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Table with 7 columns: APPLICATION NUMBER, FILING or 371(c) DATE, GRP ART UNIT, FIL FEE REC'D, ATTY DOCKET NO, TOT CLAIMS, IND CLAIMS. Row 1: 60/988,433, 11/16/2007, 210, UT07-0149-USPO

CONFIRMATION NO. 9013

REPLACEMENT FILING RECEIPT



67487
KORPAT, PC
GANGNAM P.O 1655
SEOUL, 135-616
KOREA, REPUBLIC OF

Date Mailed: 02/27/2009

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections

Applicant(s)

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Power of Attorney: The patent practitioners associated with Customer Number 67487

Permission to Access - A proper Authorization to Permit Access to Application by Participating Offices (PTO/SB/39 or its equivalent) has been received by the USPTO.

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

PUSCH CONTROL CHANNEL MULTIPLEXING

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Doc Code: PD.TO.AUTH

Document Description: Authorization to access Appl. by Trilateral Office

PTO/SB/39 (01-09)  
Approved for use through 02/28/2009. OMB 0651-0031  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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### AUTHORIZATION TO PERMIT ACCESS TO APPLICATION BY PARTICIPATING OFFICES

COMPLETE IF KNOWN

Application Number	60/988,433
Filing Date	11-16-2007
First Named Inventor	Dae Won LEE
Attorney Docket Number	UT07-0149-USPO
Title (Required)	PUSCH CONTROL CHANNEL MULTIPLEXI

Send completed form to: Commissioner for Patents  
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The undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h).

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the application-as-filed with respect to: 1) the above-identified application, 2) any foreign application to which the above-identified application claims priority under 35 USC 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified US application, and 3) any U.S. application from which benefit is sought in the above-identified application.

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**This form must be signed by an authorized party in accordance with 37 CFR 1.14(c).**

/Andrew S. PARK/

02-25-2009

Signature

Date

Andrew S. PARK

82-2-2193-0001

Printed or Typed Name

Telephone Number

PUSCH CONTROL CHANNEL MULTIPLEXING

47841

Title

Registration Number, if applicable

This collection of information is required by 37 CFR 1.14(h). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process an application). Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	4860674
<b>Application Number:</b>	60988433
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9013
<b>Title of Invention:</b>	PUSCH CONTROL CHANNEL MULTIPLEXING
<b>First Named Inventor/Applicant Name:</b>	Dae Won LEE
<b>Customer Number:</b>	67487
<b>Filer:</b>	Andrew S. Park/Soojin KIM
<b>Filer Authorized By:</b>	Andrew S. Park
<b>Attorney Docket Number:</b>	UT07-0149-USPO
<b>Receipt Date:</b>	26-FEB-2009
<b>Filing Date:</b>	16-NOV-2007
<b>Time Stamp:</b>	04:00:54
<b>Application Type:</b>	Provisional

### Payment information:

Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Authorization to access Appl. by Trilateral Office	SB39_UT07-149.pdf	144118 af307d05616e2f9af761d49dc07b8b8c947c a4f3	no	1

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Lee et al. Serial No: 60/988,433 Filed: November 16, 2007 For: PUSCH CONTROL CHANNEL MULTIPLEXING	Art Unit: Examiner: Confirmation No. 9013
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**REPLY TO LETTER RE NON-ENGLISH LANGUAGE  
APPLICATION PAPERS IN A PROVISIONAL APPLICATION**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Examiner:

In response to the Letter re Non-English Language Application Papers in a Provisional Application forwarded with the Official Filing Receipt dated November 30, 2007, for the above-identified Provisional application, and in accordance with 37 C.F.R. 1.78(a)(5), enclosed are:

1. An English Translation of the Specification; and
  2. A statement of Verification dated November 18, 2008.
- To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any additional fees due or credit any overpayment in connection with the filing of this concurrent and future replies, including extension of time fees, to Deposit Account 502290.

Respectfully submitted,

LEE, HONG, DEGERMAN, KANG & WAIMEY

Date: December 26, 2008

By: /Harry S. Lee/  
Harry S. Lee  
Registration No. 56,814

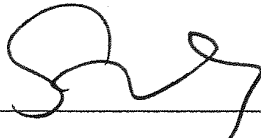
Customer No. 35884

## CERTIFICATE OF VERIFICATION

I, Sung Mi JEON of 648-23 Yeoksam-dong, Gangnam-gu, Seoul, Republic of Korea state that the attached documents are a true and complete translation to the best of my knowledge of the Korean-English language and that the writings contained in the following pages are correct English translations of the Provisional U.S. Patent Application Nos. 60/972,244; 60/987,427 and 60/988,433

Dated this 18 rd day of November, 2008

Signature of translator: \_\_\_\_\_

A handwritten signature in black ink, appearing to be 'Sung Mi JEON', written over a horizontal line.

Sung Mi JEON



## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	4523951
<b>Application Number:</b>	60988433
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9013
<b>Title of Invention:</b>	PUSCH CONTROL CHANNEL MULTIPLEXING
<b>First Named Inventor/Applicant Name:</b>	Dae Won LEE
<b>Customer Number:</b>	67487
<b>Filer:</b>	Harry Sung Lee/Maggie Wen
<b>Filer Authorized By:</b>	Harry Sung Lee
<b>Attorney Docket Number:</b>	UT07-0149-USPO
<b>Receipt Date:</b>	26-DEC-2008
<b>Filing Date:</b>	16-NOV-2007
<b>Time Stamp:</b>	20:33:51
<b>Application Type:</b>	Provisional

### Payment information:

Submitted with Payment	no
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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	2101-3573_60988433_XM.pdf	101903 <small>3fa71784cf6eee89:c613783ddf864b8389207521</small>	no	1

### Warnings:

### Information:

2	Miscellaneous Incoming Letter	2101-3573_Verificationfortranslations.pdf	28851 7de8e1c449f0b813a1bbf760e2786d91786d4d19	no	1
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<b>Information:</b>					
3	Specification	60988433_translation.pdf	2088340 0cf5933469b2dd5b8483dc37e8ca9a22fe84d7f4	no	36
<b>Warnings:</b>					
<b>Information:</b>					
<b>Total Files Size (in bytes):</b>			2219094		
<p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b>  <b>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</b></p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b>  <b>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</b></p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b>  <b>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</b></p>					

**[SPECIFICATION]**

**PUSCH CONTROL CHANNEL MULTIPLEXING**

**1. Technical Field of the Invention and the Related Art thereof**

[FIG. 1]

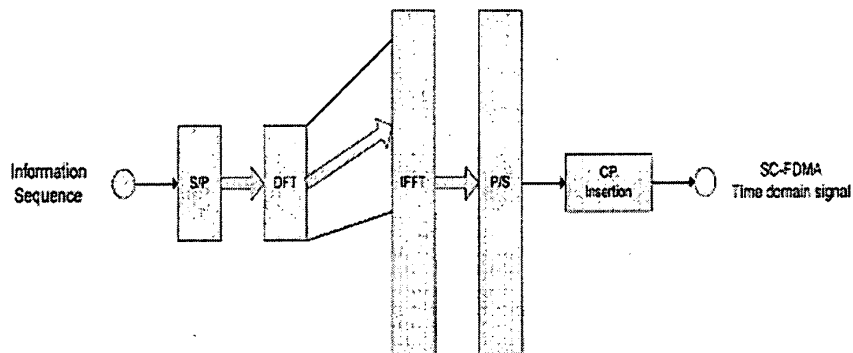


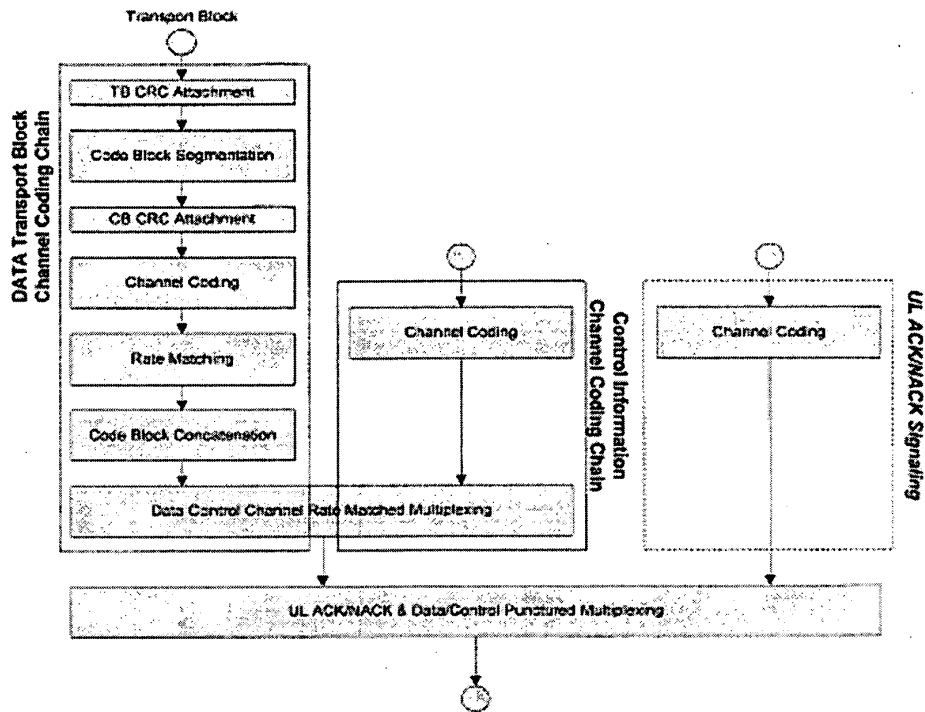
FIG. 1 shows a single carrier division multiplexing access (SC-FDMA) block diagram.

An uplink system based on a single carrier frequency division multiplexing access (SC-FDMA) technology generally transmits information using the following processes. The uplink system converts an information sequence to be transmitted into a serial-to-parallel sequence in such a way that a Discrete Fourier Transform (DFT) process is carried out. If the DFT is carried out, then an IFFT process is performed. In this case, the length of information inserted into the IFFT may be different from the IFFT size, the DFT

result associated with successive IFFT input indexes is mapped, and then the mapped result is then transferred. The IFFT resultant values are converted into parallel-to-serial data. A cyclic prefix (CP) is added to the parallel-to-serial data, such that the CP-added result is converted into an OFDM symbol format, and this OFDM symbol is transmitted via a real space-time. FIG. 1 is an exemplary block diagram for transmission of SC-FDMA information.

In order to maintain a single carrier format simultaneously while satisfying either a low peak power-to-average power ratio (PAPR) or a cubic metric (CM), information must be inserted into successive indexes when DFT-precoded information is inserted into an OFDM-formatted IFFT. In other words, the DFT-precoded information is inserted into OFDM-successive subcarriers. Therefore, in case of transmitting uplink information, information of different characters (i.e., control information and data information) is multiplexed, the multiplexed information is DFT-precoded, and the DFT-precoded result is transmitted according to an OFDM scheme.

[FIG. 2]



The data information multiplexed with the control information is divided into several code blocks on the basis of the size of a transport block to be transmitted to the uplink, and these code blocks are encoded. The encoded code blocks are concatenated to construct one data information sequence, and this data information sequence is multiplexed with the control information.

The control information capable of being transmitted along with data in the uplink is classified into two kinds of control information. This control information may be classified into an UL ACK/NACK signal used as a confirmation signal for uplink data and other control information. The UL ACK/NACK signal for downlink data is transmitted only when

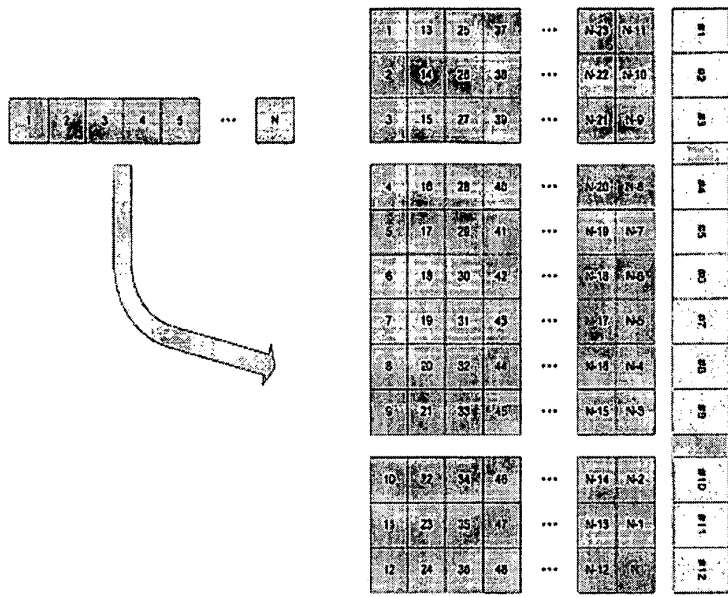
downlink data exists. A mobile station which does not recognize an obligation of receiving downlink data may don't know this obligation although it must transmit the UL ACK/NACK signal, such that two kinds of control information is discriminated, and the discriminated control information is transmitted to the uplink. All kinds of control information described in the present invention is indicative of control information except for the UL ACK/NACK signal, and the UL ACK/NACK signal will hereinafter be described in detail.

When data information is transmitted to the uplink, this data information may be transmitted along with the control information, or the data information and the control information can be transmitted along with ACK/NACK information. Otherwise, only the data information and the ACK/NACK information can be transmitted at the same time.

Transmission information sequence is transferred according to the SC-FDMA scheme. In this case, this transmission information sequence may be constructed when the data information is multiplexed with the control information or the ACK/NACK information. In this case, transmission information sequences are arranged by a time-first mapping method, such that these transmission information sequences are transmitted according to the SC-FDMA scheme. For example, it is assumed that the transmission information sequences are

transmitted using only one resource block (i.e., 12 OFDM subcarriers), information is transmitted via a single subframe, the single subframe is composed of 14 SC-FDMA symbols, and two SC-FDMA symbols are used as a reference signal acting as a pilot. In this case, the number of modulated symbols of information capable of being transmitted to the uplink is 144 (i.e.,  $12 \times 12 = 144$ ). 144 information sequence symbols are transmitted via 12 virtual subcarriers and 12 SC-FDMA symbols. These 144 sequence symbols are configured in the form of a (12x12) matrix, such that the (12x12) matrix is called a time-frequency mapper. Information sequences to be transmitted to the uplink are mapped in the direction of an SC-FDMA symbol axis one by one. The SC-FDMA symbol is divided into several sections in a time domain, such that this mapping method is called a time-first mapping method. Sequences are arranged in the direction of a time axis of the time-frequency mapper as shown in FIGS. 4 and 5. According to a method for firstly arranging sequences on a time axis, after the time-frequency mapping occurs, a DFT process is performed on sequences arranged on a frequency axis, the DFT result is inserted into a desired frequency band, and the IFFT and the cyclic prefix (CP) are added to the inserted result, such that the SC-FDMA symbol is made and transferred.

[FIG. 3]



[FIG. 4]

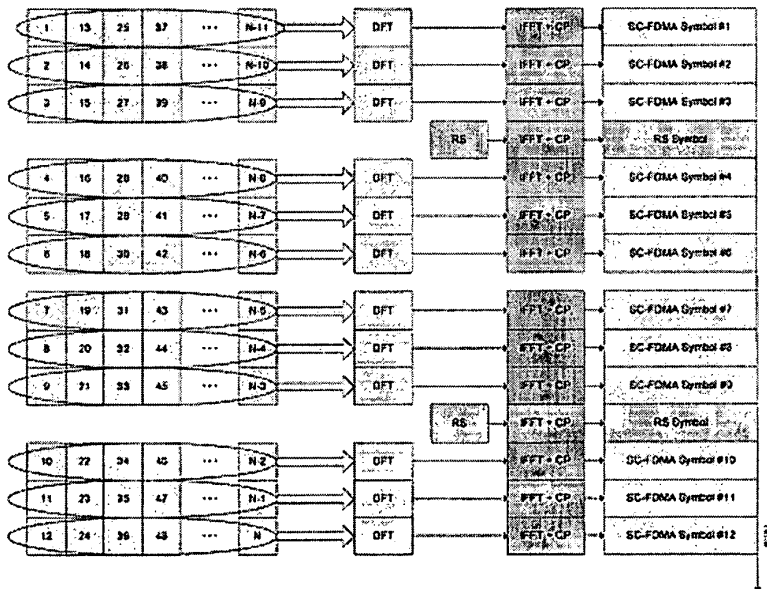




FIG. 4 shows an SC-FDMA subframe mapping method of transmission information sequences in case of a normal cyclic prefix (CP).

[FIG. 5]

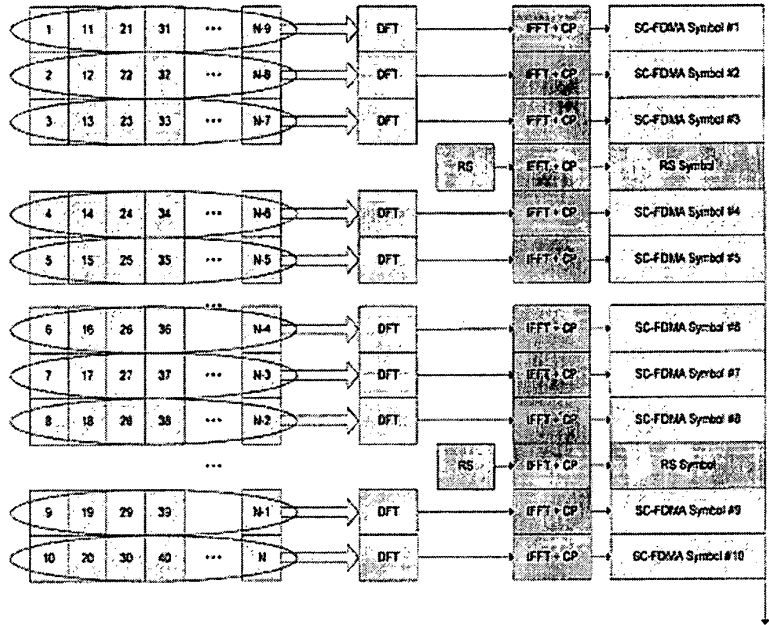


FIG. 5 shows an SC-FDMA subframe mapping method of transmission information sequences in case of an extended cyclic prefix (CP).

Data and the control information can be simultaneously transmitted in the uplink. In this case, the data information and the control information are multiplexed by a rate multiplexing process. However, ACK/NACK information is constructed when either a symbol in which data and the control information are multiplexed or a bitstream of data information is punctured, such that the ACK/NACK information

is inserted. In this case, this puncturing process subtracts specific bit information from the bitstream, and inserts new bit information into the deducted result, such that the length of inserted resultant information is equal to the length of bitstreams of overall information.

Generally, reliability of the control information must be higher than that of data. For this purpose, the control information must be multiplexed or inserted in the vicinity of a reference signal so as to implement the channel estimation performance effect, resulting in the improvement of a performance.

## **2. Constructions and Operations of the Invention**

The present invention assigns different priorities to individual information segments when data information, a bitstream, a control-information bitstream, and an ACK/NACK information sequence are multiplexed, in such a way that the individual information segments having different priorities are multiplexed. In this case, multiplexing methods and orders of the individual methods are decided according to some rules.

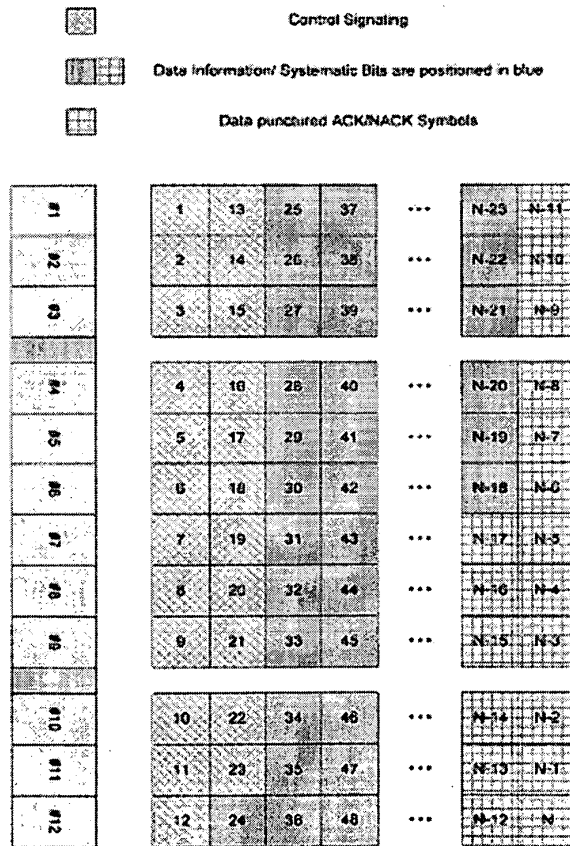
### **Method 1-a-1**

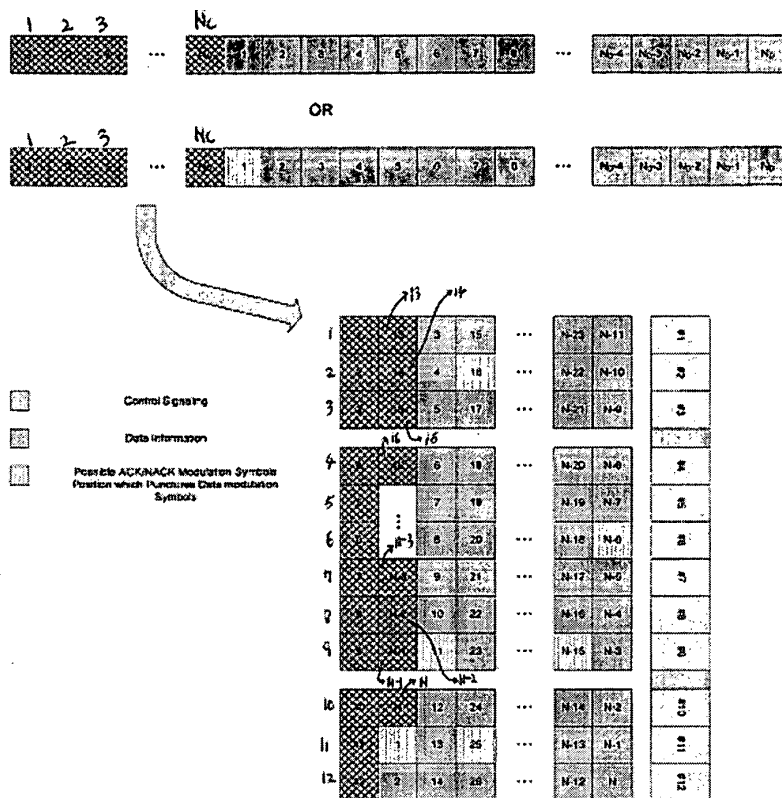
This 1-a-1 method is based on a first principle which maximally arranges control information on a time axis, and a

second principle which maximally arranges ACK/NACK information on the time axis, such that it provides the multiplexing method based on the first and second principles.

The ACK/NACK information provides the multiplexing method without puncturing control information.

[FIG. 6]





According to the above-mentioned 1-a-1 method, control information and data information are sequentially concatenated simultaneously while being multiplexed, and the concatenated resultant information is mapped to SC-FDMA symbols according to the time-first mapping method, such that the mapped result is transmitted to the uplink. If ACK/NACK information must also be transmitted, modulated symbols of this ACK/NACK information assign equal distribution to data information, and the data information is punctured and inserted. In this case, according to this equal distribution, the modulated symbols are equally distributed to an overall

length of a data-information sequence, and the distributed result is punctured. The above-mentioned puncturing process removes the modulated symbols of the data information, and the modulated symbols are inserted into the removed locations. For example, provided that a total number of modulated symbols of the data-information sequence is 100 and the number of modulated symbols of the ACK/NACK information is 8, the modulated symbols of the ACK/NACK information will be inserted by the puncturing of data-information modulated symbols at intervals of 12 modulated symbols. In this way, provided that the data-information sequences are equally punctured and this data information is composed of several code blocks, the ACK/NACK information is equally punctured from each code block, such that it prevents a performance of only a specific code block from being greatly deteriorated.

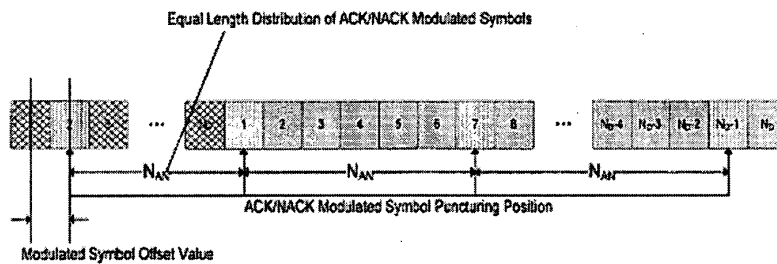
More specifically, the ACK/NACK information may be compulsorily inserted by the puncturing of modulated symbols corresponding to the number of individual code blocks. Information sections as many as the modulated symbols in all the code blocks are punctured, such that the punctured result can always prevent the performance of a specific code block from being deteriorated.

**Method 1-a-2**

This 1-a-2 method is based on a first principle which maximally arranges control information on a time axis, and a second principle which maximally arranges ACK/NACK information on the time axis, such that it provides the multiplexing method based on the first and second principles.

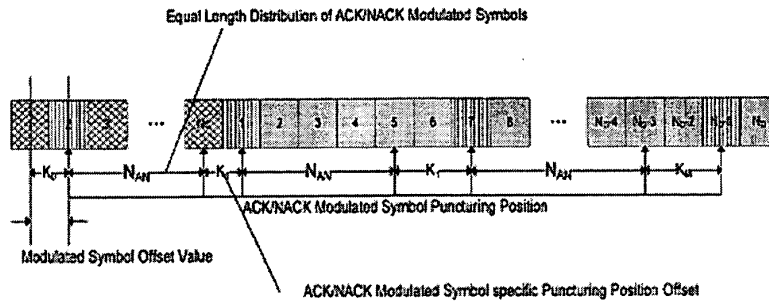
The ACK/NACK information provides another multiplexing method. This multiplexing method does not maximally perform the puncturing of the control information, and can also puncture the control information if the number of bits of the control information is higher than the number of bits of data information.

[FIG. 7]



In this case, the punctured ACK/NACK information assigns the same modulated symbol interval to the information sequence where control information and data information are multiplexed, the puncturing process is executed on the resultant ACK/NACK information, and then the punctured result is inserted.

[FIG. 8]

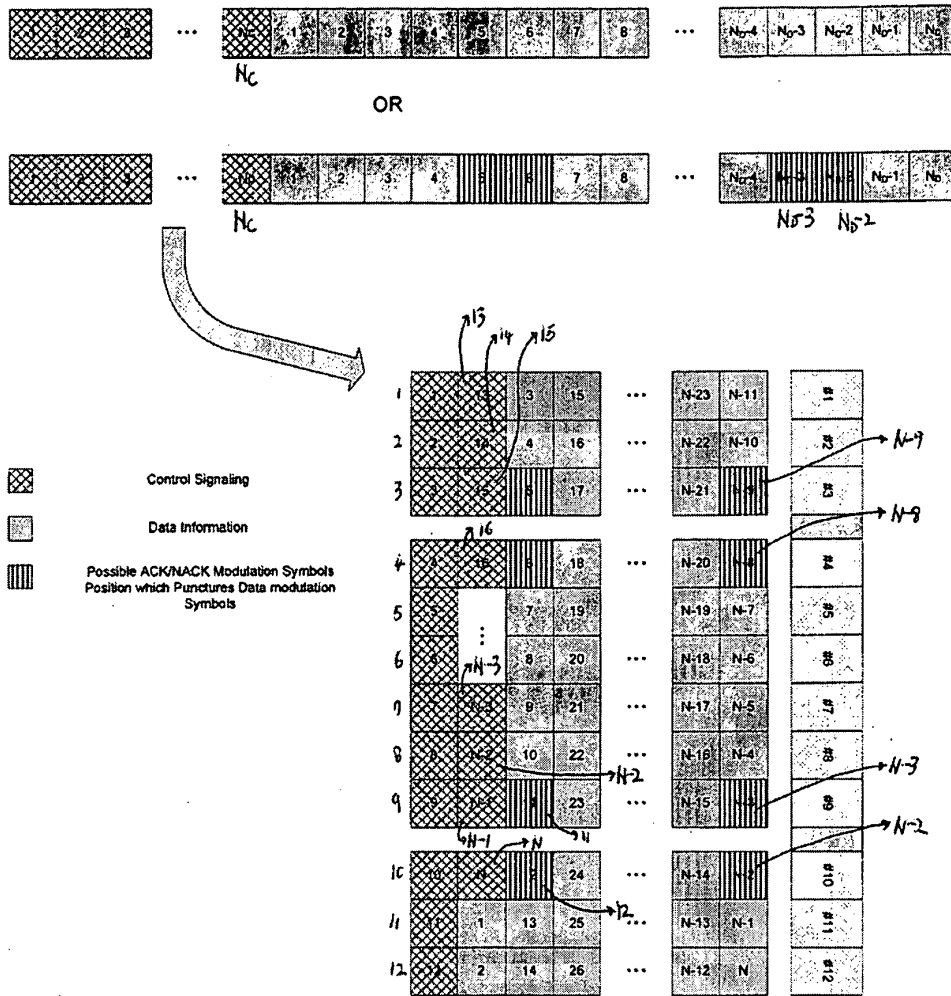


Specifically, if the interval between the modulated symbols where the punctured ACK/NACK information is inserted is equal to the number of SC-OFDM symbols via which data- or control information of the uplink subframe is transmitted, ACK/NACK modulated symbols can be transmitted to the same SC-FDMA, such that the SC-FDMA offset value is assigned to each ACK/NACK modulated symbol, such that all the ACK/NACK information sequences are not located at the same SC-FDMA symbol.

#### **Method 1-b**

This 1-b method is based on a first principle which maximally arranges control information on the time axis, and a second principle which transmits ACK/NACK information in the vicinity of a reference signal used as a pilot, such that it provides the multiplexing method based on the first and second principles.

[FIG. 9]



According to the above-mentioned 1-b method, control information and data information are sequentially concatenated simultaneously while being multiplexed, and the concatenated resultant information is mapped to SC-FDMA symbols according to the time-first mapping method, such that the mapped result is transmitted to the uplink. If ACK/NACK information must also be transmitted, this 1-b method

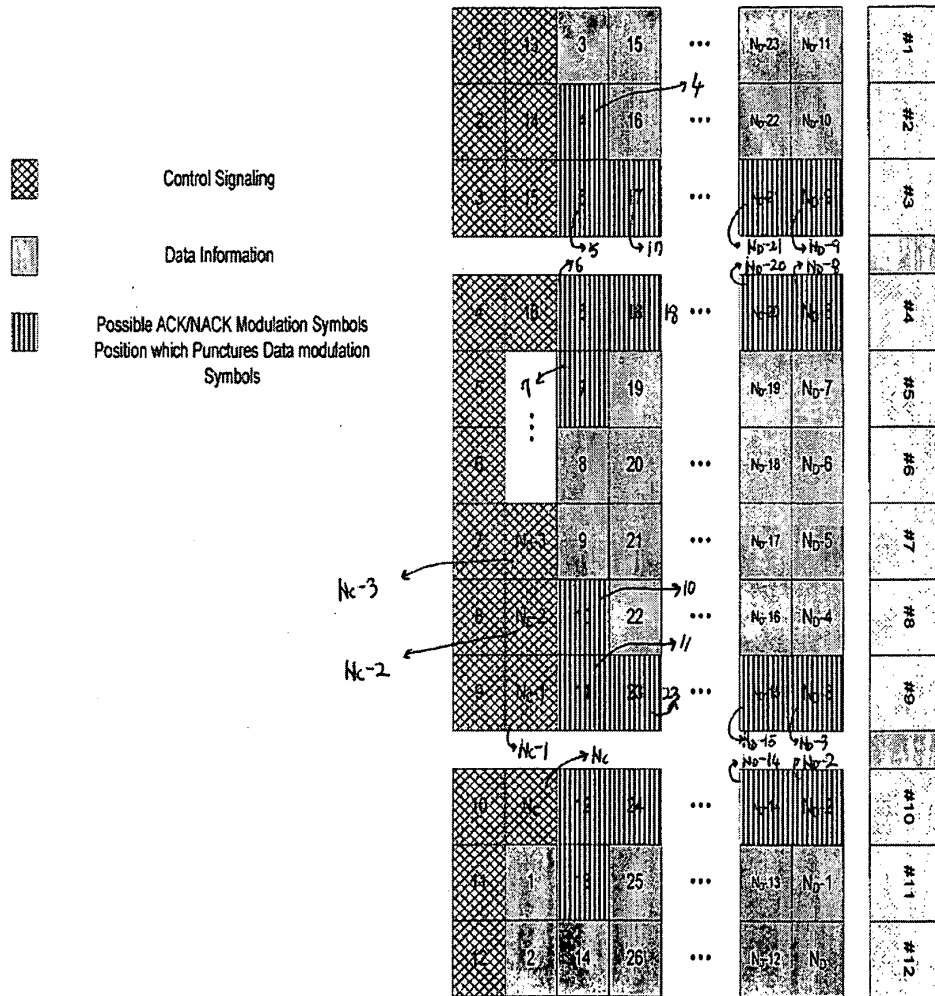


punctures the modulated symbols located in the vicinity of the reference signal in the data-information sequence without puncturing the control information, and then performs insertion of the ACK/NACK signal. In this case, in order to perform the insertion of the ACK/NACK signal, the 1-b method firstly calculates how many subcarriers (i.e., subcarriers of a virtual frequency domain) are occupied by the control information, and calculates the number of subcarriers via which the data information is transmitted to the front and rear parts of the reference symbol. As a result, the 1-a method calculates how many SC-FDMA symbols are needed for data transmission according to the amount of ACK/NACK information, and assigns the equal distribution to the front and rear parts of the reference signal symbol contained in each slot, such that the data information is punctured and inserted.

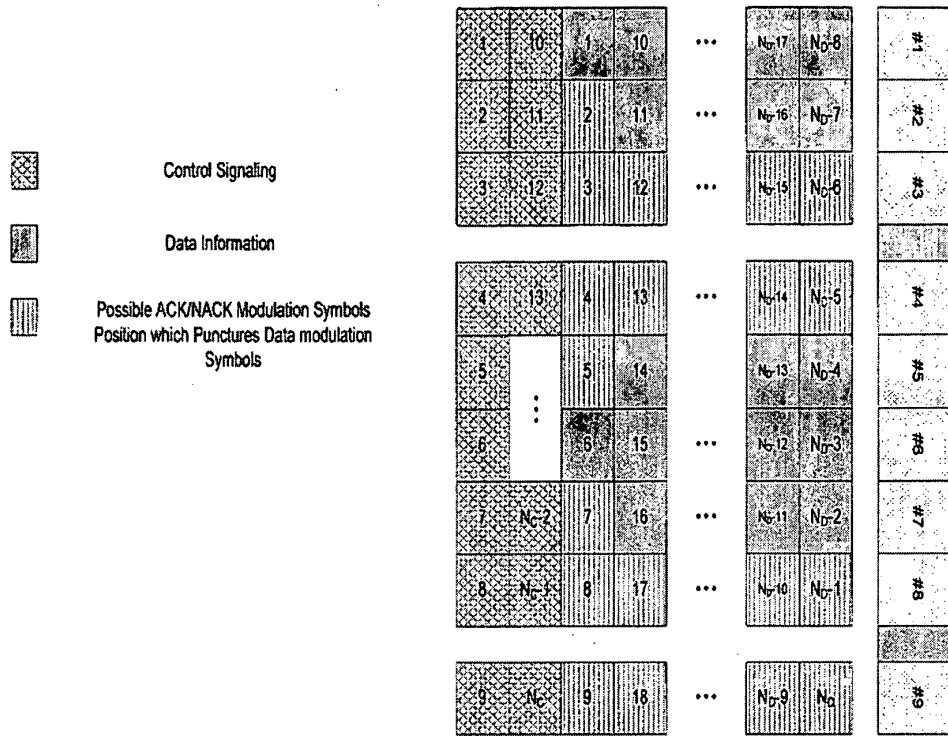
In this case, if the amount of ACK/NACK information is higher than the number of subcarriers (of the virtual frequency domain) via which data information is transmitted to the front and rear parts of the reference symbol transmitting the data information, the ACK/NACK information can be transmitted via many more SC-FDMA symbols other than the front and rear symbols of the reference symbol. In this case, the number of SC-FDMA symbols centering around the reference signal may be asymmetrical according to the SC-FDMA

subframe structure of the uplink, such that this situation must be considered when the ACK/NACK information is punctured and inserted.

[FIG. 10]



[FIG. 11]



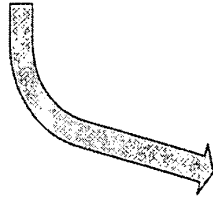
When the control information is arranged in a time domain, this control information and the data information are sequentially arranged and inserted. In this case, the ACK/NACK information is arranged in the vicinity of the reference signal, such that the control information and the data information are punctured and then the punctured result can be inserted. The above-mentioned operation is shown in FIG. 12. Substantially, the ACK/NACK information acts as the control information, priorities are assigned to control information channels, high-priority control information channels are arranged in the vicinity of the reference signal such that they more greatly protect channel estimation, and




low-priority control information channels are spread out on the time domain, and are then transmitted. For example, it is assumed that the ACK/NACK information has high priority higher than that of the ACK/NACK information in the present invention. In this case, the control information and the data information are sequentially arranged on the time domain according to the time-format mapping scheme. The arranged result is multiplexed with the data information, and the ACK/NACK information is inserted after the data- or control-information is punctured in the vicinity of the reference signal. In this way, if priorities are assigned to the control information parts, and then a resource mapping process is executed on the assigned result, the ACK/NACK information is located in the vicinity of the reference signal, such that it may acquire good channel estimation. Since the amount of ACK/NACK information removed by the puncturing process becomes lower, the ACK/NACK information may affect almost no influence on the performance of control information. Also, the multiplexing of the control information and the data information may be successively concatenated and transmitted, such that this multiplexing can be easily implemented by the multiplexing block.

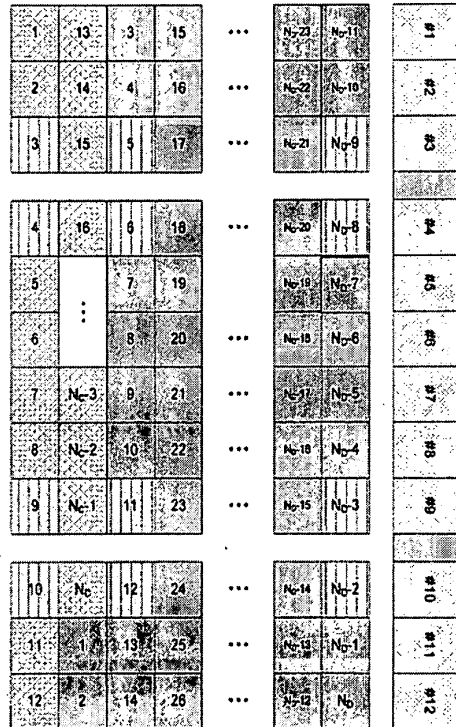
[FIG. 12]



OR



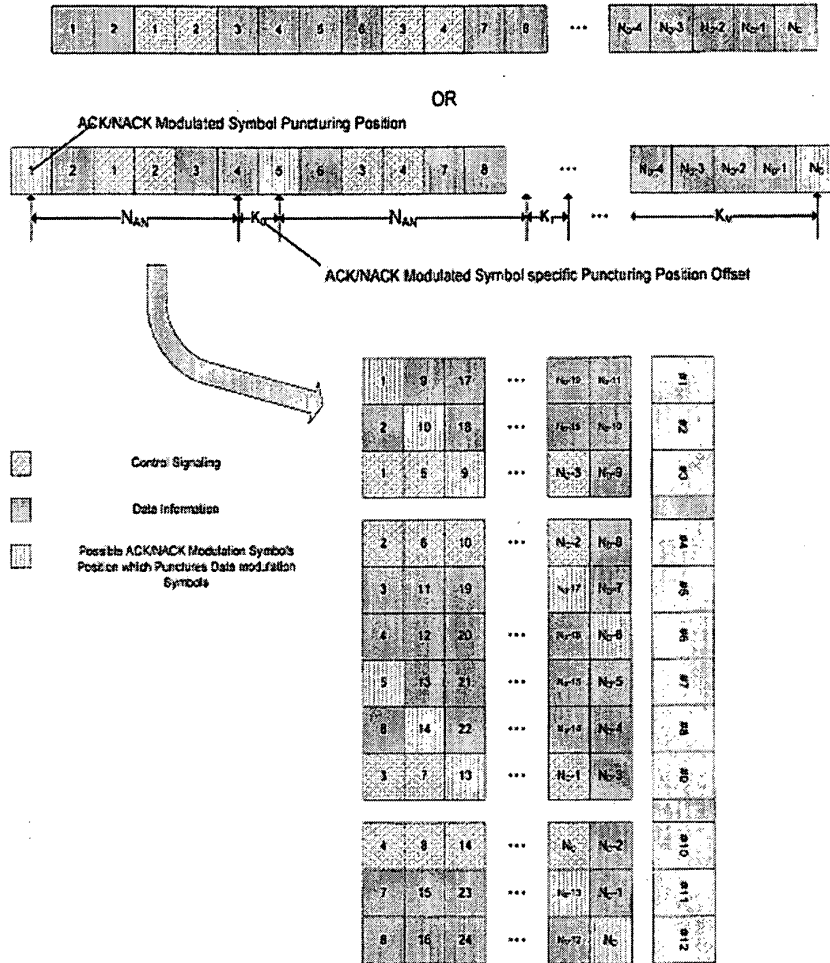
 Control Signaling  
 Data Information  
 Possible ACK/NACK Modulation Symbols  
 Position which Punctures other channel symbols



**Method 2-a**

This 2-a method transmits control information in the vicinity of the reference signal used as a pilot, and arranges ACK/NACK information on the time axis in such a way that it provides a multiplexing method.

[FIG. 13]



**Method 2-b-1**

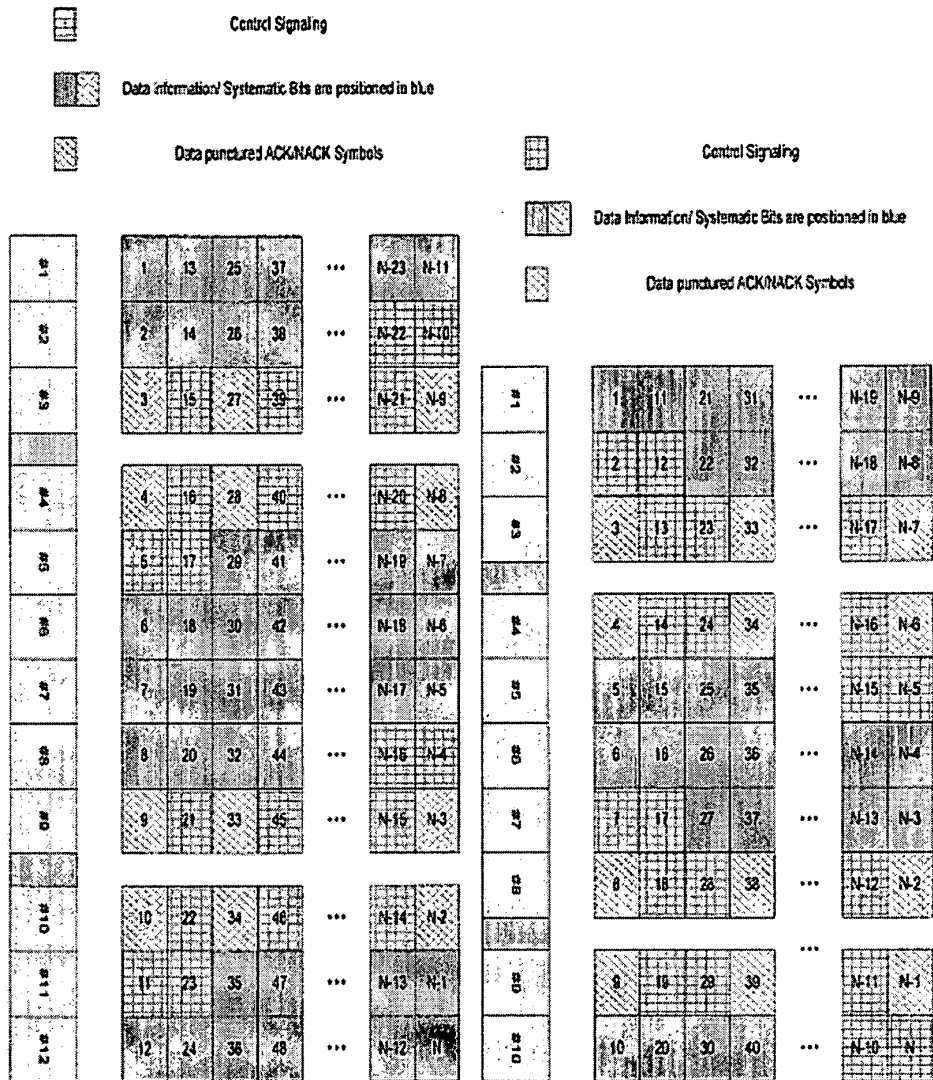
This 2-b-1 method provides a multiplexing method using a predetermined principle in which the control information and the ACK/NACK information are arranged in the vicinity of the reference signal used as a pilot. The 2-b-1 method does not consider whether the information punctured by the ACK/NACK information is the control information or the data

information, and performs the puncturing on information located in the vicinity of the reference signal in such a way that it performs a multiplexing process.

**Method 2-b-2**

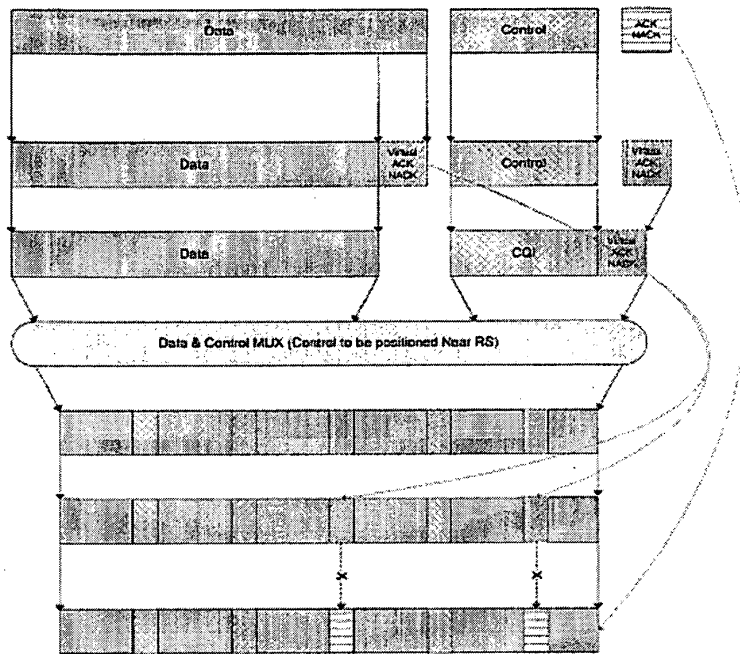
This 2-b-2 method provides a multiplexing method using a predetermined principle in which the control information and the ACK/NACK information are arranged in the vicinity of the reference signal used as a pilot. In more detail, the 2-b-2 method does not maximally puncture the control information, and controls the control information to be punctured if the number of bits of the control information is higher than that of bits of the data information, in such a way that it performs a multiplexing process.

[FIG. 14]



[FIG. 15]





Basic principles of this method can be shown in FIG. 11. A multiplexing process is executed in a block formed by the multiplexing of data and control information, such that the control information is always arranged in the vicinity of the reference signal in the SC-FDMA subframe structure. In other words, considering a total number of available SC-FDMA symbols (which allow the data- and control- information can be available for the SC-FDMA symbol index and its corresponding subframe) at the front and rear parts of the reference signal, the control information is rate-matching-processed to the SC-FDMA symbols corresponding to the front and rear parts of the reference signal, and then the rate-

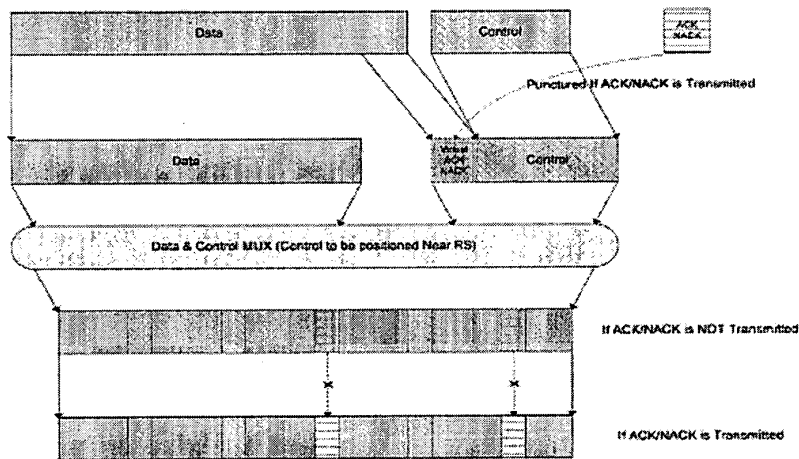
matched result is inserted in the front and rear parts of the reference signal.

Assuming that the above-mentioned multiplexing block is used, the ACK/NACK information must be punctured and inserted in the vicinity of the reference signal. In order to prevent the control information from being punctured, this ACK/NACK information takes some parts capable of being punctured by the ACK/NACK information off the data information part, and these taken parts are virtually considered to be control information, such that one data partially used as virtual control information, a bundle of the data used as the virtual control information and the control information is multiplexed.

If the ACK/NACK information is transmitted, the size of this virtual control information part is set to be equal to the amount of the transmitted ACK/NACK information. Provided that the ACK/NACK information is transmitted, this ACK/NACK information is separated from an original data information sequence and is combined with control information, and the combined result is punctured and inserted into the virtual control information part multiplexed with the data, the control information is never punctured and no punctured control information is inserted in the vicinity of the reference signal.

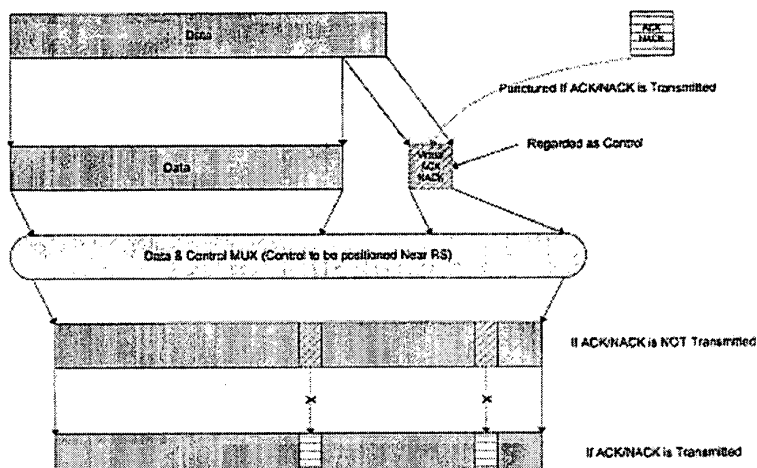
If there is no data to be transmitted, or if the number of modulated symbols of the ACK/NACK information is higher than that of modulated symbols of transmission (Tx) data, it is assumed that some parts of the control information are virtual control information, and the ACK/NACK information is punctured and inserted.

[FIG. 16]



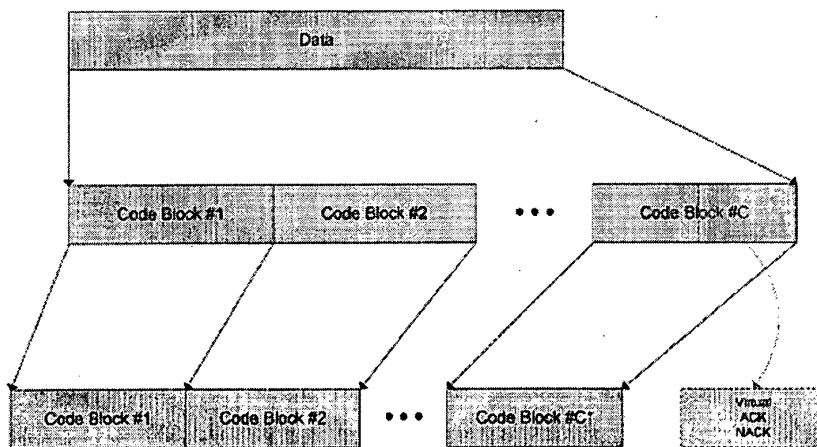
Specifically, although there is no transmission (Tx) control information in an uplink subframe to which data must be applied, it is assumed that some parts of data are virtual control information, and this virtual control information and the data part are multiplexed with each other. So, if the ACK/NACK information must be transmitted, this data part assumed as this virtual control information is punctured and inserted, and then the last result can be transmitted to the uplink.

[FIG. 17]



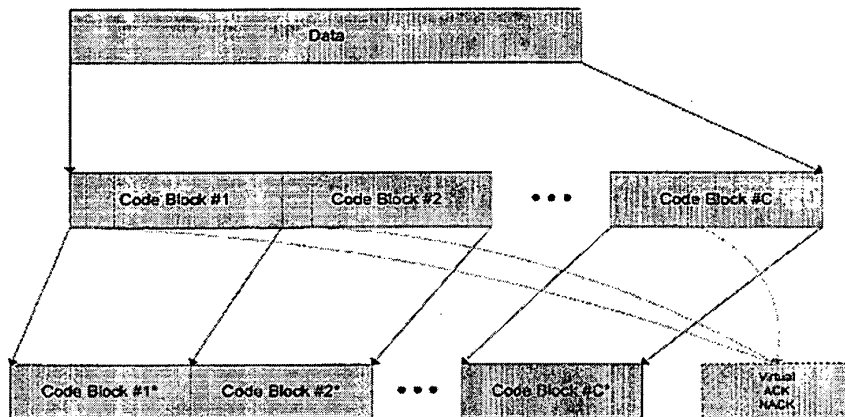
In a detailed example, there is proposed a method for separating a specific part to be treated as virtual control information from the data information. In this case, this specific part will be separately multiplexed.

[FIG. 18]



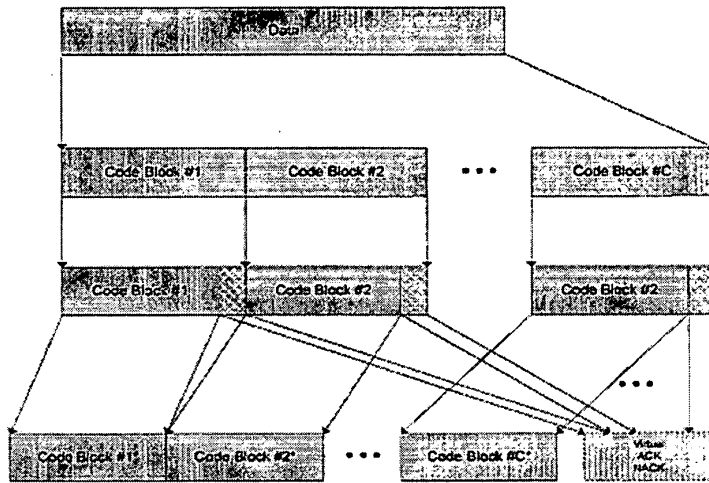
In the simplest method, the last successive parts or the first successive parts may be treated as virtual control information.

[FIG. 19]



Data information may be composed of one or more code blocks. In this case, in order to prevent a specific code block from being punctured by the ACK/NACK information, the virtual control information may be equally constructed in the entire data information amount, such that it prevents much ACK/NACK information from being punctured in a specific code block, resulting in the improvement of a system performance.

[FIG. 20]

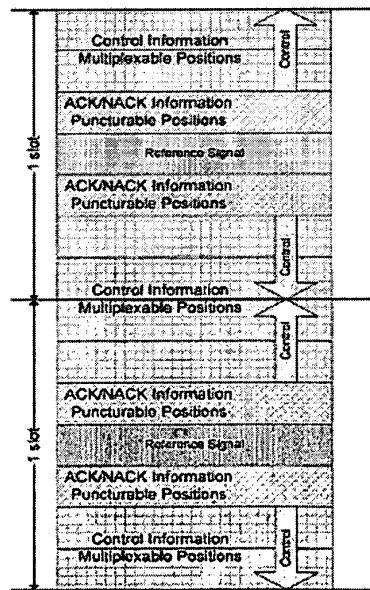
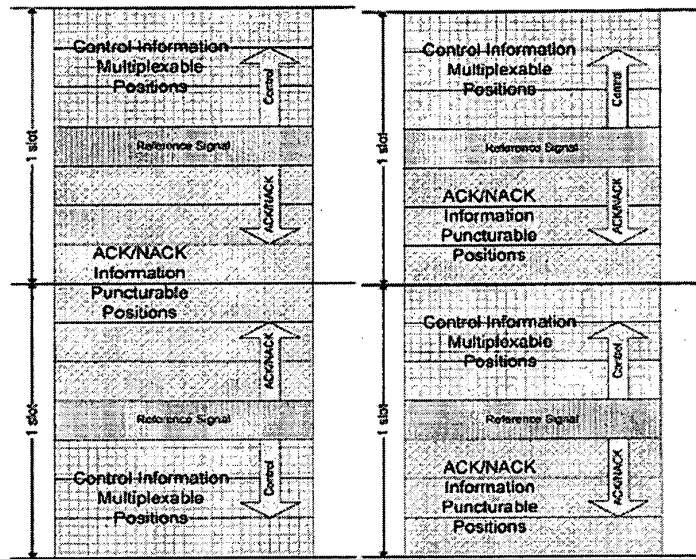


In order to guarantee a higher performance, the end part of each code block of the data information may be treated as the virtual control information, because a first part of each code block includes systematic information segments of the turbo-encoded data information in a first transmission of a specific transport block in the uplink. Some parts of the last part of each code block are always treated as the virtual control information, and systematic information is punctured by the ACK/NACK information, such that a performance of the first transmission of a specific transport block is not greatly decreased.

For another method, the ACK/NACK information and the control information are distinguished from each other by the SC-FDMA symbol, and this method prevents the control

information and the ACK/NACK information from being inserted into the same SC-FDMA symbol.

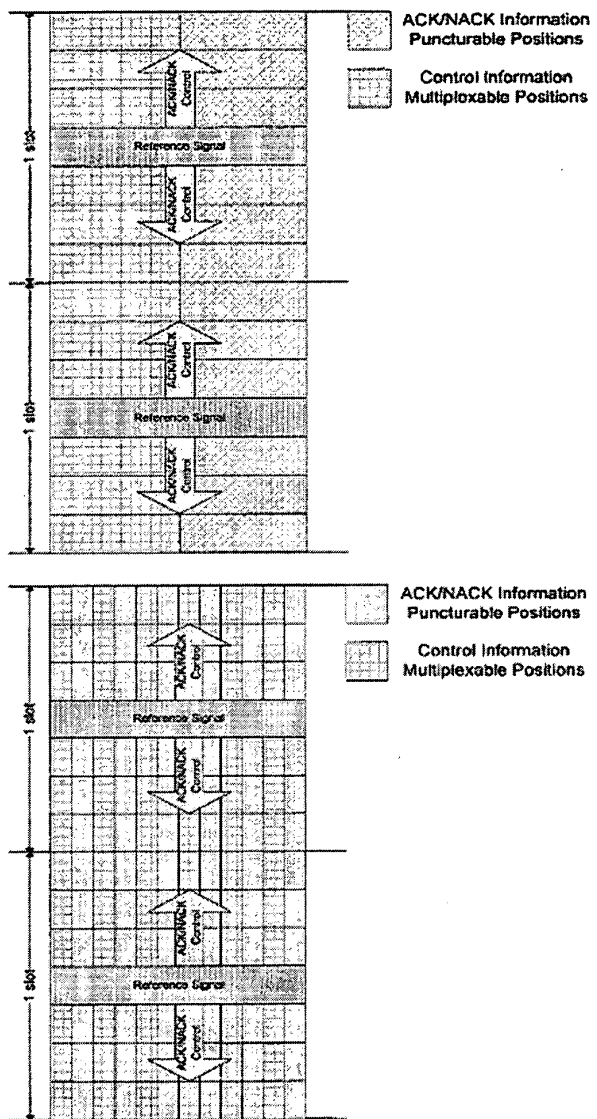
[FIG. 21]



The multiplexing or puncturing process is executed on different SC-FDMA symbol. Each control information or each ACK/NACK information is changed according to a situation of a channel at which the mobile station is located, such that the information may be multiplexed or punctured to be gradually far from the reference signal.

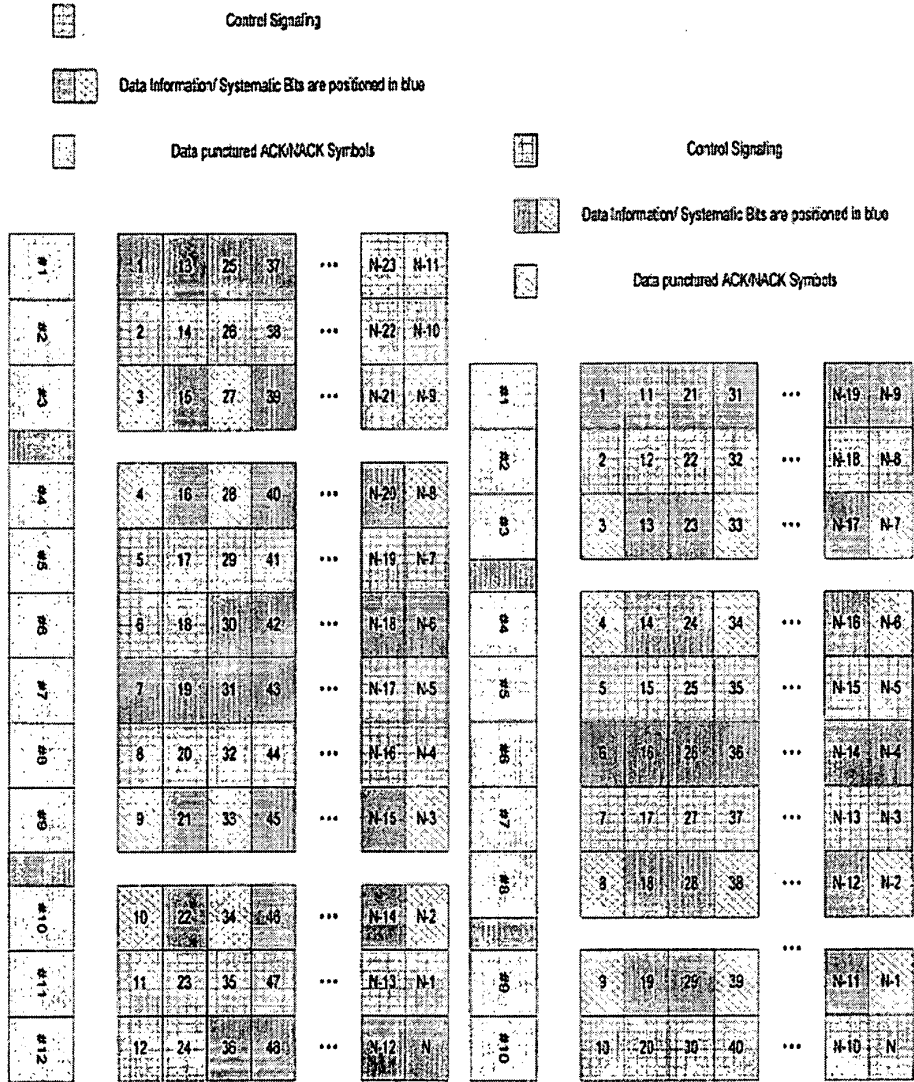
[FIG. 22]



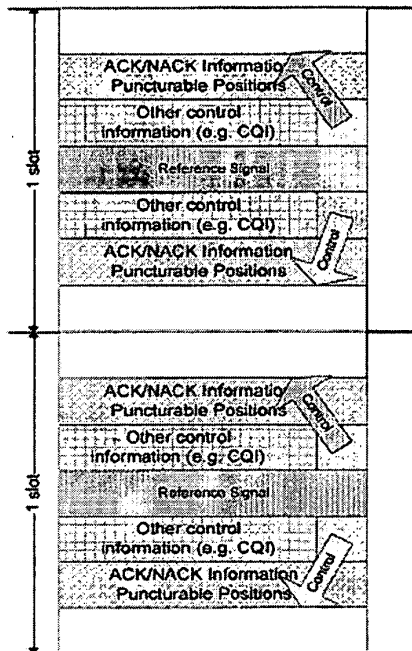


Also, the ACK/NACK information and the control information are distinguished from each other in a preceding end of the DFT precoding, such that they are not multiplexed or punctured at the same subcarrier on the virtual frequency domain.

[FIG. 23]



[FIG. 24]



If required, the ACK/NACK information and the control information are punctured, such that the punctured result may be inserted. In this case, the control information is multiplexed to prevent a minimum of control information from being punctured, and the ACK/NACK information is punctured at a specific part where the control information is not mapped to the time-frequency mapper. The above-mentioned figures 23 and 24 show an exemplary scheme which firstly allocates the control information and then fills the remaining part other than this allocated part with the ACK/NACK information.

The control information and the ACK/NACK information can be coded according to channel environments of the mobile station. In other words, the finally-coded control

information and the finally-coded ACK/NACK information can be variable. Therefore, when the control information is multiplexed, the multiplexing process must be carried out in the vicinity of the reference signal, such that a specific position filled with data by the first multiplexing process may occur. This position is filled with data according to the last information amount on the basis of a start point in the direction of any arrow shown in the above figures. This start point is not a position denoted by the arrow, but another position at which the arrow mark begins. Needless to say, data exists in another position at which the control information is not multiplexed. Therefore, the position at which all control information can be multiplexed is indicative of a space in which the control information and the data information can be interleaving-multiplexed or be successively multiplexed. The above-mentioned arrow indicates a specific direction along which much more control information is multiplexed, such that this arrow indicates the filling direction of the multiplexed information. When the multiplexing process is carried out in the arrow direction, the above space need not always be full of all the OFDM symbols and there is no need for the multiplexing process to be executed on the next OFDM symbol. In the same manner as in the control information, the ACK/NACK information is punctured in the arrow direction, such that

the resultant information is inserted. In this case, the filling direction of data is set to the arrow direction according to the final ACK/NACK information amount. It should be noted that the next OFDM symbol need not be filled with data after one OFDM symbol or area has been filled with the data.

In this way, the area in which the control information and the ACK/NACK information are finally inserted is orthogonally established in a frequency-time area, and the ACK/NACK information is formed by the puncturing of control information, such that the reliability of the control information is not deteriorated.

Also, the filling direction of the multiplexed- or punctured- control information (including ACK/NACK information) corresponds to a direction being gradually far from the reference signal (according to the final control information amount).

In the above-mentioned figures, a position where the punctured ACK/NACK information can be inserted may be replaced with another position where the multiplexed control information can be inserted.

Generally, the ACK/NACK information may be more important than other control information, the ACK/NACK information can be punctured at OFDM symbols located before and after the reference signal, and the control information

can be multiplexed with data from the next OFDM symbol close to these OFDM symbols, such that the multiplexed result is then used.



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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
60/988,433	11/16/2007	Dae Won LEE	UT07-0149-USPO

**CONFIRMATION NO. 9013**

**IMPROPER PROVISIONAL LETTER**

67487  
KORPAT, PC  
GANGNAM P.O 1655  
SEOUL, 135-616  
KOREA, REPUBLIC OF



Date Mailed: 11/30/2007

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The above-identified provisional application was filed in a language other than English. An English-language translation of a non-English provisional application and a statement that the translation is accurate must be filed in the provisional application. See 37 CFR 1.78(a)(5)(iv). Applicants are strongly encouraged to file the English-language translation of the provisional application and the statement that the translation is accurate in the provisional application before a nonprovisional application claiming the benefit of the provisional application is filed, or, alternatively, when making a claim for the benefit of the provisional application in a nonprovisional application. If, however, an English translation and a statement that the translation is accurate have not been filed in the above-identified provisional application when a nonprovisional application is filed claiming the benefit of the filing date of the provisional application, the Office should mail a Notice requiring an English translation and the statement to be filed in the provisional application and a confirmation to be filed in the nonprovisional application.

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60/988,433 11/16/2007 210 UT07-0149-USPO

CONFIRMATION NO. 9013

FILING RECEIPT



67487
KORPAT, PC
GANGNAM P.O 1655
SEOUL, 135-616
KOREA, REPUBLIC OF

Date Mailed: 11/30/2007

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections

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Power of Attorney: The patent practitioners associated with Customer Number 67487

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

PUSCH CONTROL CHANNEL MULTIPLEXING

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<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	UT07-0149-USP0
		Application Number	
Title of Invention	PUSCH CONTROL CHANNEL MULTIPLEXING		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

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<input type="checkbox"/> Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
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	Hak	Seong	KIM		
<b>Residence Information (Select One)</b> <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service					
<b>City</b>	Seoul	<b>Country Of Residence<sup>i</sup></b>	KR		

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<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	UT07-0149-USPO	
		Application Number		
Title of Invention	PUSCH CONTROL CHANNEL MULTIPLEXING			
<b>Citizenship under 37 CFR 1.41(b) i</b>		KR		
<b>Mailing Address of Applicant:</b>				
Address 1	LG ELECTRONICS INC. IP GROUP			
Address 2	533 Hogye-1dong, Dongan-gu, Anyang-si, Gyeonggi-do			
City	Anyang	State/Province		
Postal Code	431-080	Country <sup>i</sup>	KR	
<b>Applicant 4</b>				<input type="button" value="Remove"/>
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
				<input type="radio"/> Party of Interest under 35 U.S.C. 118
Prefix	Given Name	Middle Name	Family Name	Suffix
	Hyun	Wook	PARK	
<b>Residence Information (Select One)</b> <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
City	Seoul	Country Of Residence <sup>i</sup>	KR	
<b>Citizenship under 37 CFR 1.41(b) i</b>				
<b>Mailing Address of Applicant:</b>				
Address 1	LG ELECTRONICS INC. IP GROUP			
Address 2	533 Hogye-1dong, Dongan-gu, Anyang-si, Gyeonggi-do			
City	Anyang	State/Province		
Postal Code	431-080	Country <sup>i</sup>	KR	
<b>Applicant 5</b>				<input type="button" value="Remove"/>
<b>Applicant Authority</b>		<input checked="" type="radio"/> Inventor		<input type="radio"/> Legal Representative under 35 U.S.C. 117
				<input type="radio"/> Party of Interest under 35 U.S.C. 118
Prefix	Given Name	Middle Name	Family Name	Suffix
	Ki	Jun	KIM	
<b>Residence Information (Select One)</b> <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service				
City	Seoul	Country Of Residence <sup>i</sup>	KR	
<b>Citizenship under 37 CFR 1.41(b) i</b>		KR		
<b>Mailing Address of Applicant:</b>				
Address 1	LG ELECTRONICS INC. IP GROUP			
Address 2	533 Hogye-1dong, Dongan-gu, Anyang-si, Gyeonggi-do			
City	Anyang	State/Province		
Postal Code	431-080	Country <sup>i</sup>	KR	
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.				<input type="button" value="Add"/>

**Correspondence Information:**

Enter either Customer Number or complete the Correspondence Information section below.  
For further information see 37 CFR 1.33(a).

An Address is being provided for the correspondence information of this application.

Customer Number      67487

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<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	UT07-0149-USP0
		Application Number	
Title of Invention	PUSCH CONTROL CHANNEL MULTIPLEXING		
Email Address	info@kpatent.com	<input type="button" value="Add Email"/>	<input type="button" value="Remove Email"/>
Email Address	sjpark@kpatent.com	<input type="button" value="Add Email"/>	<input type="button" value="Remove Email"/>

**Application Information:**

Title of the Invention	PUSCH CONTROL CHANNEL MULTIPLEXING		
Attorney Docket Number	UT07-0149-USP0	Small Entity Status Claimed	<input type="checkbox"/>
Application Type	Provisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

**Publication Information:**

<input type="checkbox"/>	Request Early Publication (Fee required at time of Request 37 CFR 1.219)
<input type="checkbox"/>	<b>Request Not to Publish.</b> I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application <b>has not and will not</b> be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

**Representative Information:**

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.			
Please Select One:	<input checked="" type="radio"/> Customer Number	<input type="radio"/> US Patent Practitioner	<input type="radio"/> Limited Recognition (37 CFR 11.9)
Customer Number	67487		

**Domestic Benefit Information:**

This section allows for the applicant to claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c). Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.			
Prior Application Status			<input type="button" value="Remove"/>
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
Additional Domestic Priority Data may be generated within this form by selecting the Add button.			<input type="button" value="Add"/>

**Foreign Priority Information:**

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

<b>Application Data Sheet 37 CFR 1.76</b>		Attorney Docket Number	UT07-0149-USP0
		Application Number	
Title of Invention	PUSCH CONTROL CHANNEL MULTIPLEXING		

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country <sup>i</sup>	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			<input checked="" type="radio"/> Yes <input type="radio"/> No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Add

### Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Remove

#### Assignee 1

If the Assignee is an Organization check here.

Organization Name LG Electronics Inc.

#### Mailing Address Information:

Address 1 20 Yeouido-dong, Yeongdeungpo-gu

Address 2

City Seoul

State/Province

Country <sup>i</sup> KR

Postal Code

150-721

Phone Number

Fax Number

Email Address

Additional Assignee Data may be generated within this form by selecting the **Add** button.

Add

### Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Andrew S. Park/		Date (YYYY-MM-DD)	2007-11-16
First Name	Andrew	Last Name	Park	Registration Number
				47841

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

**PROVISIONAL APPLICATION FOR UNITED STATES PATENT  
IN THE NAMES OF**

Dae Won LEE, Bong Hoe KIM, Hak Seong KIM, Hyun Wook PARK and  
Ki Jun KIM

for

**PUSCH CONTROL CHANNEL MULTIPLEXING**

prepared by:

KORPAT, P.C.

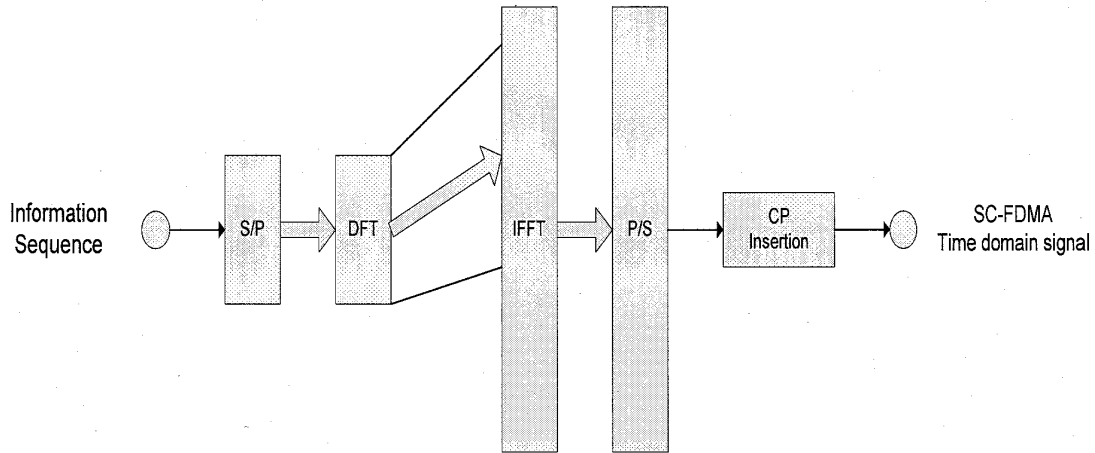
Customer Number: 67487

Attorney Docket Number: UT07-0149-USPO

Total Number of pages: 28 (including cover)



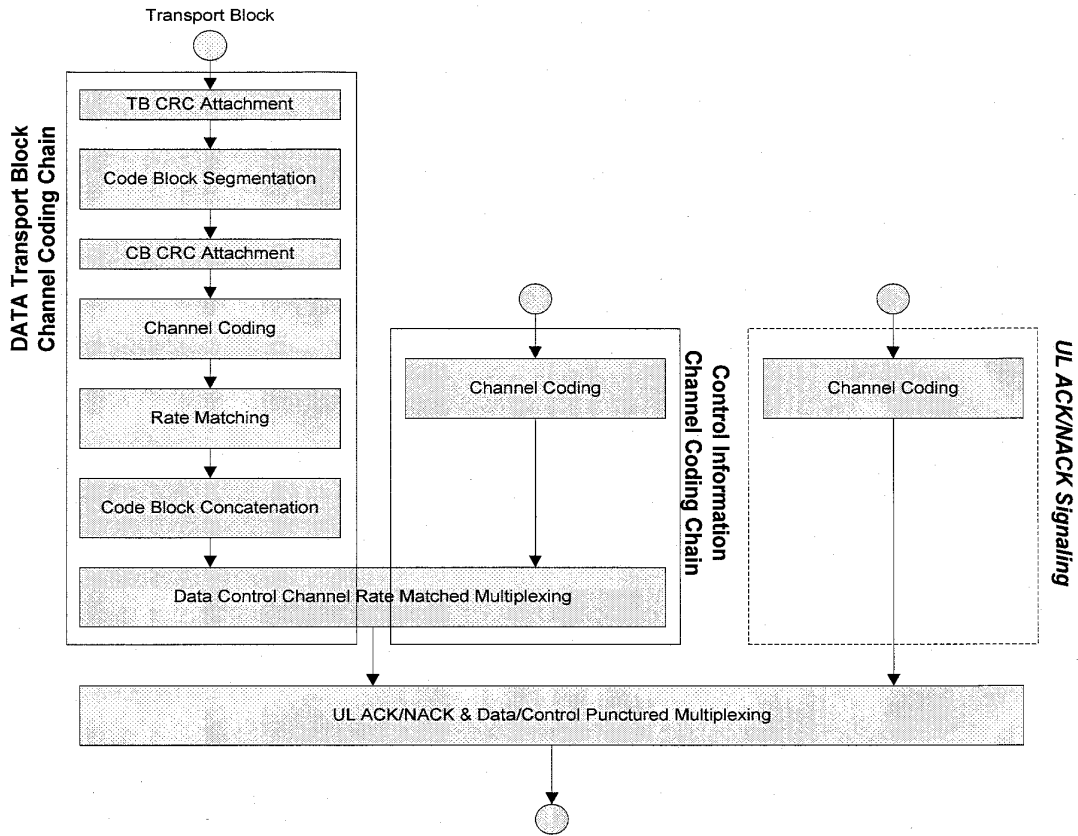
1. 발명이 속하는 기술분야 및 그 분야의 종래기술



도 1. SC-FDMA Block 도면도

Single Carrier Frequency Division Multiplexing Access (SC-FDMA) 기술을 활용하는 상향링크 시스템에서는 일반적으로 다음과 같은 과정을 걸쳐 정보가 전송된다. 전송할 information sequence를 Discrete Fourier Transform 하기 위하여 serial-to-parallel sequence로 변경하고, DFT를 하고 난 후 IFFT가 취해진다. 이 때 IFFT에 삽입되는 정보의 길이는 IFFT의 크기와 똑같지 않을 수 있으며, 반드시 연속된 IFFT 입력 index에 DFT한 결과가 mapping되어 전송된다. IFFT를 취해진 값들은 다시 parallel-to-serial로 변경되고, Cyclic Prefix가 더해져 OFDM symbol의 구조형태로 변경되어 실제 시공간으로 통하여 전송된다. [도 1]은 SC-FDMA 정보전송의 block도면도의 한 예이다.

Single Carrier 형질을 유지하면서, 낮은 Peak Power-to-Average Power Ratio (PAPR) 또는 Cubic Metric (CM)을 충족시키기 위해서는 OFDM 형식으로 IFFT에 DFT precoding이 된 정보를 insertion할 때에는 연속된 index에 정보를 insertion해야 한다. 즉 OFDM의 연속된 subcarrier에 DFT precoding된 정보를 insertion하는 것이다. 그러므로 상향링크로 정보를 전송할 때에는 서로 다른 성격을 가진 정보 (e.g. 제어정보와 데이터 정보)라도 같이 Multiplexing되어 한꺼번에 DFT precoding을 거쳐 OFDM 방식으로 전송된다.



도 2.

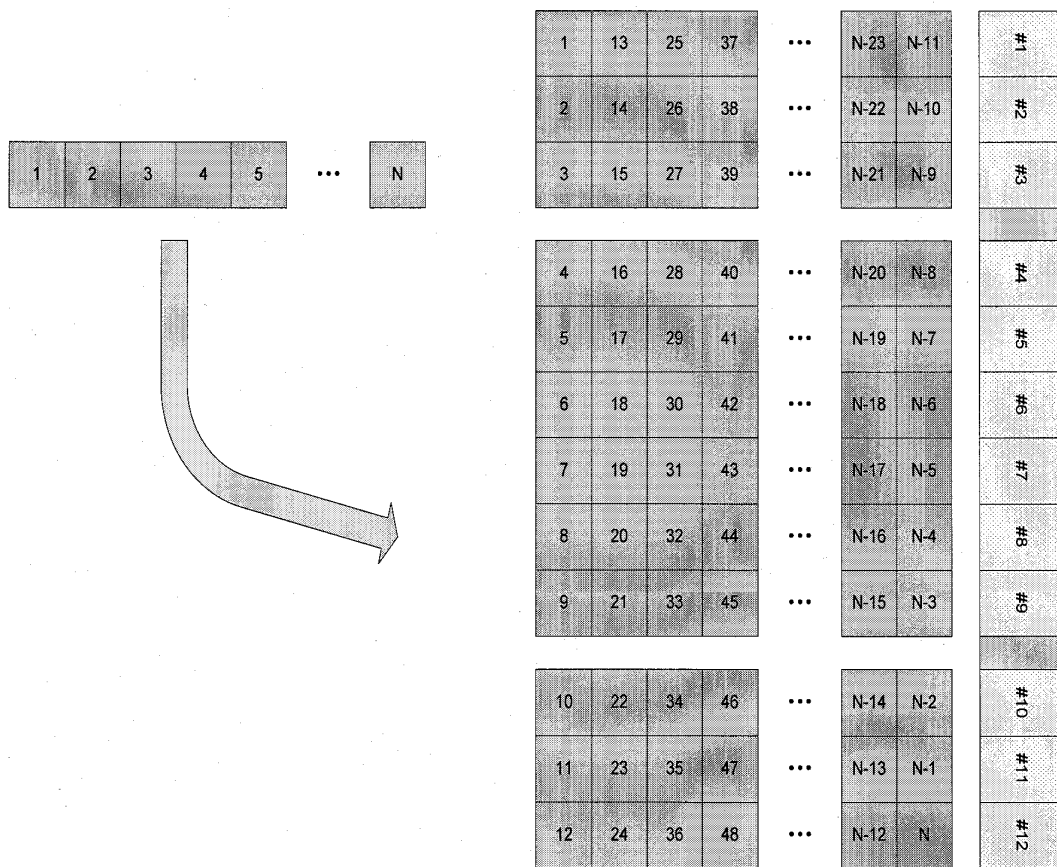
제어정보와 Multiplexing 되는 Data 정보는 상향링크로 전송해야하는 Transport Block 크기에 의하여 여러개의 Code block 으로 나뉘어 Encoding 을 거치고, 다시 합쳐서저서 (concatenation) 되어 한가지의 Data 정보 sequence 로 제어정보와 Multiplexing 된다.

상향링크에서 데이터와 함께 전송가능한 제어정보는 2 가지로 분류된다. 하향링크 데이터에 대한 확인신호인 UL ACK/NACK 신호와 그 외의 제어정보로 구분이 될 수 있다. 하향링크 데이터에 대한 확인신호는 하향링크 데이터가 존재할 때에만 전송되며, 하향링크 데이터를 받아야 하는지 모르는 단말기에서는 자신이 UL ACK/NACK 신호를 전송해야함에도 불구하고 모르는경우가 발생할 수 있기 때문에, 두 가지 제어정보를 구분하여 데이터와 함께 상향링크로 전송하게 된다. 그러므로 본 발명에서 언급하는 모든 제어정보는 UL ACK/NACK 를 제외한 제어정보이며, UL ACK/NACK 신호는 직접 언급하도록 하겠다.

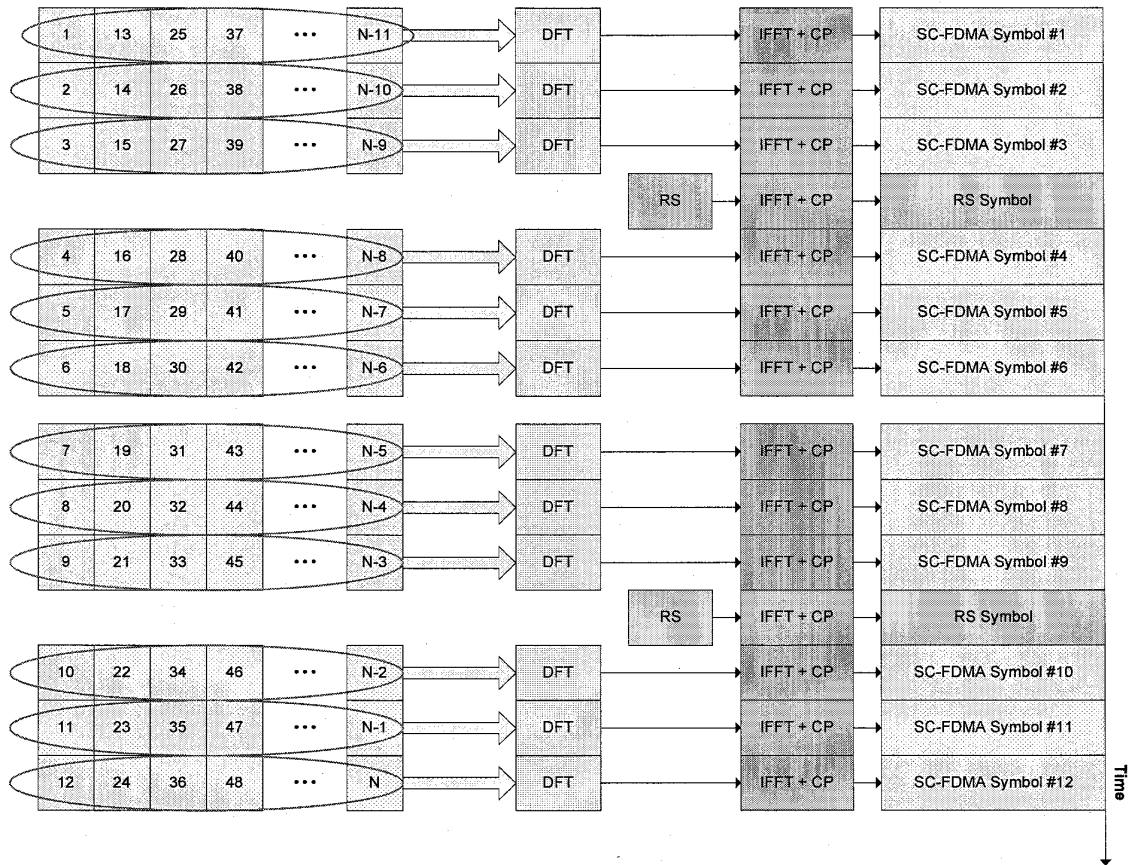
데이터정보가 상향링크로 전송될 때, 제어정보와 함께 전송될 수 있으며, 또는 데이터정보와 제어 정보 함께 ACK/NACK 정보가 같이 전송될 수 있으며, 또한 데이터 정보와 ACK/NACK 정보만이 같이 전송 가능하다.

데이터 정보가 제어정보 혹은 ACK/NACK 정보와 multiplexing 되어 전송되기 위하여 만들어진 전송 정보 sequence 는 SC-FDMA 방식으로 전송된다. 이 때 전송정보 sequence 는 time-first mapping 방법에 의하여 sequence 가 나열되며, 이에 따라 SC-FDMA 방식으로 전송된다. 예를

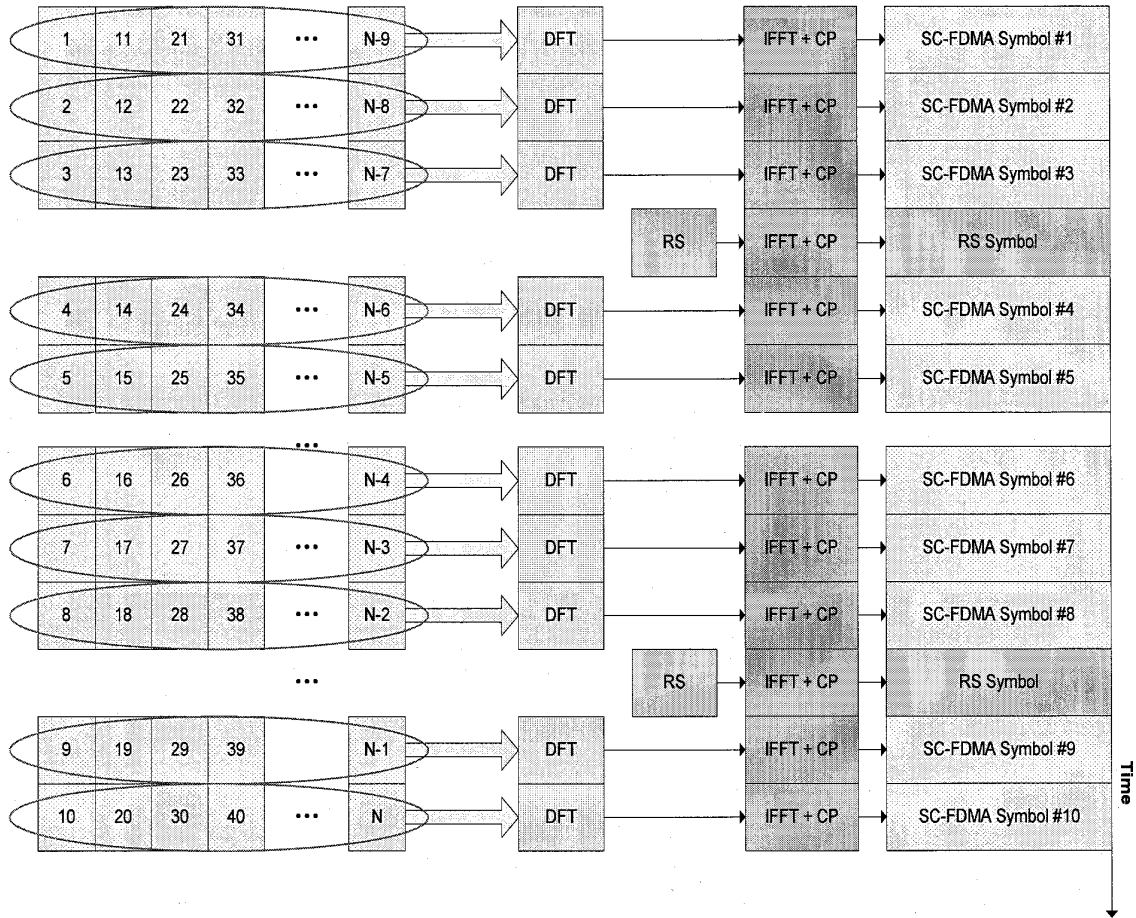
들면, 전송되는 정보 sequence 가 1 개의 Resource Block 즉 12 개의 OFDM subcarrier 를 사용하여 전송된다고 하고, 정보는 한 subframe 을 통하여 전송된다고 하고, 한 subframe 에는 14 개의 SC-FDMA symbol 으로 구성되어 있고, 이 중 2 개의 SC-FDMA symbol 를 파일럿 신호인 reference signal 로 사용한다고 가정한다. 이 때 상향링크로 전송 할 수 있는 정보의 modulated 된 symbol 의 수는  $12 \times 12 = 144$  개이다. 144 개의 정보 sequence symbol 이 12 개의 virtual subcarrier 와 12 개의 SC-FDMA symbol 을 통하여 전송된다. 이것을 12 곱하기 12 의 행렬구조로 나타낸것을 Time-Frequency Mapper 라 부르고, 상향링크로 전송되어야 하는 정보 sequence 는 SC-FDMA symbol 축으로 먼저 한개씩 Mapping 되어 진다. SC-FDMA symbol 는 시간상으로 구분이 되어 있기 때문에 이를 Time-First Mapping 이라 불린다. Time-Frequency Mapper 에서 Time 축으로 먼저 sequence 를 [도 4] 과 [도 5]와 같이 나열한다. 이렇게 Time 축으로 먼저 나열하는 방법으로 Time-Frequency Mapping 이 다 일어난 후, Frequency 축으로 나열된 sequence 를 DFT 과정을 걸치고, 원하는 주파수 대역에 insertion 된 다음 IFFT 와 cyclic prefix 가 더해져 SC-FDMA symbol 로 만들어져 전송된다.



도 3.



도 4. Normal Cyclic Prefix 일 때 전송 정보 sequence 의 SC-FDMA subframe mapping 방법



도 5. Extended Cyclic Prefix 일 때 전송 정보 sequence 의 SC-FDMA subframe mapping 방법

상향링크의 예서는 데이터가 전송될 때 제어정보 또한 동시에 전송될 수 있다. 이 때 제어정보와 데이터 정보는 rate matching 을 통한 multiplexing 된다. 그러나 ACK/NACK 정보는 데이터와 제어 정보가 multiplexing 된 symbol 또는 그냥 데이터 정보의 bit stream 를 puncturing 하여 ACK/NACK 정보가 삽입된다. 여기서 Puncturing 은 bit stream 중에서 특정 bit 정보를 빼고 새로운 bit 정보들을 삽입하여, 새로운 정보를 삽입하고도 전체 정보 bit stream 의 길이를 같도록 하는 방법을 서술한다.

일반적으로 제어정보는 데이터보다 reliability 가 높아야 하며, 그렇기 위해서는 reference signal 근방에 multiplexing 또는 삽입되어야 channel estimation performance 의 효과를 얻어 성능향상을 기대 할 수 있기도 하다.

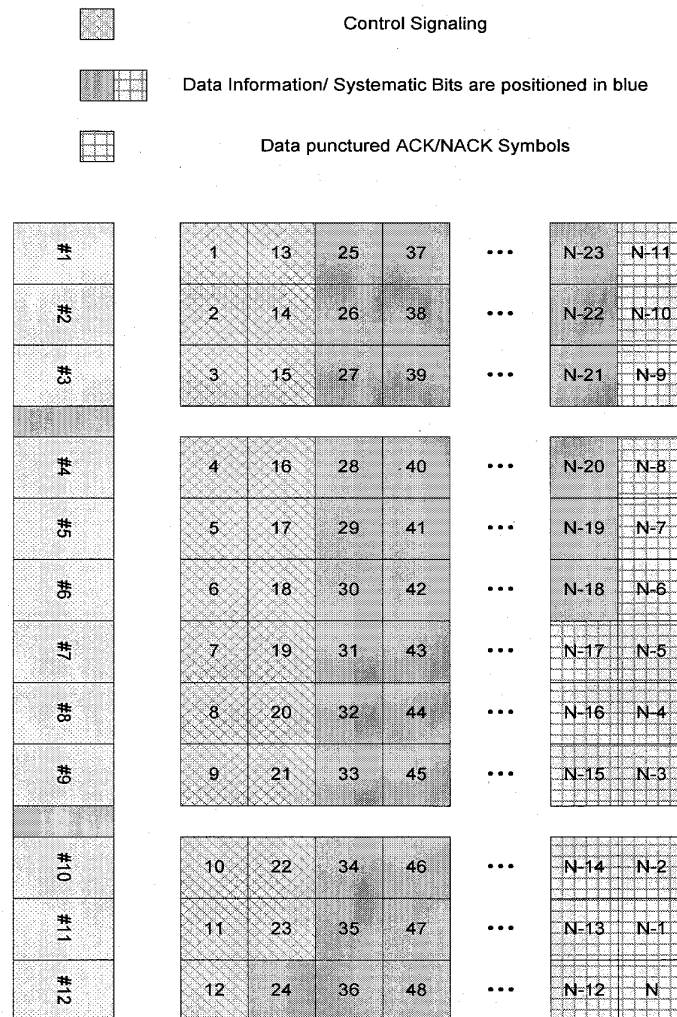
## 2. 발명의 구성 및 작용

본 발명은 데이터 정보 bit stream 과 제어정보 bit stream 그리고 ACK/NACK 정보 sequence 의 Multiplexing 을 할 때 각 정보들에게 대해서 서로 다른 우선순위를 두고 Multiplexing 하는 방법들을 제안한다. 이 때 각 방법은 몇가지 원칙을 가지고 Multiplexing 방법 및 순서가 결정된다.

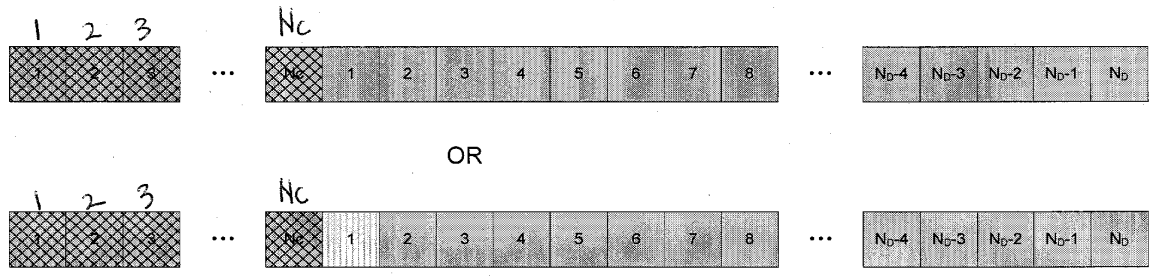
### 방법 1-a-1.

이 방법은 제어정보를 최대한 시간축상에서 나열하는 원칙과 더불어 ACK/NACK 정보 또한 최대한 시간축상에서 나열하는 원칙을 가지고 Multiplexing 방법을 제안한다.

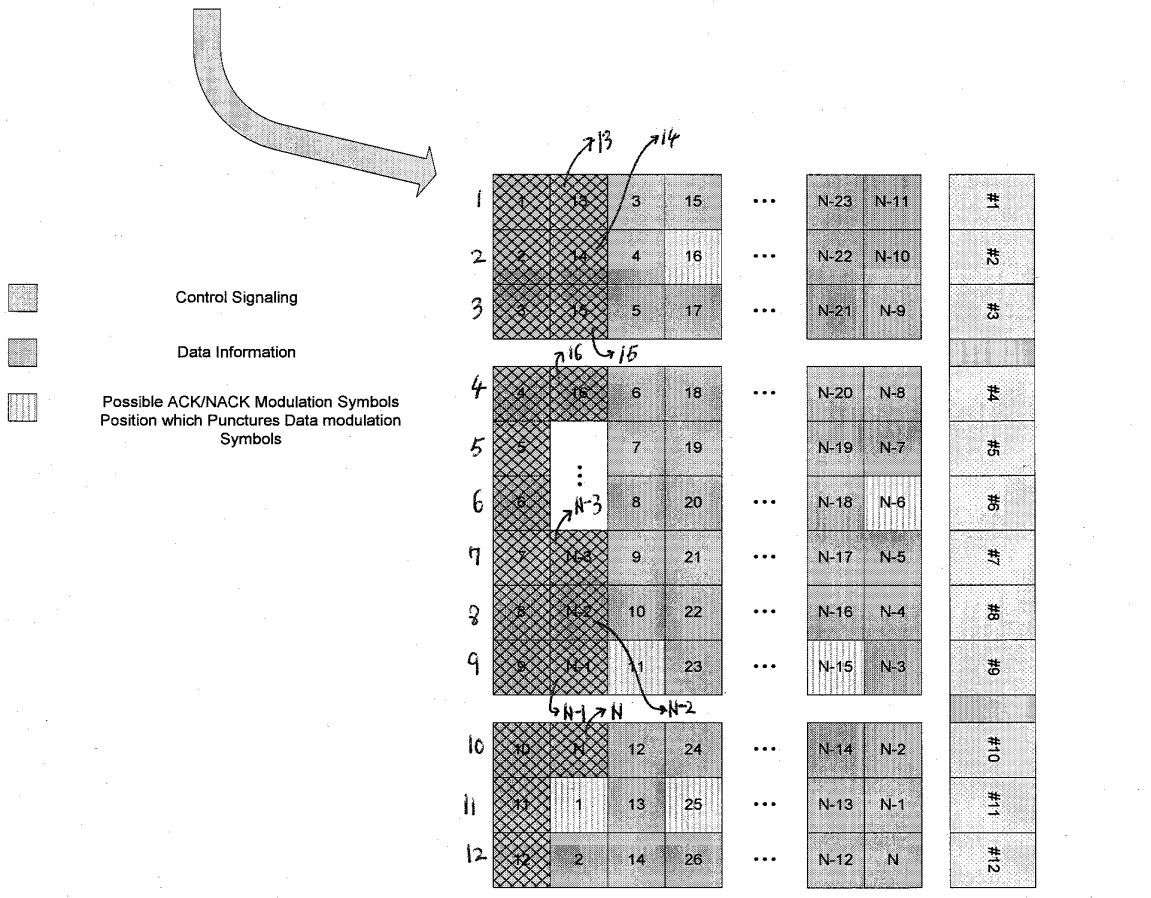
ACK/NACK 정보는 제어정보를 절대로 puncturing 하지 않는 원칙으로 Multiplexing 방법을 제안한다.



도 6.



OR



이 방법에서는 제어정보와 Data 정보가 Multiplexing 될 때 sequential 하게 concatenation 하여 Time-First Mapping 에 의하여 SC-FDMA symbol 들에 mapping 되어 상향링크로 전송된다. 만약에 ACK/NACK 정보 또한 전송되어야 한다면, 전송되어야 하는 ACK/NACK 정보 modulated Symbol 들은 Data 정보에 Equal Distribution (즉 Data 정보 sequence 에서 전체 길이에 균등하게 나누어 puncturing 한다) 을 가지고 Data 정보를 Puncturing(Data 정보 modulated Symbol 를 제거하고 그 위치에)하여 삽입된다. 예를 들어 Data 정보 Sequence 의 Modulated Symbol 를 총 개

수가 100 개라고 가정하고, ACK/NACK 정보의 modulated symbol 의 개수는 8 개라고 한다면, 12 개의 Modulated Symbol 간격으로 ACK/NACK 정보의 modulated symbol 이 Data 정보의 modulated symbol 를 puncturing 하여 삽입될 것이다. 이렇게 Data 정보 sequence 에 대해 균등하게 puncturing 하여 삽입되는 이유는 Data 정보가 여러개의 code block 으로 이루어져 있을 때 ACK/NACK 정보가 각 각의 code block 으로 부터 균등하게 puncturing 하여 삽입되어 특정 code block 만 performance 를 매우 저하시키지 못하도록 한다.

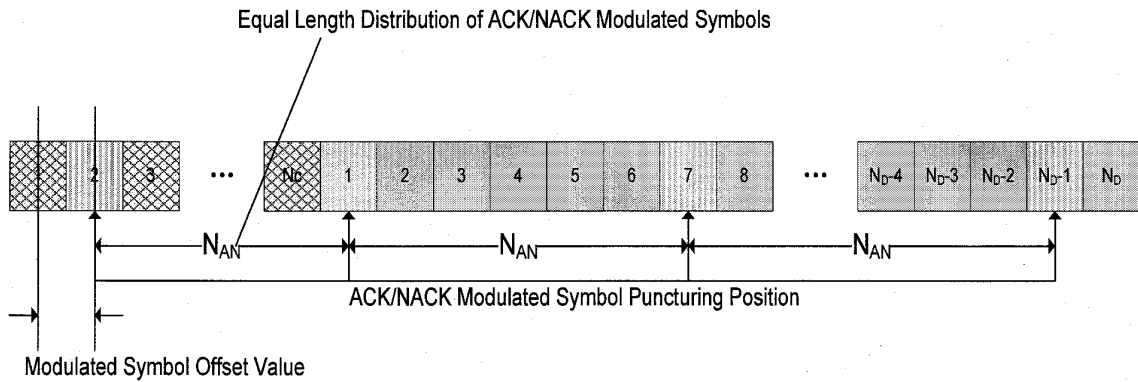
또한 더욱 특징적으로 강제적으로 ACK/NACK 정보가 각 각의 code block 으로부터 동일한 숫자의 modulated symbol 를 puncturing 하여 삽입될 수 있다. 모든 code block 에서 같은 modulated symbol 개수만큼 정보가 puncturing 됨으로 어느 특정 code block 의 성능이 특별히 저하되는 것을 항상 방지가능하다.

**방법 1-a-2.**

이 방법은 제어정보를 최대한 시간축상에서 나열하는 원칙과 더불어 ACK/NACK 정보 또한 최대한 시간축상에서 나열하는 원칙을 가지고 Multiplexing 방법을 제안한다.

ACK/NACK 정보는 제어정보를 최대한 puncturing 하지 않되, 제어정보의 bit 수가 Data 정보의 bit 에 비하여 많을때에는 제어정보 또한 puncturing 하는 원칙으로 Multiplexing 방법을 제안한다.

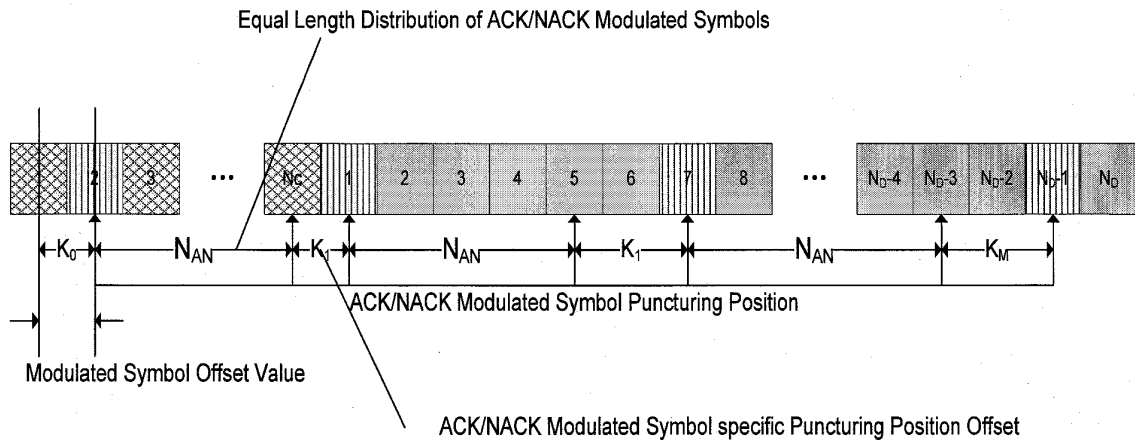
이 방법은 방법 1-a-1 과 비슷한 과정을 걸쳐 Data 와 제어정보와 ACK/NACK 이 Multiplexing 된다.



도 7.

단 이때 Puncturing 하여 삽입되는 ACK/NACK 정보는 제어정보와 Data 정보가 전체에 대하여 Multiplexing 된 정보 sequence 에 대하여 동일한 Modulated Symbol 간격을 두고 Puncturing 하여 삽입된다.



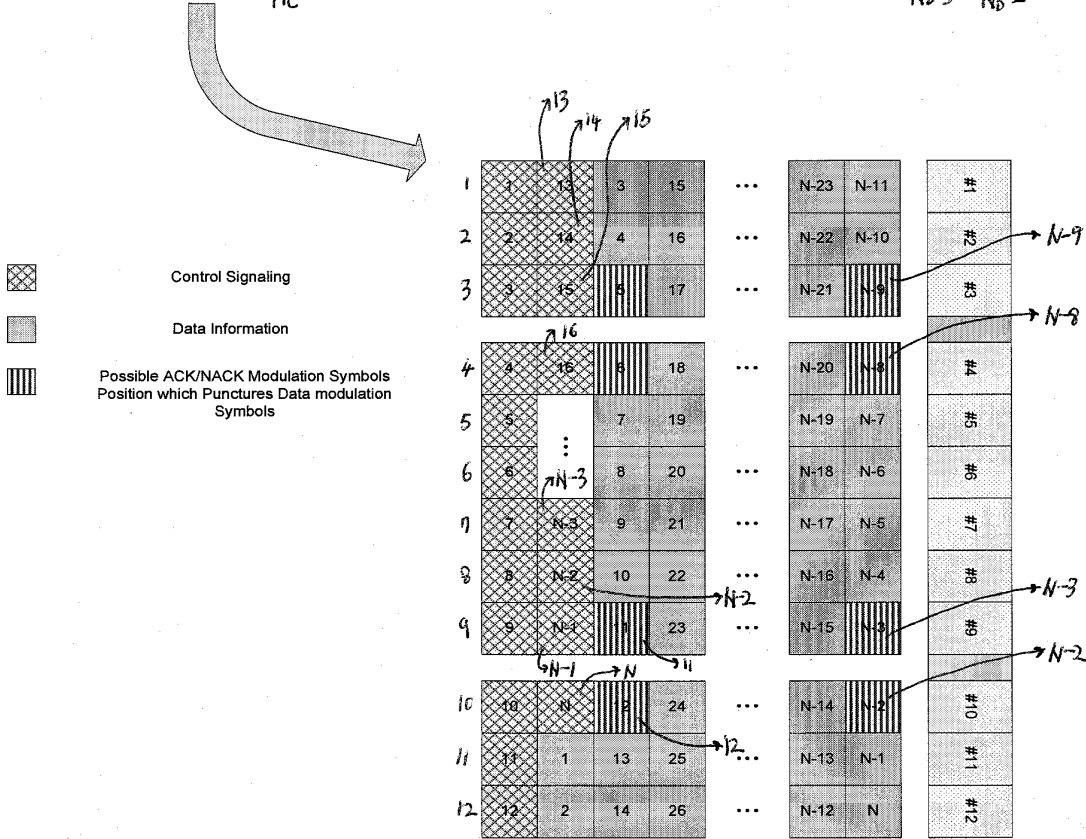
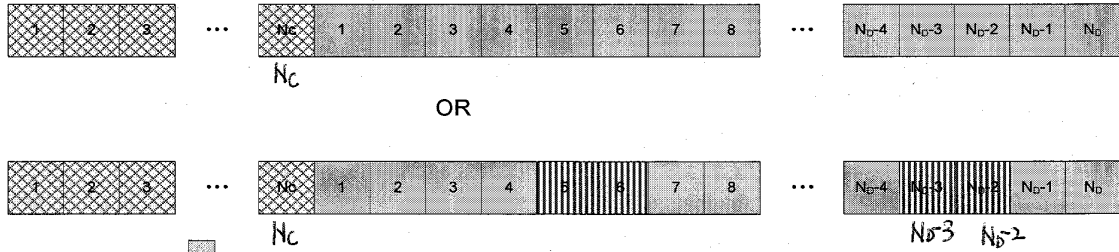


도 8.

특수한 예로써 만약에 ACK/NACK 정보가 puncturing 하여 삽입되는 Modulated Symbol의 간격이 상향링크의 subframe의 Data 또는 제정정보가 전송되는 SC-OFDM symbol 수와 동일할 때에는 ACK/NACK Modulated Symbol은 모두 같은 SC-FDMA에 전송될 수 있으므로, 각 각의 ACK/NACK Modulated Symbol마다 SC-FDMA offset 값을 두어 모든 ACK/NACK 정보 sequence가 같은 SC-FDMA symbol에 위치하지 않도록 할 수 있다.

방법 1-b.

이 방법은 제어정보를 최대한 시간축상에서 나열한다는 원칙과 더불어 ACK/NACK 정보는 파일럿인 Reference Signal 근처에 전송하라는 원칙을 가지고 Multiplexing 방법을 제안한다.

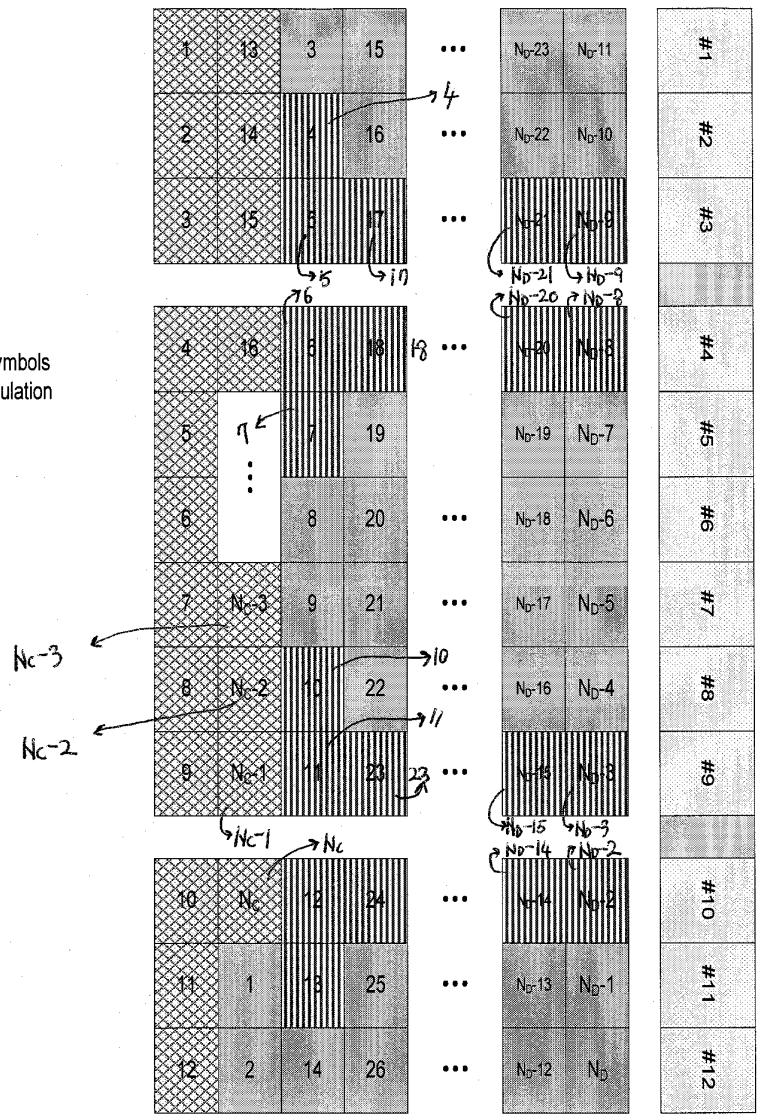
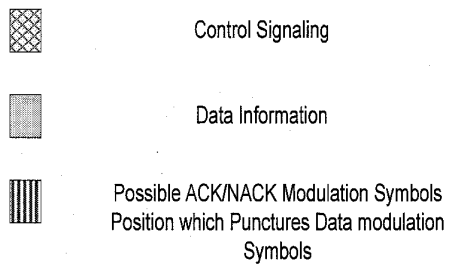


도 9

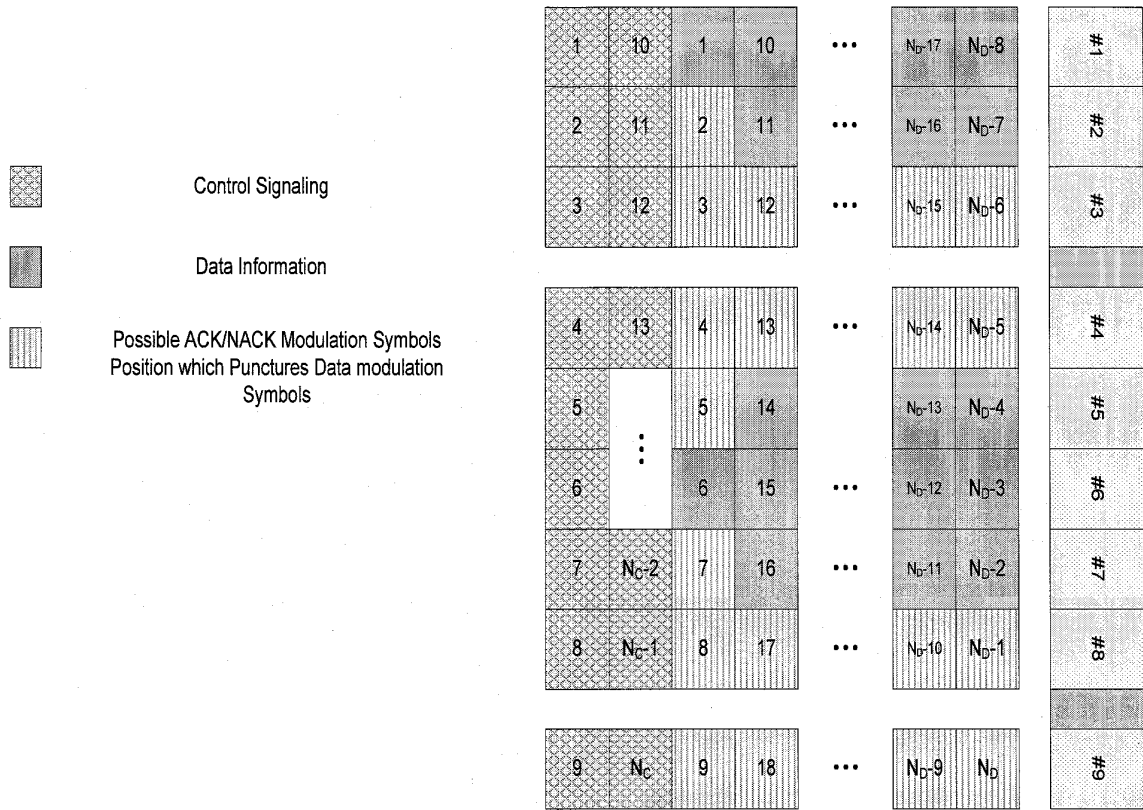
이 방법에서는 제어정보와 Data 정보가 Multiplexing 될 때 sequential 하게 concatenation 하여 Time-First Mapping 에 의하여 SC-FDMA symbol 들에 mapping 되어 상향링크로 전송된다. 만약에 ACK/NACK 정보 또한 전송되어야 한다면, 제어정보를 puncturing 하지 않는 한에서, Data 정보 Sequence 에서 Reference Signal 근처의 modulated Symbol 를 puncturing 하여 ACK/NACK 신호를 삽입한다. 이 때 삽입하기 위해서는 우선적으로 제어정보가 몇개의 (virtual frequency domain 의)subcarrier 를 차지하고 있는지 계산하고, 그로부터 Reference Symbol 앞뒤로 Data 정보가 전송되는 (virtual frequency domain 의)subcarrier 수를 계산한다. 이로부터 ACK/NACK 정보

량에 따라 몇개의 SC-FDMA symbol 에 걸쳐서 전송될지 계산한 후, 각 각의 Slot 에 있는 Reference Signal Symbol 앞뒤로 Equal Distribution 을 가지고 Data 정보를 puncturing 하여 삽입 된다.

이 때 특징적으로 ACK/NACK 정보가 Data 정보가 전송되는 Reference Symbol 앞뒤로 Data 정보가 전송되는 (virtual frequency domain 의) subcarrier 수 보다 많을 때는 ACK/NACK 정보는 Reference Symbol 의 앞뒤 Symbol 외의 더 많은 SC-FDMA symbol 에 걸쳐 전송될 수 있다. 이 때 상향링크의 SC-FDMA subframe 의 구조에 따라 Reference Signal 중심으로 존재하는 SC-FDMA symbol 의 숫자가 대칭적으로 구성되지 않을 수 있기 때문에, ACK/NACK 정보를 puncturing 하여 삽입할 때에는 이를 고려하여 삽입해야한다.

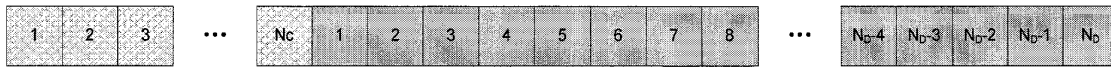


도 10.

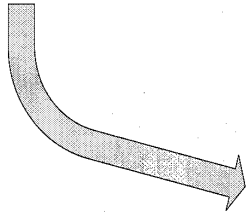





도 11.

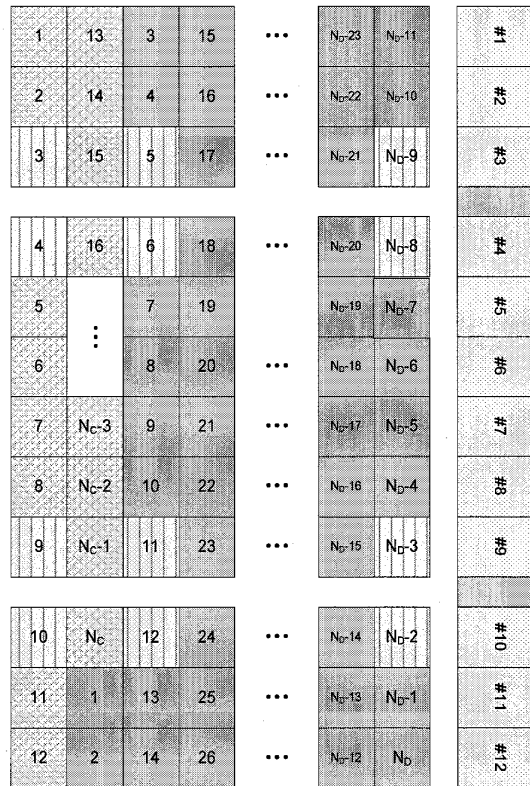
제어정보가 시간상에서 나열된다고 할 때 Data 정보와 순차적으로 나열하여 들어갈 수 있다. 이 때 ACK/NACK 정보가 reference signal 근처에 배치되어 제어정보와 Data 정보를 puncturing 하여 들어 갈 수 있다. 이 것이 [도 12]에 나타나어 있다. 실질적으로 ACK/NACK 정보 또한 제어 정보이기 때문에, 제어정보 채널들중에서 서로간에 Priority 를 주어 높은 Priority 를 가지고 있는 제어정보 채널이 Channel Estimation 의 보호를 더욱 잘 받기 위하여 Reference Signal 근처에 배치되고, Priority 가 비교적 낮은 제어정보 채널은 시간상에 펼쳐져서 전송되는 것이다. 한가지 특수한 실시예로써 본 발명에서 언급하는 제어정보와 ACK/NACK 정보중에서 ACK/NACK 정보가 보다 제어정보보다 Priority 가 높다고 가정하자, 이때 제어정보는 데이터와 같이 Time-First Mapping 방식에 의하여 시간상에 순차적으로 나열되어 Data 와 Multiplexing 되고, ACK/NACK 정보는 Reference Signal 근처에 Data 또는 제어정보를 Puncturing 하여 삽입된다. 이렇게 제어정보들 사이에 Priority 를 두어 Resource mapping 을 하면, ACK/NACK 정보는 Reference Signal 근처에 있기 때문에 좋은 channel estimation 효과를 볼 수 있으며, 제어정보는 ACK/NACK 정보에 의하여 puncturing 되어 없어지는 정보가 작아지기 때문에, ACK/NACK 이 puncturing 하여 제어정보의 성능저하에 큰 영향을 미치지 않을 수 있다. 또한 제어정보와 Data 정보의 Multiplexing 이 간단하게 연속적으로 이어서 전송되는 구조로 될 수 있기때문에 Multiplexing Block 에 의하여 구현함에 있어서 간단하게 할 수 있는 특징이 있다.



OR



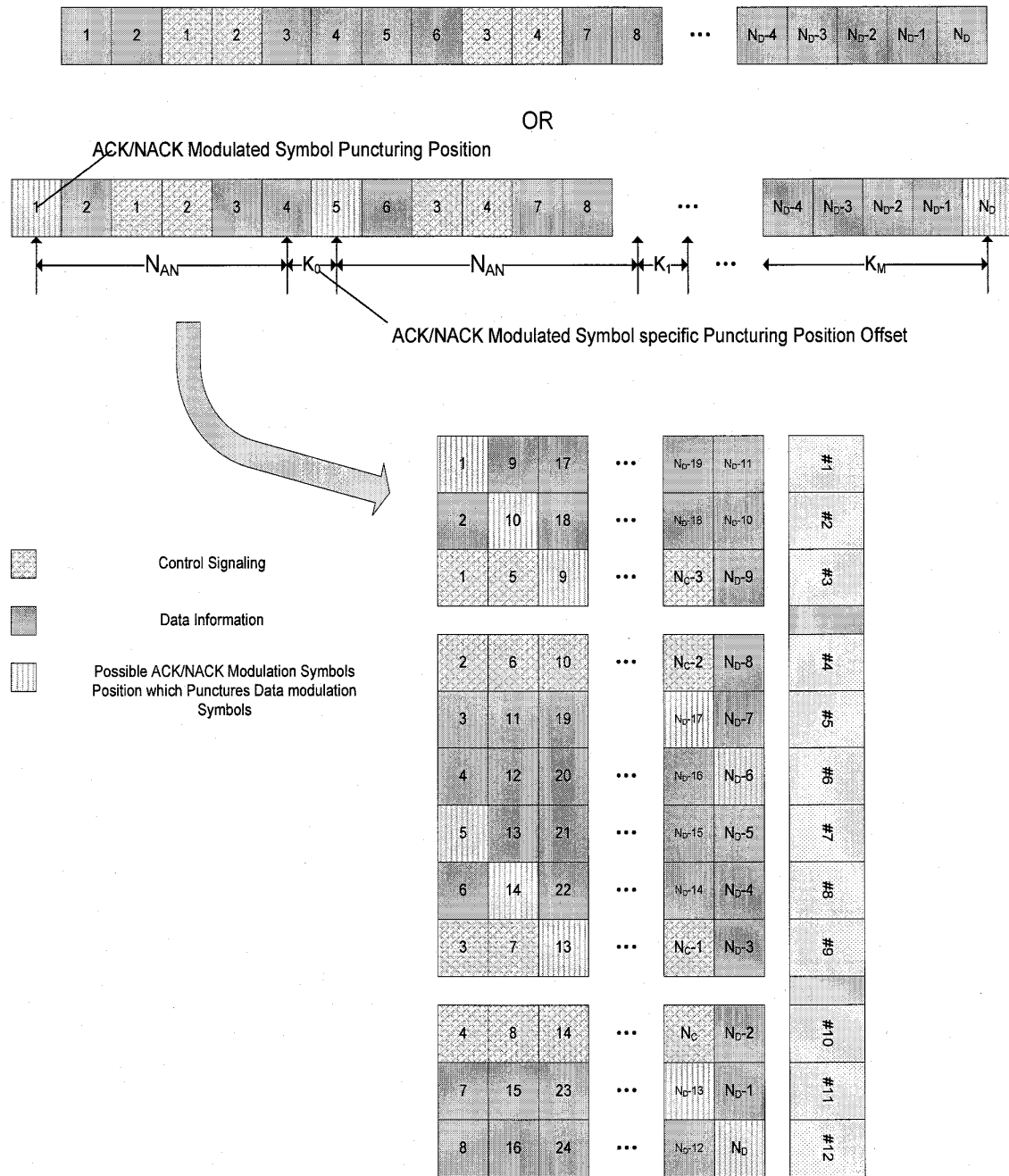
 Control Signaling  
 Data Information  
 Possible ACK/NACK Modulation Symbols  
 Position which Punctures other channel symbols



도 12

방법 2-a.

이 방법은 제어정보를 파일럿인 Reference Signal 근처에 전송하고, ACK/NACK 정보를 시간축상에서 나열하는 원칙을 가지고 Multiplexing 방법을 제안한다.



도 13

**방법 2-b-1.**

이 방법은 제어정보와 ACK/NACK 정보를 파일럿인 Reference Signal 근처에 배치하는 원칙을 가지고 Multiplexing 방법을 제안한다. ACK/NACK 정보가 puncturing 하는 정보가 제어정보 또는 Data 정보인지 상관하지 않고, Reference Signal 근처에 있는 정보에 Puncturing 하는 원칙을 가지고 Multiplexing 하는 방법을 제안한다.

**방법 2-b-2.**

이 방법은 제어정보와 ACK/NACK 정보를 파일럿인 Reference Signal 근처에 배치하는 원칙을 가지고 Multiplexing 방법을 제안한다. ACK/NACK 정보는 제어정보를 최대한 puncturing 하지 않되, 제어정보의 bit 수가 Data 정보의 bit 에 비하여 많을때에는 제어정보 또한 puncturing 이 가능하도록 하는 원칙으로 Multiplexing 방법을 제안한다.





Control Signaling



Data Information/ Systematic Bits are positioned in blue



Data punctured ACK/NACK Symbols



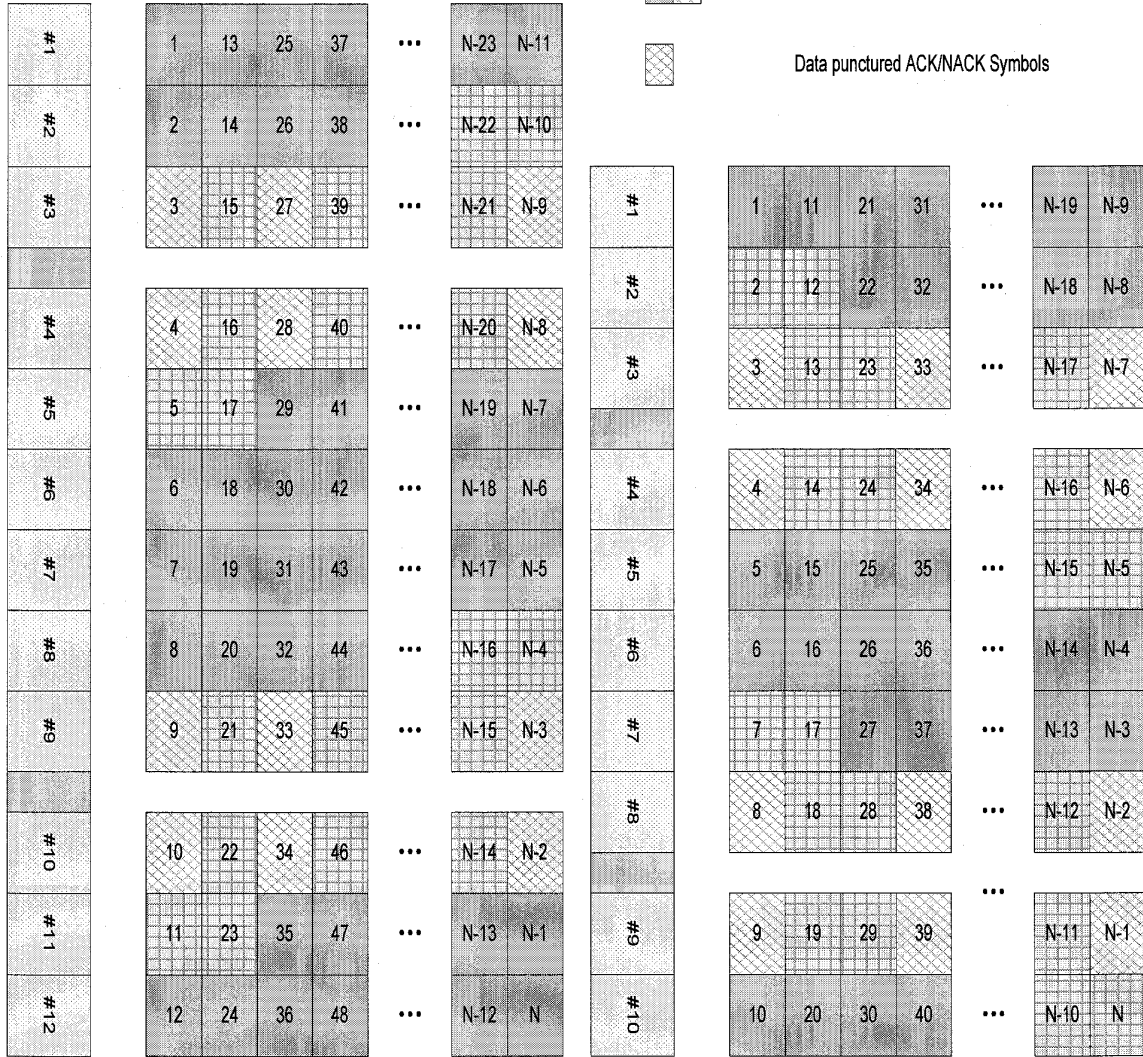
Control Signaling



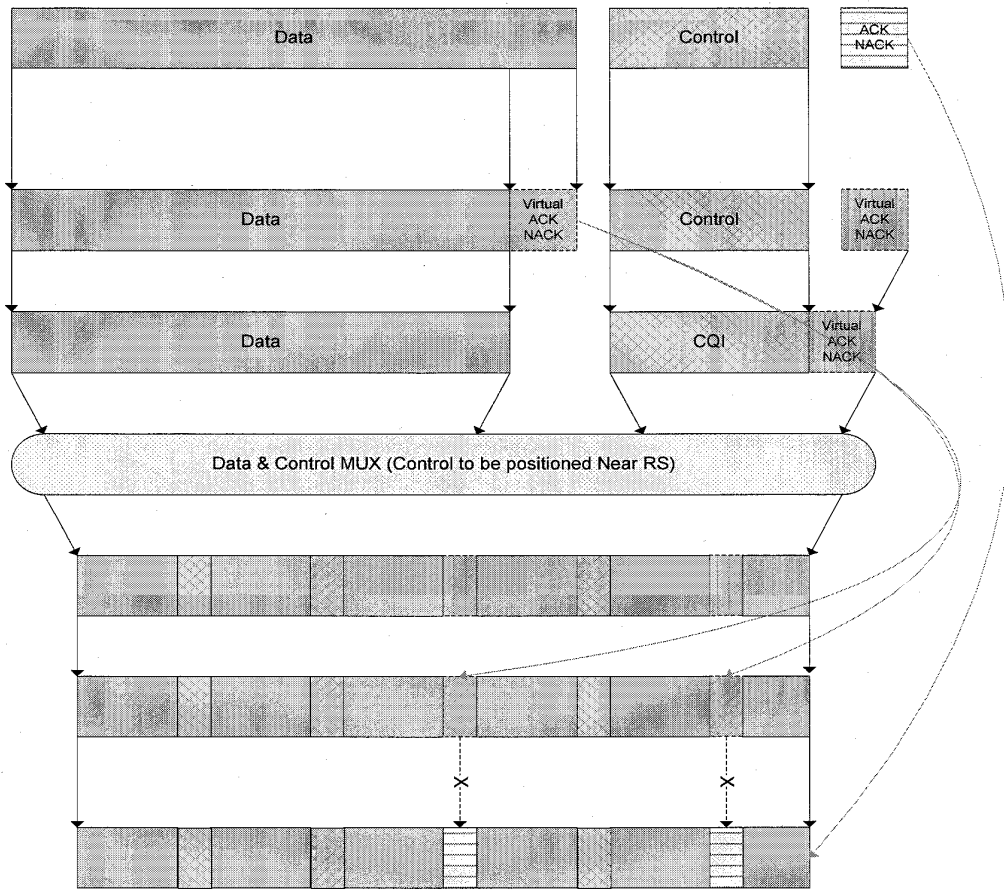
Data Information/ Systematic Bits are positioned in blue



Data punctured ACK/NACK Symbols



도 14



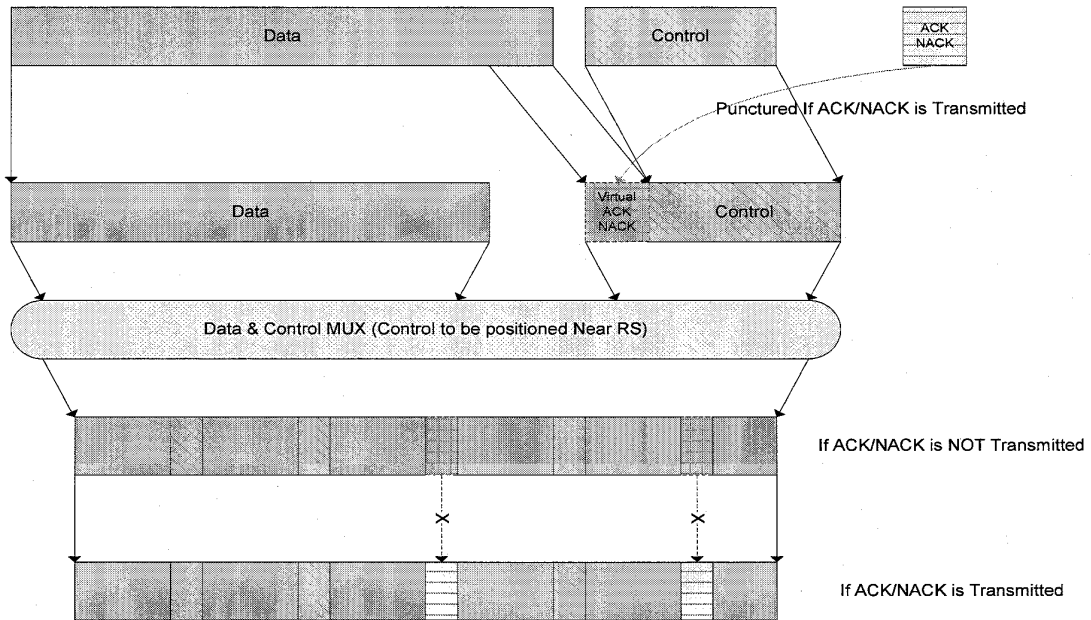
도 15

이 방법은 기본적인 원리는 [도 11]으로 설명될 수 있다. Data 정보와 제어정보가 Multiplexing 되는 Block 에서는 제어정보가 SC-FDMA subframe 구조에서 반드시 Reference Signal 근처로 배치될 수 있도록 Multiplexing 해주는 Block 이다. 즉 Reference Signal 앞뒤로 위치는 SC-FDMA symbol index 와 그 해당 subframe 에 Data 와 제어정보가 사용가능한 총 SC-FDMA symbol 수를 가만하여, Reference Signal 앞뒤에 해당하는 SC-FDMA symbol 에 제어정보가 Rate Matching 되어 삽입되는 것이다.

이러한 Multiplexing Block 를 가정으로, ACK/NACK 또한 Reference Signal 근처에 puncturing 하여 삽입되어야 하며, ACK/NACK 정보는 제어정보를 puncturing 하지 않기 위하여, 미리 Data 정보 부분에서 ACK/NACK 정보에 의하여 puncturing 가능한 일부분을 띄여와 제어정보로 가상적으로 생각하여 일부분이 가상 제어정보로 떨어진 Data 정보와 가상 제어정보로 떨어진 Data 와 제어정보의 묶음이 Multiplexing 된다.

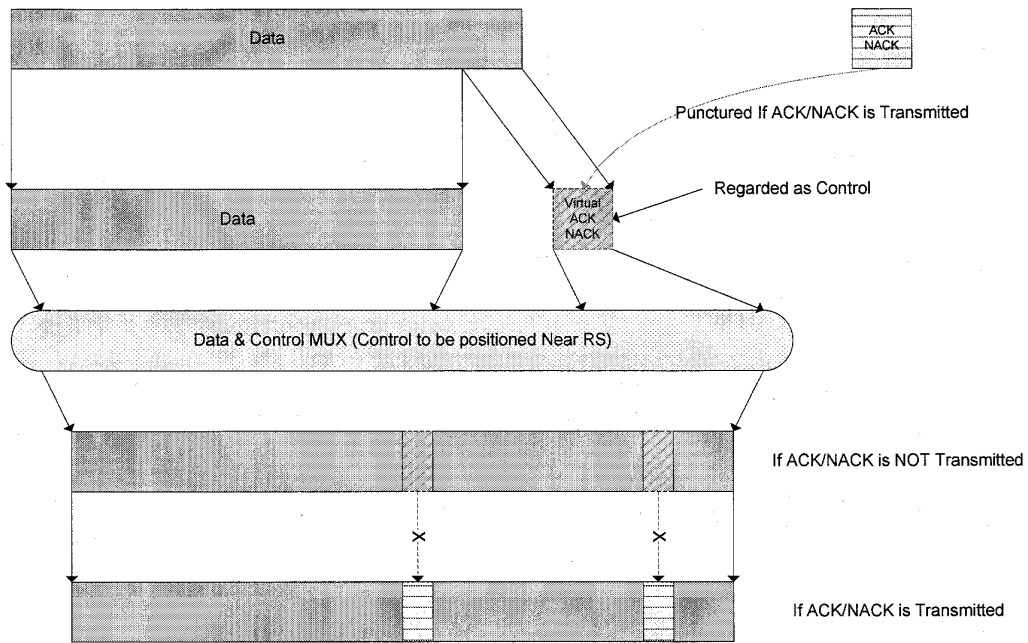
그리고 이 가상의 제어정보부분의 크기는 만약에 ACK/NACK 정보가 전송된다면 전송될때의 정보량와 동일하게 설정하고, 만약에 ACK/NACK 정보가 전송된다면 원래의 Data 정보 sequence 에서 떨어져서 제어정보와 함께 묶여 Data 와 Multiplexing 이 된 가상 제어정보 부분에 Puncturing 해서 들어간다면, 절대로 제어정보를 puncturing 하여 Reference Signal 근처에 삽입되지 않는다.

만약에 전송해야하는 데이터가 없거나, ACK/NACK 의 Modulated symbol 수가 전송하는 Data 의 Modulated symbol 수 보다 많을 때는 제어정보의 일부분을 가상 제어정보가 가정하고, ACK/NACK 이 puncturing 하여 삽입된다.



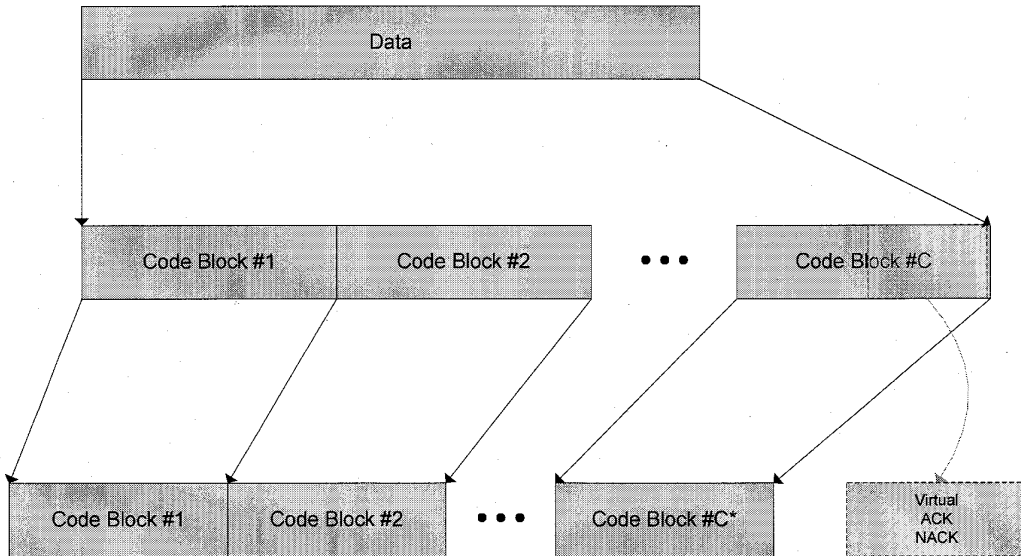
도 16

특수한 실시예로써, Data 를 전송해야하는 상황링크 subframe 에서 전송할 제어정보가 없을 때에도, Data 의 일부분을 가상 제어정보가 가정하고 가상 제어정보와 Data 부분을 Multiplexing 한다. 그리하여, 만약에 ACK/NACK 이 전송해야한다고 할 때 그 가상 제어정보로 가정한 Data 부분을 Puncturing 하여 삽입되어 상황링크로 전송가능하다.



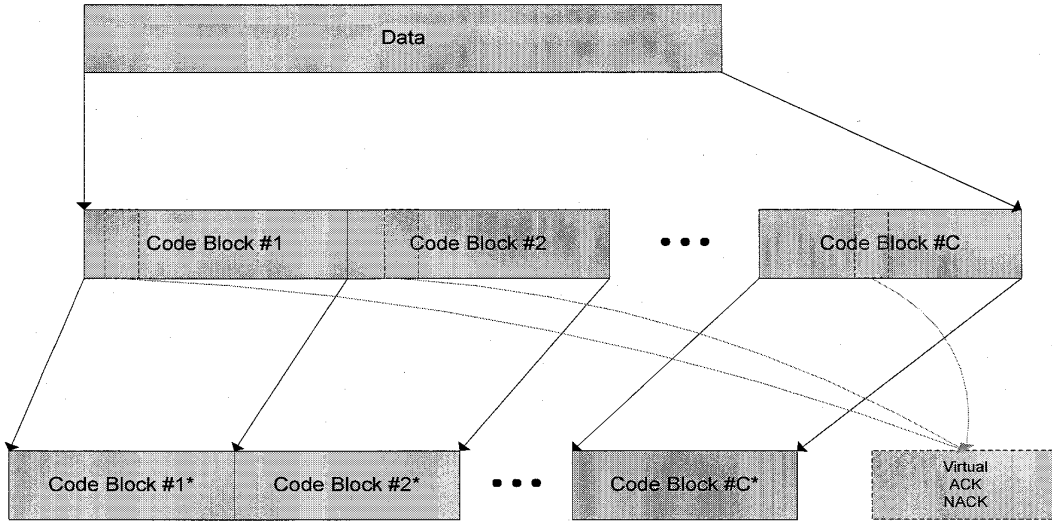
도 17

구체적인 실시예로써, Data 정보에서 Multiplexing 을 따로 할 가상 제어정보로 취급할 부분을 나누는 방법을 제시한다.



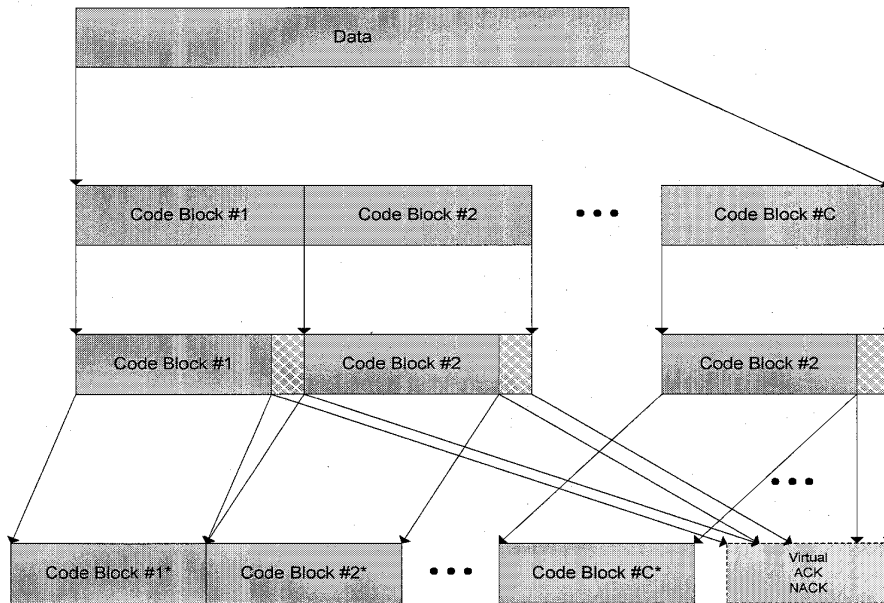
도 18

가장 간단하게는 가장 마지막 또는 가장 첫부분의 연속적인 부분을 가상제어정보로 취급하는 것이다.



도 19

Data 정보는 한개 또는 여러개의 code block 으로 이루어질 수 있다, 이 때 특정 한 code block 이 ACK/NACK 정보에 의하여 많이 puncturing 되는것을 막기 위하여 전체 Data 정보량에서 균등 하게 가상 제정정보를 구성하는 것이다. 이렇게 함으로써 특정 code block 에서 ACK/NACK 이 많 이 puncturing 하는것을 막을 수 있으며, 성능향상을 꾀할 수 있다.

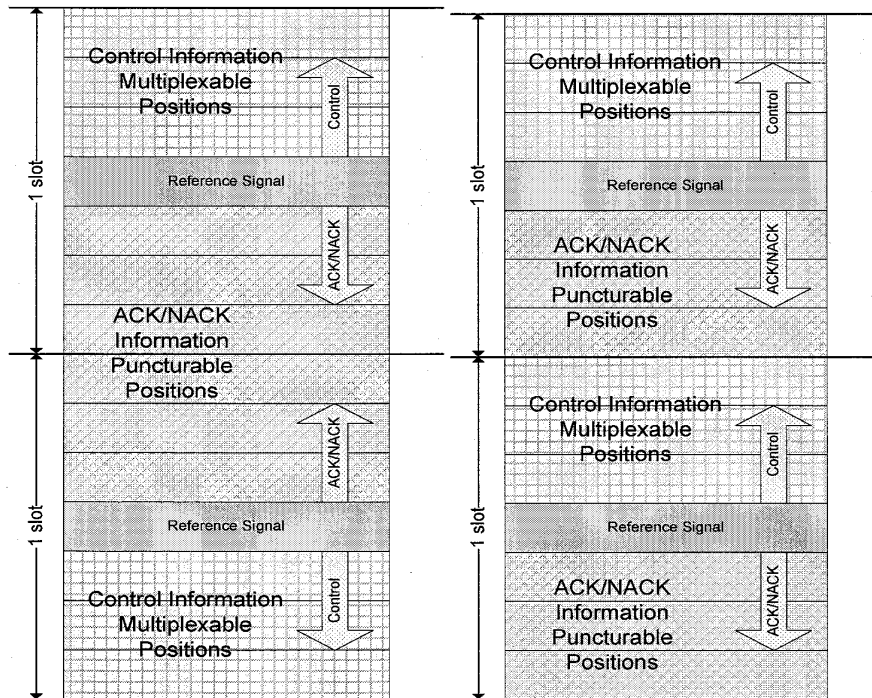


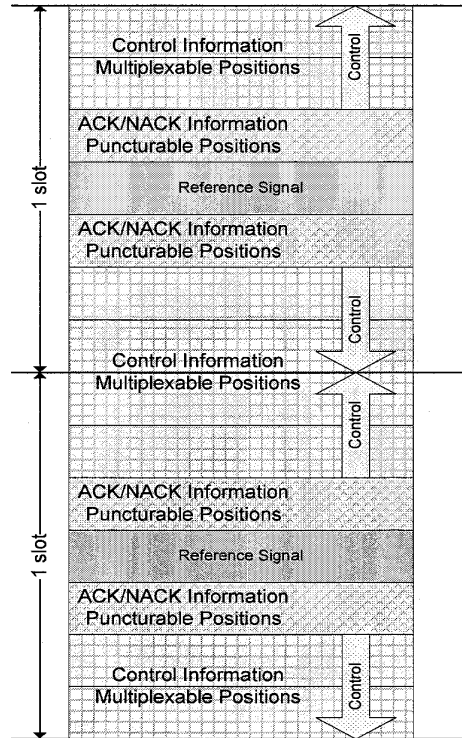
도 20

조금더 성능을 보장하기 위하여 Data 정보의 각 code block 의 끝부분을 가상 제정정보로 취급할 수 도 있다. 이는 상향링크에서 특정 transport block 의 첫번째 transmission 에서 각 code block 의 첫부분은 Turbo Encoding 된 Data 정보의 Systematic 정보들이 있기 때문이다. 항상 각 code

block 의 마지막부분의 일부분을 가상 제어정보로 취급을 함으로써, systematic 정보를 ACK/NACK 이 puncturing 하여 특정 transport block 의 첫번째 transmission 의 성능을 크게 저하 하지 않을 수 있다.

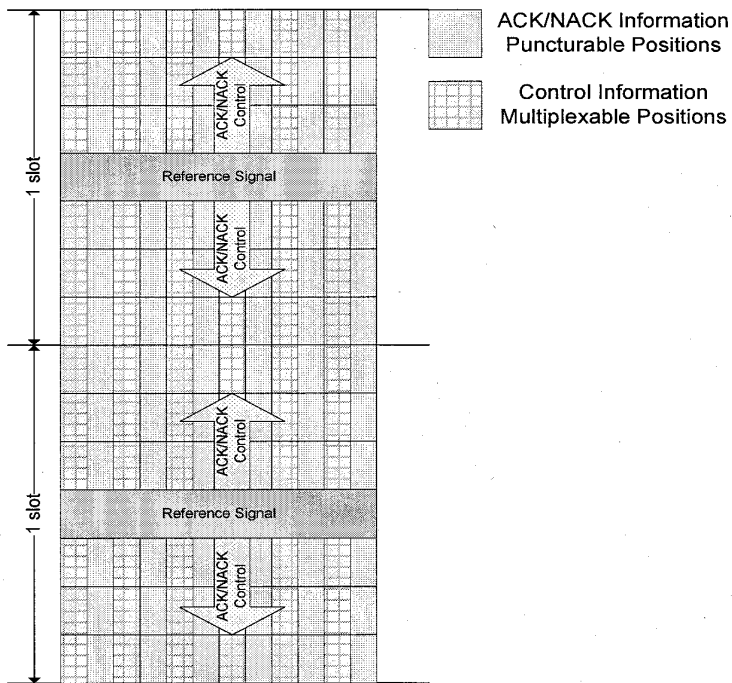
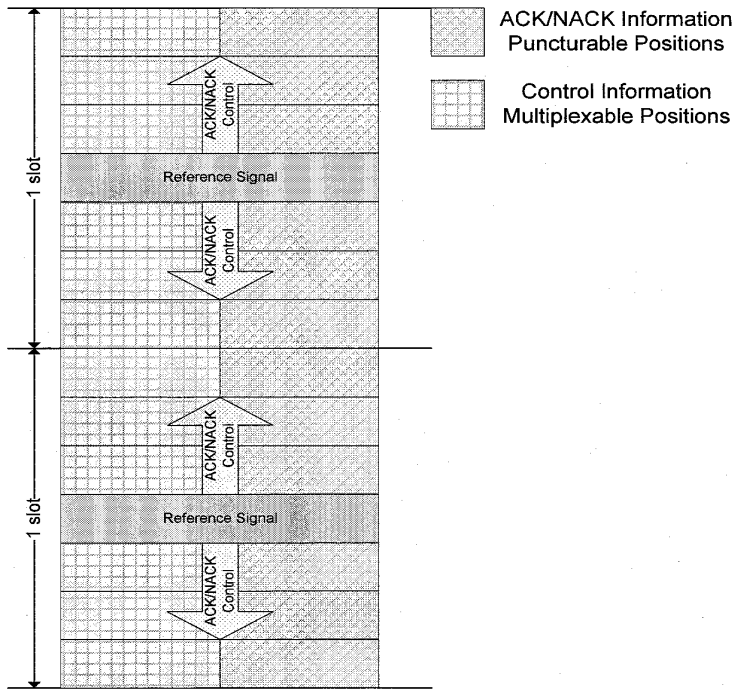
또 다른 방법은 ACK/NACK 정보와 제어정보를 SC-FDMA symbol 로 구분하여, 절대로 제어정보 와 ACK/NACK 정보가 같은 SC-FDMA symbol 상에서 삽입되지 않도록 하는 방법이다.





도 21

서로 다른 SC-FDMA symbol 에 Multiplexing 또는 puncturing 되도록 하고, 각 제어정보 또는 ACK/NACK 정보는 단말기가 위치한 Channel 상황에 따라 가변하기 때문에, 점차적으로 Reference Signal 부터 멀어지는 방향으로 정보를 Multiplexing 하거나 Puncturing 한다.



도 22

또는 ACK/NACK 정보와 제어정보를 DFT precoding 전단에서 virtual frequency domain 상의 subcarrier 로 같은 Subcarrier 에 multiplexing 또는 puncturing 도지 않도록 구분하는 것이다.





Control Signaling



Data Information/ Systematic Bits are positioned in blue



Data punctured ACK/NACK Symbols



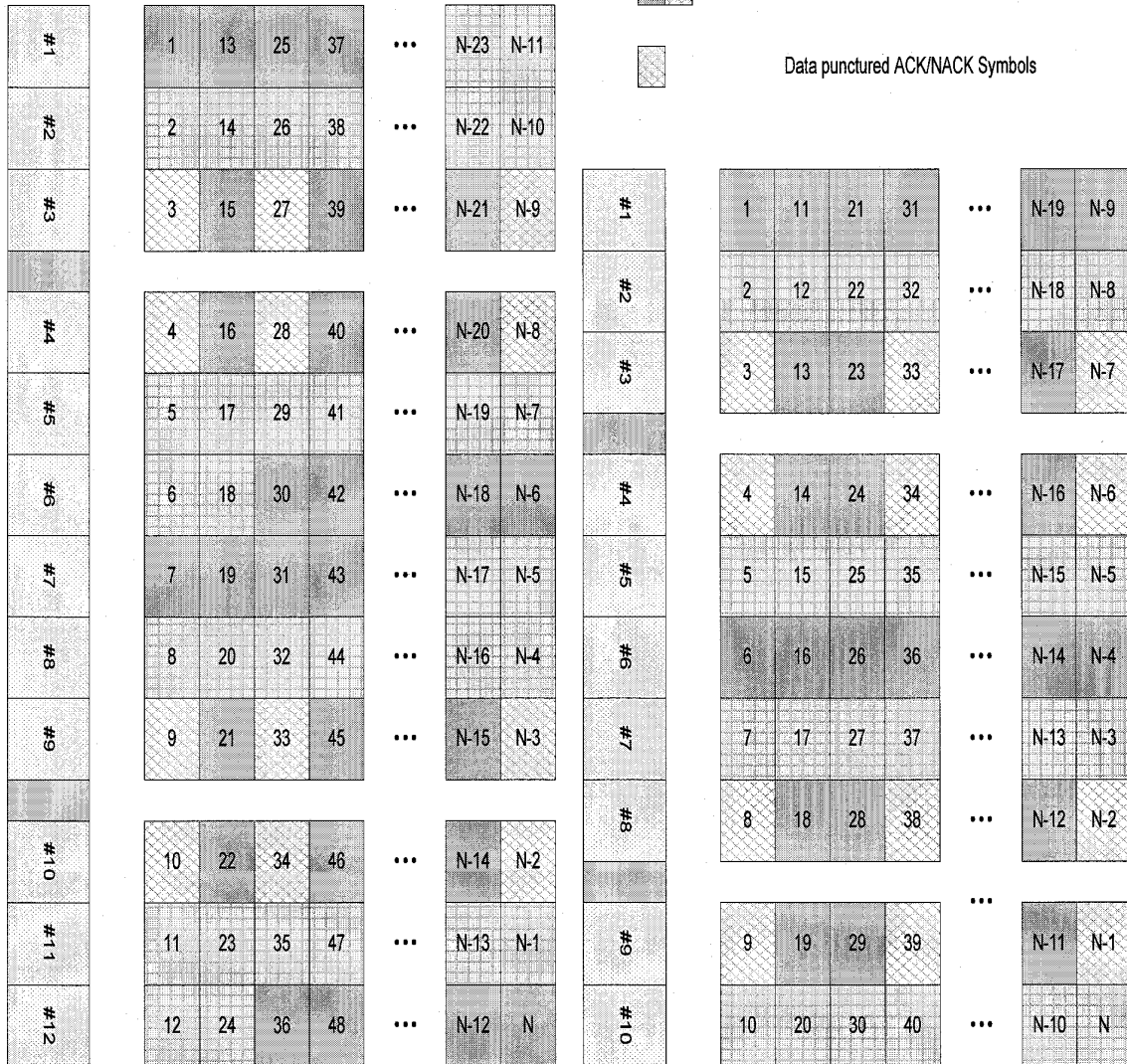
Control Signaling



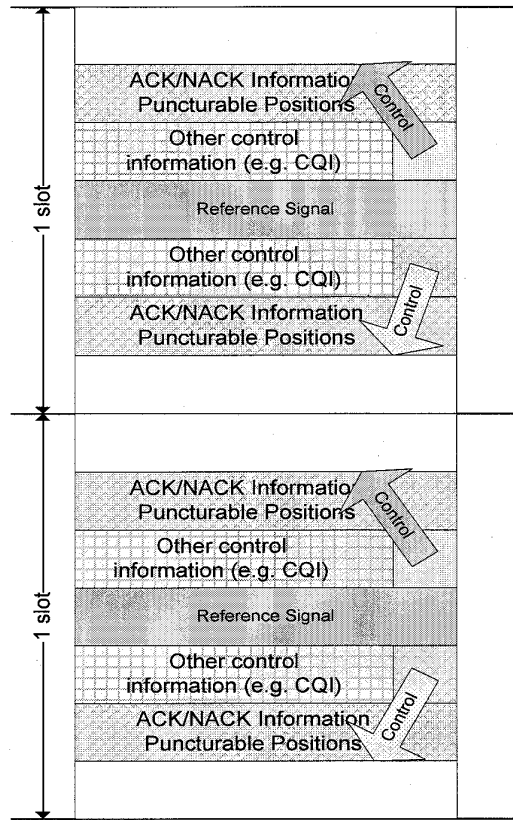
Data Information/ Systematic Bits are positioned in blue



Data punctured ACK/NACK Symbols



도 23



도 24

상황에 따라서 ACK/NACK 정보가 제어정보를 puncturing 하여 삽입될 수도 있다. 이때는 최소한의 제어정보가 puncturing 되지 않도록 되도록이면, 제어정보가 multiplexing 하여 Time-Frequency Mapper 에 Mapping 되어 있지 않은 부분에 ACK/NACK 을 puncturing 하여 전송한다. 위 도면은 제어정보가 먼저 할당되고 남은 부분부터 ACK/NACK 이 채워지는 방식을 보인 것이다.

제어정보와 ACK/NACK 정보는 단말기가 처해있는 채널 환경에 따라 coding 이 가변할 수 있다. 즉, coding 이 된 최종적인 제어정보와 ACK/NACK 정보는 가변가능하다는 뜻이다. 그러므로, 제어정보가 Multiplexing 될 때에는 reference signal 근처에 multiplexing 되어야 함으로, 가장 먼저 부터 multiplexing 하여 채워지는 위치가 생길 수 있다. 이 위치는 다음 모든 도형에 나와있는 화살표 방향의 시작점 (화살표가 가르키는 위치가 아니고 화살표그림이 시작되는 위치)부터 최종적인 정보량에 따라 채워지게 된다. 물론 제어정보가 Multiplexing 되어있지 않는 위치에는 데이터가 존재 한다. 그러므로 아래의 모든 제어정보가 multiplexing 될 수 있는 position 이란, 제어정보가 데이터와 (interleaved 또는 연속적)으로 multiplex 될 수 있는 공간을 말하며, 화살표는 더욱 많은 제어정보가 multiplex 될 때 multiplex 되어 점점 채워져 나아가는 방향을 나타낸다. 화살표 방향으로 multiplex 될 때 반드시 모든 OFDM symbol 를 다 채우고 그다음 OFDM symbol 에 multiplex 될 필요는 없다. ACK/NACK 또한 제어정보와 마찬가지로 화살표 방향으로 데이터를 puncturing

하여 정보가 삽입된다. 이때 ACK/NACK 의 최종적인 정보량에 따라 화살표 방향으로 채워지게 되며, 반드시 한 OFDM symbol 또는 영역을 다 채워야지만 그 다음 OFDM symbol 를 채워야 하는 필요는 없다.

이렇게 제어정보와 ACK/NACK 이 최종적으로 삽입되는 영역을 주파수 시간영역에서 orthogonal 하게 설정을 함으로써 ACK/NACK 정보는 제어 정보를 puncturing 하여 제어정보의 reliability 가 떨어지지 않는다.

또한 multiplexing 또는 puncturing 하여 삽입되는 제어정보는 (ACK/NACK 포함) 모두 reference signal 으로 부터 멀어지는 방향으로 점차적으로 채워진다 (제어정보의 최종적인 정보량에 따라). 위에 있는 나와있는 모든 그림에서 ACK/NACK 이 puncturing 하여 들어갈 수 있는 position 과 Control 정보가 Multiplexing 해서 들어갈 수 있는 position 은 서로 뒤바뀔 수 있다.

일반적으로 ACK/NACK 정보는 다른 제어정보에 비하여 더욱 중요하다고 생각할 수 있으므로, 위 그림과 같이 ACK/NACK 정보는 바로 reference signal 앞뒤의 OFDM symbol 에 puncturing 가능 하도록 하며, 제어정보는 그 바로 옆 OFDM symbol 부터 데이터와 multiplexing 되어 채워지는 방법 또한 존재한다.

## Electronic Patent Application Fee Transmittal

<b>Application Number:</b>				
<b>Filing Date:</b>				
<b>Title of Invention:</b>	PUSCH CONTROL CHANNEL MULTIPLEXING			
First Named Inventor/Applicant Name:	Dae Won LEE			
<b>Filer:</b>	Andrew S. Park/Sooyoung JANG			
<b>Attorney Docket Number:</b>	UT07-0149-USP0			
Filed as Large Entity				
<b>Provisional Filing Fees</b>				
<b>Description</b>	<b>Fee Code</b>	<b>Quantity</b>	<b>Amount</b>	<b>Sub-Total in USD(\$)</b>
<b>Basic Filing:</b>				
Provisional application filing	1005	1	210	210
<b>Pages:</b>				
<b>Claims:</b>				
<b>Miscellaneous-Filing:</b>				
<b>Petition:</b>				
<b>Patent-Appeals-and-Interference:</b>				
Post-Allowance-and-Post-Issuance:				
<b>Extension-of-Time:</b>				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
<b>Total in USD (\$)</b>				<b>210</b>

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	2475828
<b>Application Number:</b>	60988433
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	9013
<b>Title of Invention:</b>	PUSCH CONTROL CHANNEL MULTIPLEXING
<b>First Named Inventor/Applicant Name:</b>	Dae Won LEE
<b>Customer Number:</b>	67487
<b>Filer:</b>	Andrew S. Park/Sooyoung JANG
<b>Filer Authorized By:</b>	Andrew S. Park
<b>Attorney Docket Number:</b>	UT07-0149-USP0
<b>Receipt Date:</b>	16-NOV-2007
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<b>Time Stamp:</b>	01:02:01
<b>Application Type:</b>	Provisional

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### File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	UT07-149_USP0_ADS.pdf	1238969 059b2d24b17dda82b656bebe77f5bcd5d7e402e3	no	5

### Warnings:

### Information:

2	Specification - Not in English	UT07-149_USP0_SPEC.pdf	8515575 c2de332a186ffe0e9179ae07e9a381d7b87219fd	no	28
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### Information:

3	Fee Worksheet (PTO-06)	fee-info.pdf	8120 5eacb9ef386c05e8361ca3d1bbf6fd06e07e4089	no	2
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