thus, the base station apparatus can orthogonally separates signals sent from each user apparatus. Even when non-orthogonal CAZAC code is used, the user apparatus can be
30 identified with lower interference as compared with the case in which a random sequence is used. Further, by determining the contents of the first to twelfth factors used for the uplink control signal for each user apparatus, contents of acknowledgement
35 information and/or channel state information can be identified.

In step B3, the base station apparatus

performs processing such as retransmission control
and resource assignment based on acknowledgement
information (ACK/NACK) and/or channel state
information (CQI) reported from the user apparatus
5 by the uplink control signal.

According to the present embodiment, the
mapping position of the information addressed to the
user apparatus in the downlink L1/L2 control signal
and resources for the uplink control signal
10 including ACK/NACK are uniquely determined by using
the predetermined correspondence relationship. Thus,
it becomes unnecessary to report resources to be
used for the uplink control signal one by one.
Since it is only necessary to prepare resources for
15 (the number of multiplexed users and the number of
times of retransmission) at most, resources can be
saved as compared with the after-mentioned second
embodiment.

[Embodiment 2]

20 Fig.13 shows a block diagram of the user
apparatus according to a second embodiment of the
present invention. In general, the user apparatus
is similar to one described with reference to Fig.2.
But, the user apparatus shown in Fig.13 is different
25 from one shown in Fig.2 in processing of the unit
340' for determining resource block number of the
downlink data signal, and the code information and
resource information unit 342'.

The unit 340' for determining the resource
30 block number of the downlink data signal extracts
control information addressed to the user apparatus
from the downlink L1/L2 control signal, and
determines a resource block to which the downlink
data signal addressed to the user apparatus is
35 mapped. For the sake of explanation, it is assumed
that the downlink data signal is transmitted to the
user apparatus using a Y-th resource block (RB-Y).

In addition to specifying code information like the unit 342 shown in Fig.2, the code information and resource information unit 342' refers to a list indicating correspondence
5 relationship between the location (RB-Y) of the resource block used for the downlink data signal and resources of the uplink control signal, and specifies which resource should be used for transmitting the uplink control signal including the
10 acknowledgement information. The specified code information and resources are reported to each component like the case of the first embodiment.

Fig.14 shows a block diagram of the base station apparatus according to the second embodiment
15 of the present invention. In general, the base station apparatus shown in Fig.14 is similar to one shown in Fig.7. But, the base station apparatus shown in Fig.14 is different from that shown in Fig.7 in processing on the code information and
20 resource information unit 742'. First, the scheduler 722 reports information indicating a resource block to which the downlink data signal addressed to each user apparatus is mapped, to the code information and resource information unit 742'.
25 Assuming that a data signal addressed to a user apparatus is mapped to a Y-th resource block (RB-Y), information indicating that "the resource block is RB-Y" is reported to the code information and resource information unit 742' as to the user
30 apparatus.

In addition to specifying code information like 742 shown in Fig.7, the code information and resource information unit 742' refers to
predetermined correspondence relationship between
35 the resource block number (RB-Y) and resources of the uplink control signal including ACK/NACK for the data signal transmitted using the resource block, so

that the code information and resource information unit 742' specifies which resource should be used for transmitting the uplink control signal in the future.

5 Fig.15 shows an example of the
correspondence relationship. In the example shown
in the figure, as to 16 resource block numbers,
ACK/NACK for the first to eighth resource blocks are
transmitted by the first hopping control signal
10 (Fig.1), and ACK/NACK for the ninth to sixteenth
resource blocks are transmitted by the second
hopping control signal (Fig.1).

 In the present embodiment, since the
resource block number used for the user apparatus
15 and the resources for the uplink control signal
including ACK/NACK are uniquely determined by the
predetermined correspondence relationship, it is not
necessary to report, to the user apparatus,
information indicating which resource should be used
20 for uplink control signal one by one. Since
resources for the uplink control signal are uniquely
derived from the resource block number used for the
user apparatus, it is not necessary to identify
whether the data signal transmitted by the resource
25 block is based on persistent scheduling or not. In
addition, since the resource block number is used as
a basis, instead of using the mapping position of
the control signal like the first embodiment,
resources for uplink control signal can be easily
30 specified.

 As described above, while the present
invention is described with reference to specific
embodiments, the respective embodiments are merely
exemplary, so that a skilled person will understand
35 variations, modifications, alternatives, and
replacements. While specific numerical value
examples are used to facilitate understanding of the

present invention, such numerical values are merely
examples, so that any appropriate value may be used
unless specified otherwise. Classification into
each embodiment is not essential in the present
5 invention, and equal to or more than two embodiments
may be used as necessary. For convenience of
explanation, while the apparatus according to the
embodiments of the present invention is explained
using functional block diagrams, such an apparatus
10 as described above may be implemented in hardware,
software, or a combination thereof. The present
invention is not limited to the above embodiments,
so that variations, modifications, alternatives, and
replacements are included in the present invention
15 without departing from the spirit of the present
invention.

The present international application
claims priority based on Japanese patent application
No.2007-073724, filed in the JPO on March 20, 2007
20 and the entire contents of the Japanese patent
application No.2007-073724 is incorporated herein by
reference.

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CLAIMS

1. A user apparatus for transmitting an uplink control signal to a base station apparatus using a single carrier scheme, comprising:
- a unit configured to receive a downlink control signal and a downlink data signal;
 - a unit configured to prepare acknowledgement information indicating positive acknowledgement or negative acknowledgement for the downlink data signal;
 - a unit configured to prepare the uplink control signal including the acknowledgement information;
 - a unit configured to transmit the uplink control signal using different resources which are different from resources that can be used for an uplink data signal; and
 - a storage unit configured to store predetermined correspondence relationship which uniquely associates resources of the downlink control signal or the downlink data signal with resources used for the uplink control signal.
2. The user apparatus as claimed in claim 1, wherein the predetermined correspondence relationship uniquely associates a frequency and an OFDM symbol to which the downlink control signal for the user apparatus is mapped with a time slot to which the uplink control signal is mapped.

3. The user apparatus as claimed in claim
2, wherein, when communication is performed by
persistent scheduling in downlink, the uplink
control signal including the acknowledgement
5 information is transmitted by resources different
from the different resources.

10

4. The user apparatus as claimed in claim
1, wherein the predetermined correspondence
relationship uniquely associates a resource block to
which the downlink data signal is mapped with a time
15 slot to which the uplink control signal is mapped.

20

5. The user apparatus as claimed in claim
1, wherein the uplink control signal includes a
plurality of unit block sequences each of which is
obtained by multiplying all chips of an orthogonal
code sequence for the user apparatus by a same
25 factor.

30

6. The user apparatus as claimed in claim
5, wherein factors by which each of a plurality of
unit blocks having the same contents is multiplied
represent an orthogonal code sequence.

35

7. A base station apparatus for receiving an uplink control signal from the user apparatus using a single carrier scheme, comprising:

5 a unit configured to transmit a downlink control signal and a downlink data signal;

10 a unit configured to receive an uplink control signal including acknowledgement information indicating positive acknowledgement or negative acknowledgement for the downlink data signal, using different resources which are different from resources that can be used for the uplink data signal; and

15 a storage unit configured to store a predetermined correspondence relationship which uniquely associates resources of the downlink control signal or the downlink data signal with resources used for the uplink control signal.

20

8. A method used in a mobile communication system which uses a single carrier scheme in uplink, comprising, comprising:

25 a step in which a downlink control signal and a downlink data signal are transmitted from a base station apparatus to a user apparatus;

30 a step in which a user apparatus prepares an uplink control signal including acknowledgement information indicating positive acknowledgement or negative acknowledgement for the downlink data signal; and

35 a step in which the uplink control signal is transmitted from the user apparatus to the base station apparatus using different resources which are different from resources that can be used for an uplink data signal,

wherein the resources used for the uplink
control signal are uniquely derived in the base
station apparatus and in the user apparatus from
resources of the downlink control signal or the
5 downlink data signal according to a predetermined
correspondence relationship.

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