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(54) **Title:** COMMUNICATION APPARATUS, COMMUNICATION METHOD AND PROGRAM

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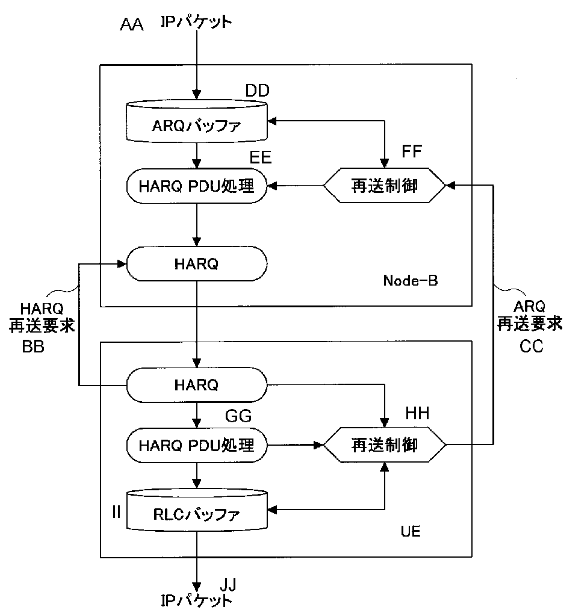

AA IP PACKET
DD ARQ BUFFER
EE HARQ PDU PROCESS
FF RETRANSMISSION CONTROL
BB HARQ RETRANSMISSION REQUEST
CC ARQ RETRANSMISSION REQUEST
GG HARQ PDU PROCESS
HH RETRANSMISSION CONTROL
II RLC BUFFER
JJ IP PACKET

(57) **Abstract:** A communication apparatus comprises a means that performs error detections of N packet data units received in N transmission processes; a means that transmits an affirmative-response representative signal or a first retransmission request signal in accordance with a result of that error detection; a storing means that stores the packets, which are subjects of the affirmative response, in preparation for transfer to an upper-order layer; a means that, when the order of the packets that are the subjects of the affirmative response is intermittent, further confirms the necessity of retransmissions for the missing packets and then transmits a second retransmission request signal; and a means that corrects the order of the packet data units and transfers the packets from the storing means to the upper-order layer.

(57) 要約: 通信装置は、Ｎ個の伝送プロセスで受信されたＮ個のパケットデータユニットに対して誤り検出を行う手段と、誤り検出結果に応じて、肯定応答を示す信号又は第１の再送要求信号を送信する手段と、肯定応答の対象となったパケットを上位レイヤへの転送に備えて格納する格納手段と、肯定応答の対象となったパケットの順序が断続的であった場合に、欠如したパケットについて再送が必要なことを更に確認した上で第２の再送要求信号を送信する手段と、パケットデータユニットの順序を揃えて前記格納手段から上位レイヤへパケットを転送する手段とを有する。

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DESCRIPTION

COMMUNICATION APPARATUS, COMMUNICATION METHOD AND PROGRAM

TECHNICAL FIELD

The present invention relates to the technical field of mobile communications, and more particularly relates to a communication apparatus, method and program for communicating packets by issuing Hybrid Automatic Repeat reQuests (HARQ).

BACKGROUND ART

In this technical field, Automatic Repeat reQuest (ARQ) method is utilized for improved communication reliability. In the ARQ method, received packets are subjected to error detection, and the transmitter side is requested to retransmit packets including unacceptably significant errors. The error detection may be conducted in accordance with any existing technique such as CRC (Cyclic Redundancy Check) scheme. In response to receipt of the request, the transmitter side retransmits the requested packets. As a result, it is possible to partially prevent an application in the receiver side from running without any packet.

FIG. 1 shows an exemplary operation of the ARQ method. For example, Internet Protocol (IP) based packets A, B, C, ... are received from an upper apparatus and stored in a reception buffer in a base station in the order (S1). The received IP packet is divided into fixed length blocks for transmission in a lower layer (S2). Then, radio transmission of a predefined number of blocks is sequentially carried out via physical channels, and the blocks are received at a mobile station

(S3). In the illustrated example, two blocks are transmitted in each transmission time interval (TTI). The mobile station conducts error detection on the received packets. The received packets are stored in a RLC (reception) buffer in the mobile station (S4). In this case, retransmission requests for error detected packets are transmitted to the base station. In the illustrated example, errors are detected for the 11th and 12th blocks as illustrated in “NG”, and the mobile station requests the base station to retransmit the blocks. The mobile station forwards error free packets to layers above the RLC such as an application layer (S5). A packet including the detected error, which corresponds to packet C in the illustration, is discarded, and then the mobile station waits for an appropriate packet and after completion of the retransmission procedure, forwards the retransmitted packet to an upper layer.

For further improvement in the communications reliability, a Hybrid ARQ (HARQ) scheme resulting from the error correction scheme being combined with the ARQ scheme is proposed. This may be also employed in the HSDPA (High Speed Downlink Packet Access) scheme.

FIG. 2 is a schematic block diagram illustrating a base station and a mobile station in accordance with the HARQ scheme, and FIG. 3 shows an exemplary operation of the HARQ scheme. IP packets A, B, C, … are received from an upper apparatus and stored in an RLC/ARQ or reception buffer (FIG. 2) in a base station in order (S1 in FIG. 3). The received IP packets are divided into fixed length blocks in the RLC buffer in FIG. 2 (S2). Then, one or more fixed length blocks are bundled and transmitted in an HARQ-PDU processing unit depending on the radio environment. The individual blocks are identified with the sequence number (SN = 1, 2, …). The

IP packets are radio transmitted via physical channels in unit of a predefined number of blocks and are received in a mobile station (S3). Packet data units including one or more blocks are assigned the respective numbers (TSN = 1, 2, …), and processes for transmitting information items specified by the numbers are assigned process numbers (P1, P2, …). The mobile station performs error detection on the received packets, and if an error is detected as illustrated in "NG", the mobile station requests the base station to retransmit the associated packet. The received packets are stored in a reordering buffer illustrated in FIG. 2 (S4). The reordering buffer holds packets not being in need of retransmission until missing packets are received. In the illustrated example, an error is detected for a packet data unit corresponding to TSN = 2 (whose process number is P2), and the mobile station requests the base station to retransmit it. In response, the base station conducts retransmission. In the illustrated example, the retransmitted packets are received without any error and stored in the reordering buffer. At this stage, the retransmission requests are carried out in a MAC sublayer. The stored packets are reordered in the reordering buffer in order of the TSN number. The properly reordered packets are decomposed into packet data units (RLC-PDUs) in the RLC layer and then stored in the RLC buffer (S5). It is determined whether the packets stored in the RLC buffer are also continuous in terms of the sequence number SN. The determination is made because in an exemplary case of an error still being detected even after the maximum retransmission times are reached in the HARQ, a missing packet may still be detected in a packet in the RLC buffer. In such a case, retransmission in the RLC layer is requested by the mobile station to the base station. At this stage, the retransmission request operations are carried out in the RLC layer (also referred to as an ARQ layer). The mobile station forwards error free packets to an upper layer such as an application layer from the RLC. For packets including error detected blocks, the mobile station waits for an appropriate packet and after completion of the retransmission procedure, forwards the retransmitted packets to the upper layer (S6). The above-mentioned conventional ARQ and HARQ methods are described in non-patent document 1 publicly disclosed at the filing date of the base priority application of the present application.

Non-patent document 1: 3GPP TS 25.301 6.4.0, Internet <URL: http://www.3gpp.org>

SUMMARY

Since the sequence number SN for specifying packet data units in the RLC layer and the number TSN for specifying packet data units in the MAC layer are represented with fixed numbers of bits, these numbers are cyclically assigned to the packets. For example, if the sequence number SN is represented with 12 bits, $2^{12} = 4{,}096$ numbers are cyclically used. For this reason, in the case of a single number being assigned to each transmitted packet, the receiver side cannot determine without difficulty whether the received packet belongs to the current cycle or the previous cycle.

In order to eliminate such inconvenience, some technique referred to as transmission stalling is conventionally used. In this technique, without confirmation response from the receiver side, the number of continuously transmittable packet data units is limited in the transmitter side. Specifically, 2,048 packets following the packet of SN = i, that is, the packets of SN (i+1) through (i+2049), may be continuously transmitted after transmission of the packet of SN = i while the SN (i+2050) and subsequent packets are prevented from being transmitted until ACK (confirmation response or affirmative response) is obtained. Once the transmitter obtains the confirmation response for the packet of SN = i, 2,048 packets of SN = (i+2) through (i+2051) may be transmitted after transmission of the packet of SN = (i+1) without confirmation response of the packet of SN = i+1. The number or size of packets transmittable without confirmation response is referred to as a transmission window. Each time a confirmation response is consecutively obtained, the range of the transmission window is incrementally shifted in the increasing direction of the SN. On the other hand, if a confirmation response is not consecutively obtained, the range of the transmission window is not shifted. By limiting the number of packets transmittable without confirmation response to half of the maximum of numbers that can be represented, the receiver can determine whether received packets are retransmitted ones. Such a scheme is also referred to as Stop And Wait (SAW) scheme.

As stated above, the retransmission operations are carried out in both the MAC layer and the RLC layer. In any of the layers, the packet data units are specified with a fixed number of bits, and thus the transmission stalling may be carried out in the retransmission operations in both layers. However, the packet data units have different sizes in the MAC layer and the RLC layer, and the reception timings of confirmation responses (ACKs) after data transmission may differ from each other in the MAC layer and the RLC layer. As a result, the transmission window has different sizes in the layers.

In general, confirmation responses may be more quickly obtained in the MAC layer than the RLC layer. For example, the size of the transmission window for retransmission request operations in the RLC layer can be set to be 2,048, and the size of the transmission window in the MAC layer can be set to be 16. It is assumed that the maximum number of the TSN is equal to 32.

However, if the transmission stalling is carried out separately in the MAC layer and the RLC layer, the transmitter can transmit only packets belonging to both transmission windows. In other words, even if data belongs to one of the transmission windows, if it is not within the range of the other transmission window, transmission of the data is prevented. FIG. 4 shows separate operations of the transmission stalling. In the illustrated example, it is assumed that confirmation responses have been already obtained for the packets of SN = 1, 2, while no confirmation response has been obtained for the packet of SN = 3. At this time point, the packets of SN = 4 through 2051 following the packet of SN = 3 may be continuously transmitted, while the packet of SN = 2052 and the subsequent packets are prevented from being transmitted. On the other hand, in the illustrated example, the packet of SN = 3 is included in the packet data unit of TSN = 13. Thus, according to the transmission stalling in the MAC layer, the packets of TSN = 14 through 29 following the packet of TSN = 13 may be continuously transmitted, while the packet of TSN = 30 and the subsequent packets are prevented from being transmitted. As a result, the packets of SN = 3 through 918 may be continuously transmitted, while the packet of SN = 919 and the subsequent packets are prevented from being transmitted. In this manner, according to the conventional scheme, the transmitter side can transmit only packets belonging to both transmission windows, which may be disadvantageous from the viewpoint of improved throughput.

A need exists to provide a communication apparatus, a retransmission control method and a program for forwarding packets appropriately and quickly in a communication system in accordance with N process SAW based retransmission control.

According to an aspect of the invention, there is provided a communication apparatus for receiving packet data in accordance with an N process SAW based hybrid ARQ method, comprising an error detection unit conducting error detection on each of multiple packet data received in multiple transmission processes; a first transmission unit transmitting an acknowledgement signal or a first retransmission request signal depending on a result of the error detection; a storage unit storing acknowledged packet data for forwarding to an upper layer; a second transmission unit, if acknowledged packet data are not running, determining whether missing packet data must be retransmitted and transmitting a second retransmission request signal and a forwarding unit reordering the packet data and forwarding the reordered packet data from the storage unit to the upper layer.

According to another aspect of the invention, there is provided a method of receiving packet data in accordance with an N process SAW based hybrid ARQ method, comprising the steps of conducting error detection on each of multiple packet data received in multiple transmission processes; transmitting an acknowledgement signal or a first retransmission request signal depending on a result of the error detection; storing acknowledgement packet data in a storage unit for forwarding to an upper layer and determining order of the packet data; if the determined order is not running, determining whether missing packet data must be retransmitted and transmitting a second retransmission request signal and reordering the packet data and forwarding the reordered packet data from the storage unit to the upper layer.

According to yet another aspect of the invention, there is provided a program causing a communication apparatus to receive packet data in accordance with an N process SAW based hybrid ARQ method, comprising the steps of conducting error detection on each of multiple packet data received in multiple transmission processes; transmitting an acknowledgement signal or a first retransmission request signal depending on a result of the error detection; storing an acknowledged packet data in a storage unit for forwarding to an upper layer and determining order of the packet data; if the determined order is not running, determining whether missing packet data must be

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retransmitted and transmitting a second retransmission request signal and reordering the packet data and forwarding the reordered packet data from the storage unit to the upper layer.

According to the embodiments of the present invention, packets can be appropriately and quickly transmitted in a communication system in accordance with N process SAW based retransmission control.

[THE NEXT PAGE IS PAGE 8]

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows a conventional retransmission operation;

FIG. 2 shows a schematic functional block diagram of a conventional base station and a conventional mobile station;

FIG. 3 shows a conventional retransmission operation;

FIG. 4 is a diagram for explaining a problem of a conventional retransmission operation;

FIG. 5A shows a conventional protocol hierarchy;

FIG. 5B shows a protocol hierarchy according to the present invention;

FIG. 6 shows a schematic functional block diagram illustrating a base station and a mobile station according to one embodiment of the present invention;

FIG. 7 shows a retransmission operation according to one embodiment of the present invention; and

FIG. 8 is a flowchart of a retransmission request operation according to one embodiment of the present invention.

LIST OF REFERENCE SYMBOLS

UE: user equipment

ARQ: automatic retransmission request

HARQ: hybrid automatic retransmission request

PDU: packet data unit

RLC: radio link control

MAC: media access control

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the present invention will be described from the viewpoint of protocol hierarchy. Conventional protocol hierarchy will be also described for comparison.

FIG. 5A shows an exemplary layer model for conventional techniques as illustrated in FIGS. 2 and 3. As stated above, received packets are subjected to error detection in the layer 1/MAC layer, and in response to error detection (or detection of significant errors exceeding acceptable level) as indicated in CRC-NG in the illustration, retransmission of the error packet is requested. In the RLC/ARQ layer, it is determined whether the sequence numbers SNs are consecutive, and if it is detected that a certain sequence number is missing, retransmission of the packet is requested. Data transmission from the MAC layer to the RLC/ARQ layer is carried out under conditions where the packet order is conserved. Operations for arranging the order are carried out in a reordering buffer. Transmission of packets to an upper layer under conditions of the order being arranged is referred to as In Sequence Delivery (ISD). Also, data transmission of packets from the RLC/ARQ layer to an upper layer (an application layer or a PDCP layer in the illustration) is carried out in accordance with ISD. In the RLC layer, the sequence number SN is monitored, and if it is detected that a certain sequence number is missing, the retransmission is carried out to maintain the packet order in the RLC reception buffer.

This scheme may be preferable from the viewpoint of reliable arrangement of the data order. However, since two transmission stalling operations are separately carried out by using different transmission windows, the throughput may be degraded as stated above. On the other hand, the essential purpose of the retransmission is to supply a series of consecutive packets without any missing packet to an application layer and/or others. Thus, it may not be a requirement to fulfill respective ISDs in the two separate transmission stalling operations. The present invention can conserve the order of packets forwarded to an upper layer without the duplicated transmission stalling operations through improved triggering of retransmission requests.

FIG. 5B shows an exemplary layer model for the present invention. The type and name of layers where operations are carried out are only by way of example, and the present invention may be applied to various systems where the N process SAW scheme based HARQ method is used. In the layer 1/MAC layer, received packets with CRC are subjected to error detection, and in response to error detection (or detection of significant errors exceeding acceptable level) as indicated in CRC-NG in the illustration, retransmission of the error packet is requested. In the RLC/ARQ layer, it is determined whether the sequence numbers SNs are consecutive, and if it is detected that a certain sequence number is missing, it is determined whether retransmission of the relevant packet must be truly requested. Then, if so, the retransmission is requested. While data transmission from the RLC/ARQ layer to an upper layer is carried out in ISD, the order may not be conserved in data transmission from the MAC layer to the RLC/ARQ layer. In other words, the transmission is carried out in Out of Sequence Delivery (OSD). Unlike conventional schemes, the order conservation is conducted based on not the sequence number (TSN number) in the HARQ layer but the sequence number (SN number) in the ARQ layer. For this reason, there is a single transmission window in the transmission stalling. Note that the sequence numbers in the HARQ layer and the ARQ layer may be integrated and managed. In application to the above-mentioned example, the packet order is conserved by using the transmission window having the size of 2,048 sequence numbers, and the other transmission window having the size of 16 TSN numbers is not used. As a result, it is possible to substantially avoid degraded throughput as conventionally experienced. However, the present invention differs from conventional techniques in triggering of retransmission requests in the RLC/ARQ layer. Even if it is detected that a certain sequence number is missing, retransmission is not requested before it is determined that retransmission of the relevant packet must be truly requested. In this manner, triggering of the retransmission requests is improved, resulting in omission of one of the two transmission stalling operations, and thus well-ordered packets can be promptly forwarded to an application layer and other layers.

[First Embodiment]

Hereinafter, one embodiment of the present invention will be described in the context of downlink transmission from a base station to a mobile station. However, the present invention can be also applied to the inverse data transmission direction.

FIG. 6 shows a schematic block diagram illustrating a base station and a mobile station operating in the HARQ method according to one embodiment of the present invention, and FIG. 7 shows an exemplary operation thereof. A retransmission request operation is described in detail with reference to FIG. 8. IP packets A, B, C, … from an upper apparatus are consecutively stored in an ARQ or reception buffer (FIG. 6) in the base station (S1 in FIG. 7). The received IP packets may be divided into fixed length blocks in the ARQ buffer in FIG. 6. The present invention can be used regardless of the PDU size. Thus, the PDU size is made uniform in the illustration in FIG. 7, but various sizes of PDU may be used. For convenience, transmitted packets are identified with the sequence number (SN = 1, 2, …).

These packets are radio transmitted in physical channels and are received at a mobile station (S2). The process number (P1, P2, …) is assigned to processes for transmitting information specified with the SN. The mobile station conducts error detection on the received packets, and if an error is detected as shown in "NG", the mobile station requests the base station to retransmit the relevant packets. For simplicity of explanation, the retransmission request at this stage is referred to as "HARQ retransmission request". Processing units as shown in "HARQ" in the base station and the mobile station in FIG. 6 are responsible for operations associated with the retransmission request in the layer 1/MAC layer.

The received packets are stored in the ARQ buffer (S3). The ARQ is used to buffer the received packets like the RLC buffer in FIG. 2, but the ARQ buffer may operate differently from the RLC buffer in coordination with the retransmission control unit, for example, in that it may refrain from the retransmission requests even in cases of the packet order being inconsecutive in the buffer. In these cases, it is determined whether the sequence numbers SN for the packets stored in the ARQ buffer are inconsecutive, and if needed, a retransmission request is issued. For simplicity of explanation, the transmission request in this stage is referred to as "ARQ retransmission request".

The mobile station forwards error free packets to an upper layer (an application layer and/or others) above the RLC. For a packet including an error detected block, the mobile station waits for an appropriate packet and forwards the retransmitted packet after completion of the retransmission operation (S4).

FIG. 8 is a flowchart illustrating an exemplary operation associated with a retransmission request. The operation illustrated in this flowchart is mainly carried out in the retransmission control unit in a mobile station. At step S1, the mobile station receives and decodes a downlink shared control channel.

At step S2, it is determined whether there exists data destined for the mobile station. If no data is destined for the mobile station, the control proceeds to step S3 where the mobile station waits for the next transmission time interval. Then, the control returns to step S1.

At step S4, the mobile station receives and decodes the data destined for itself in a shared data channel.

At step S5, the mobile station conducts error detection on the decoded packets. If a significant error exceeding an acceptable level is detected, the control proceeds to step S6 where the mobile station request a base station to retransmit the relevant packet. Then, the control returns to step S1.

At step S7, if no error or an error less significant than the acceptable level is detected, the mobile station transmits confirmation responses (ACK) for the packets. The confirmation response indicates that the relevant packet has been properly received in the mobile station.

At step S8, the sequence number of the properly received packet is identified, and then it is determined whether the identified sequence number is the smallest in packets to be received. In other words, it is determined whether the order of the packets to be acknowledged is consecutive. If the identified sequence number is the smallest, the control proceeds to step S3 and then returns to step S1. For example, assuming that the packet of the sequence number SN = 1 has been just received, the next smallest sequence number becomes 2. On the other hand, if the identified sequence number does not correspond to the smallest sequence number, the control proceeds to step S9. This may correspond to a situation where after proper reception of the packet of SN =1, the packet of SN = 2 becomes a packet to be retransmitted and the packet of SN = 3 has been properly received.

At step S9, it is determined whether there is an HARQ process (retransmission process) where the retransmission operation has not been finished. This determination is made, for example, by the retransmission control unit verifying operations in the HARQ processing unit. If there is no retransmission process that has not been finished, the control proceeds to step S10. Otherwise, the control proceeds to step S12.

At step S10, the mobile station requests the base station to retransmit a missing packet identified at step S8 (ARQ retransmission request). Subsequently, the control proceeds to step S11 where the mobile station waits for the next transmission time interval. Then, the control returns to step S1. According to the embodiment of the present invention, unlike conventional schemes, even if the order of packets to be acknowledged is not consecutive, a retransmission request is not immediately issued. It is determined at step S9 whether an unfinished retransmission process exists, and if no unfinished retransmission process exists, the retransmission request is issued. As a result, it is possible to advantageously avoid unnecessary retransmission requests.

At step S12, the mobile station stores in a memory which packet is being retransmitted (specifically, the sequence number of the packet) and the process number of the process by which the packet is to be retransmitted.

At step S13, after all stored processes where the packets are under retransmission have been finished, the retransmitted packets whose sequence numbers are stored at step S12 are subjected to error detection.

At step S14, the retransmitted packets are subjected to error detection. If an error is within the acceptable range, the relevant packet is stored in the ARQ buffer. The control proceeds to step S3 where the mobile station waits for the next transmission time interval. Then, the control returns to step S1. On the other hand, if the error exceeds the acceptable level, the control proceeds to step S10 where the mobile station requests the base station to retransmit the improperly received packet (ARQ retransmission request). For example, this may correspond to situations where the maximum time of retransmission has been carried out but the packet could not be received with satisfactory quality and/or where the packet has not been received with satisfactory quality during a predefined period of delay time. The control proceeds to step S11 where the mobile station waits for the next transmission time interval. Then, the control returns to step S1.

The specific embodiments of the present invention have been described above, but the present invention is not limited to the embodiments and various modifications and variations can be made within the spirit of the present invention.

This international patent application is based on

Japanese Priority Application No. 2005-379990 filed on December 28, 2005, the entire contents of which are hereby incorporated by reference.

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The claims defining the invention are as follows:

1. A communication apparatus for receiving packet data in accordance with an N process SAW based hybrid ARQ method, comprising:

an error detection unit conducting error detection on each of multiple packet data received in multiple transmission processes;

a first transmission unit transmitting an acknowledgement signal or a first retransmission request signal depending on a result of the error detection;

a storage unit storing acknowledged packet data for forwarding to an upper layer;

a second transmission unit, if acknowledged packet data are not running, determining whether missing packet data must be retransmitted and transmitting a second retransmission request signal; and

a forwarding unit reordering the packet data and forwarding the reordered packet data from the storage unit to the upper layer.

2. The communication apparatus as claimed in claim 1, wherein the second retransmission request signal is generated if a retransmission process for the missing packet data is not being carried out or if an error is detected in the missing packet data even after completion of the retransmission process for the missing packet data.

3. The communication apparatus as claimed in claim 1, wherein the order of packet data is determined with sequence numbers assigned to the respective packet data.

4. A method of receiving packet data in accordance with an N process SAW based hybrid ARQ method, comprising the steps of:

conducting error detection on each of multiple packet data received in multiple transmission processes;

transmitting an acknowledgement signal or a first retransmission request signal depending on a result of the error detection;

storing acknowledgement packet data in a storage unit for forwarding to an upper layer and determining order of the packet data;

if the determined order is not running, determining whether missing packet data must be retransmitted and transmitting a second retransmission request signal; and reordering the packet data and forwarding the reordered packet data from the storage unit to the upper layer.

5. The method as claimed in claim 4, wherein the second retransmission request signal is generated if a retransmission process for the missing packet data is not being carried out or if an error is deterred in the missing packet data even after completion of the retransmission process for the missing packet data.

6. A program causing a communication apparatus to receive packet data in accordance with an N process SAW based hybrid ARQ method, comprising the steps of:

conducting error detection on each of multiple packet data received in multiple transmission processes;

transmitting an acknowledgement signal or a first retransmission request signal depending on a result of the error detection;

storing an acknowledged packet data in a storage unit for forwarding to an upper layer and determining order of the packet data;

if the determined order is not running, determining whether missing packet data must be retransmitted and transmitting a second retransmission request signal; and

reordering the packet data and forwarding the reordered packet data from the storage unit to the upper layer.

7. The program as claimed in claim 6, wherein the second retransmission request signal is generated if a retransmission process for the missing packet data is not being carried out or if an error is detected in the missing packet even after completion of the retransmission process for the missing packet data.

8. A communication apparatus for receiving packet data in accordance with an N process SAW based hybrid ARQ method, said apparatus being substantially as herein disclosed with reference to any one or more of Figs. 1-8 of the accompanying drawings.

9. A method of receiving packet data in accordance with an N process SAW based hybrid ARQ method, said method being substantially as herein disclosed with reference to any one or more of Figs. 1-8 of the accompanying drawings.

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10. A program causing a communication apparatus to receive packet data in accordance with an N process SAW based hybrid ARQ method, said program being substantially as herein disclosed with reference to any one or more of Figs. 1-8 of the accompanying drawings.

DATED this Twenty-Eighth Day of January, 2011

NTT DoCoMo, Inc.

Patent Attorneys for the Applicant

SPRUSON & FERGUSON

[3309709_1]:wxb

FIG.1

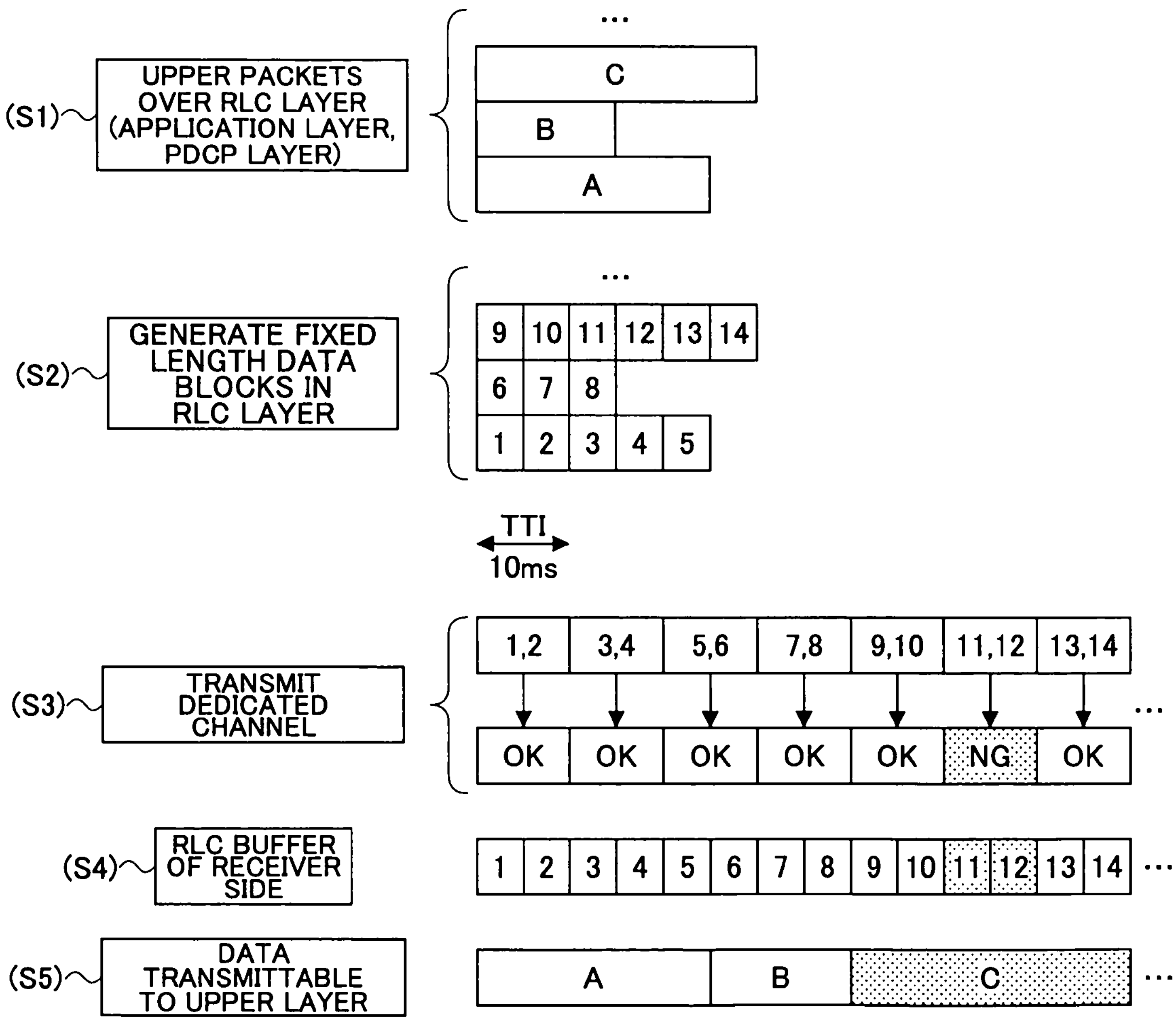

(S1)
UPPER PACKETS OVER RLC LAYER (APPLICATION LAYER, PDCP LAYER)
C
B
A
(S2)
GENERATE FIXED LENGTH DATA BLOCKS IN RLC LAYER
9 10 11 12 13 14
6 7 8
1 2 3 4 5
TTI
10ms
(S3)
TRANSMIT DEDICATED CHANNEL
1,2 3,4 5,6 7,8 9,10 11,12 13,14
OK OK OK OK OK NG OK
(S4)
RLC BUFFER OF RECEIVER SIDE
1 2 3 4 5 6 7 8 9 10 11 12 13 14
(S5)
DATA TRANSMITTABLE TO UPPER LAYER
A
B
C

FIG.2

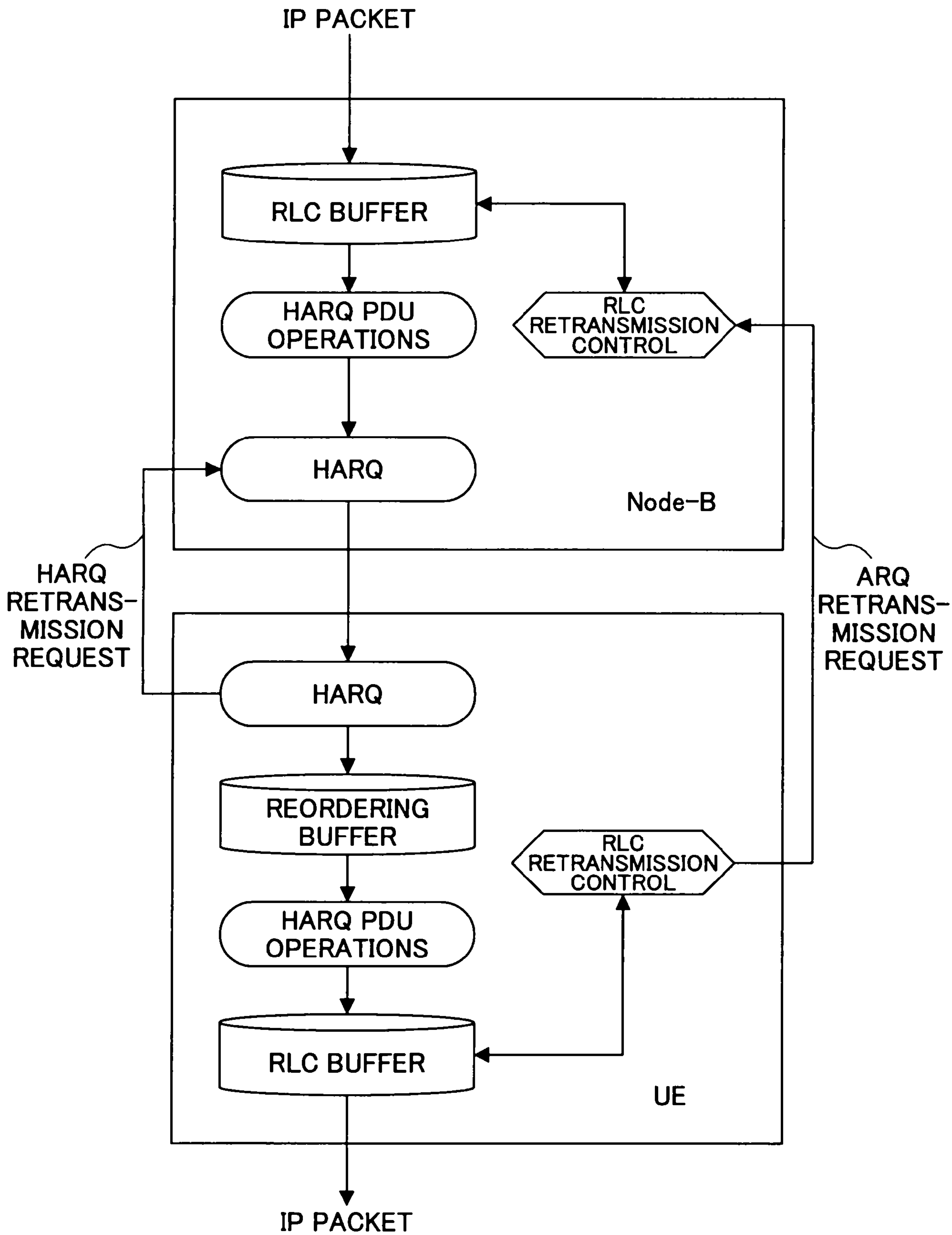
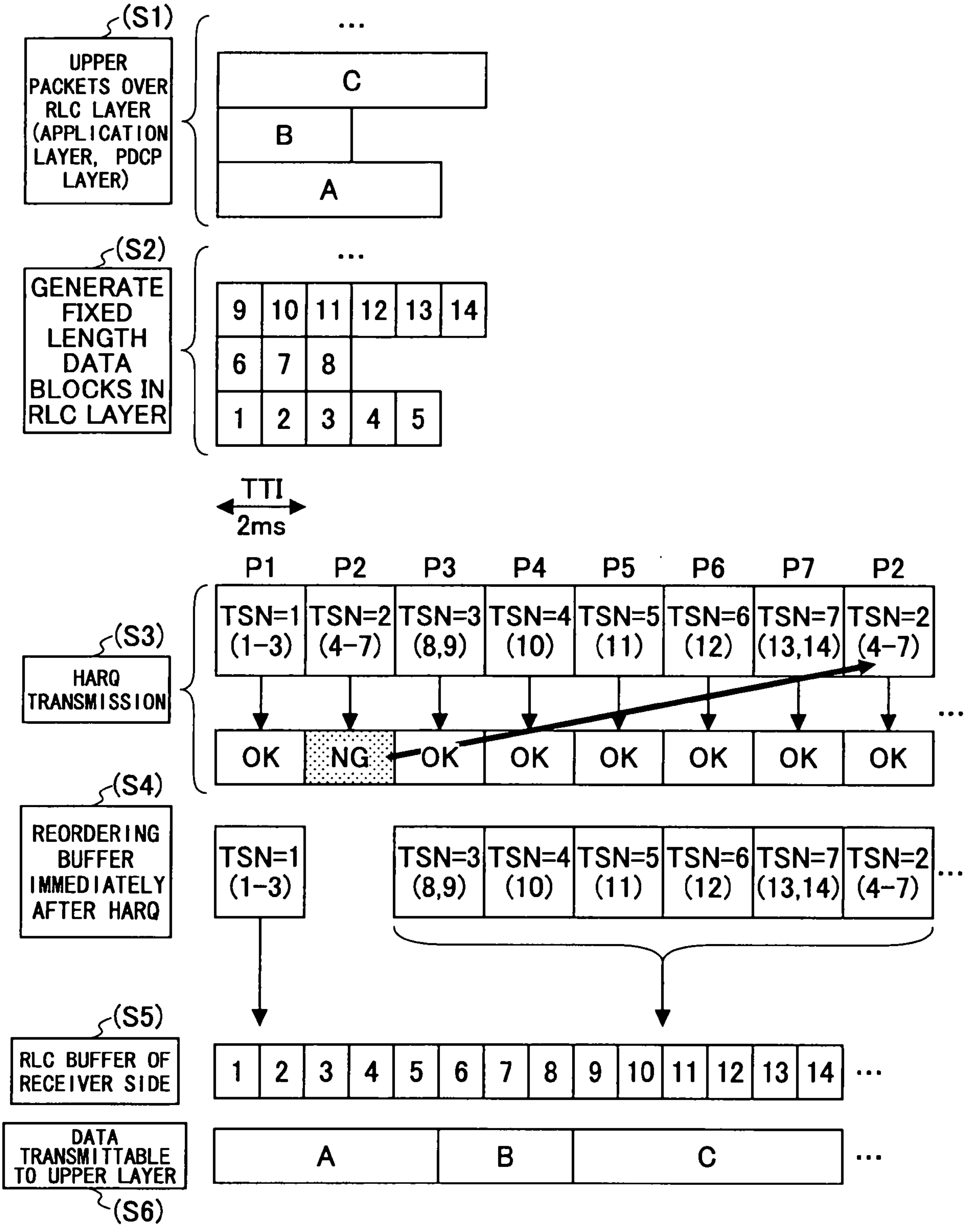
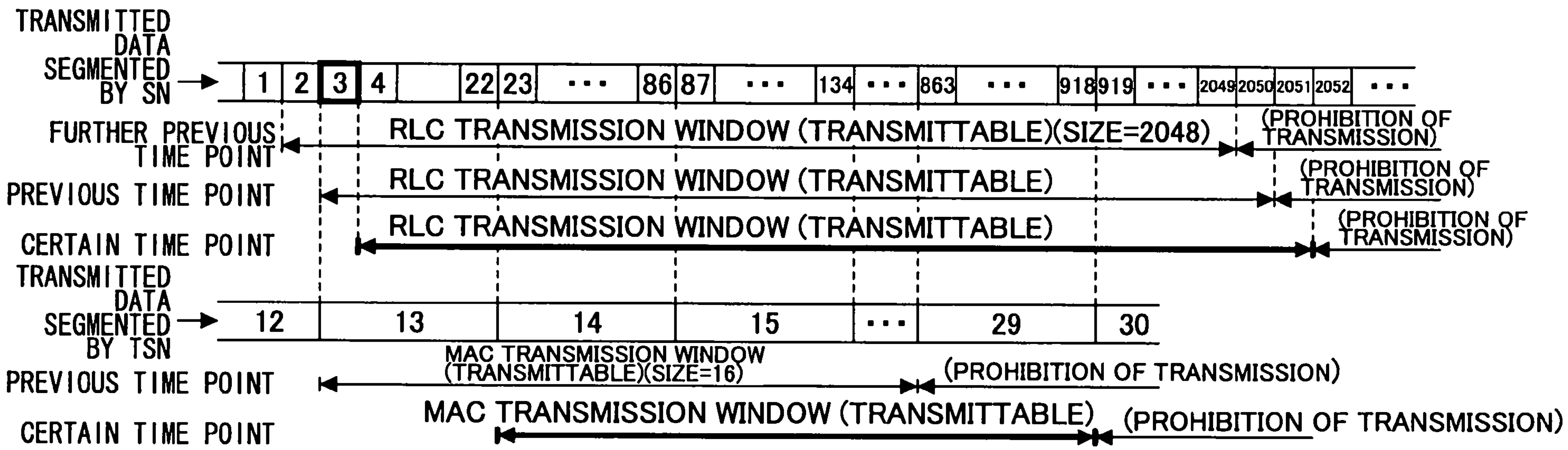

IP PACKET
RLC BUFFER
HARQ PDU OPERATIONS
RLC RETRANSMISSION CONTROL
HARQ
Node-B
HARQ RETRANS-MISSION REQUEST
ARQ RETRANS-MISSION REQUEST
HARQ
REORDERING BUFFER
RLC RETRANSMISSION CONTROL
HARQ PDU OPERATIONS
RLC BUFFER
UE
IP PACKET

FIG.3



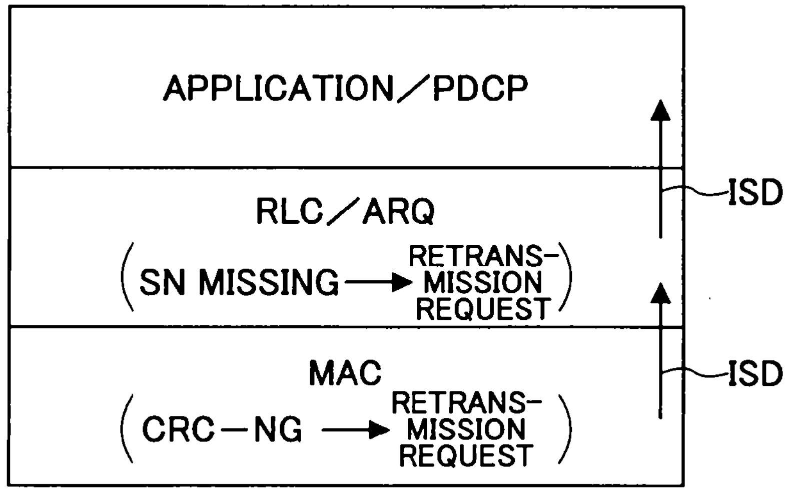
(S1)
UPPER PACKETS OVER RLC LAYER (APPLICATION LAYER, PDCP LAYER)
...
C
B
A
(S2)
GENERATE FIXED LENGTH DATA BLOCKS IN RLC LAYER
...
9 10 11 12 13 14
6 7 8
1 2 3 4 5
TTI
2ms
P1 P2 P3 P4 P5 P6 P7 P2
(S3)
HARQ TRANSMISSION
TSN=1 (1-3)
TSN=2 (4-7)
TSN=3 (8,9)
TSN=4 (10)
TSN=5 (11)
TSN=6 (12)
TSN=7 (13,14)
TSN=2 (4-7)
OK NG OK OK OK OK OK OK
...
(S4)
REORDERING BUFFER IMMEDIATELY AFTER HARQ
TSN=1 (1-3)
TSN=3 (8,9)
TSN=4 (10)
TSN=5 (11)
TSN=6 (12)
TSN=7 (13,14)
TSN=2 (4-7)
...
(S5)
RLC BUFFER OF RECEIVER SIDE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 ...
DATA TRANSMITTABLE TO UPPER LAYER
A B C ...
(S6)

FIG.4



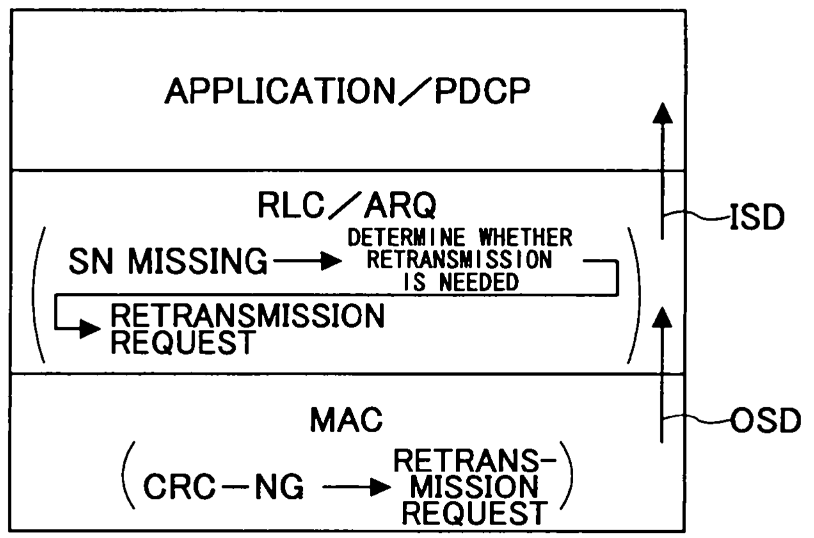
TRANSMITTED DATA SEGMENTED BY SN
1
2
3
4
22
23
• • •
86
87
• • •
134
• • •
863
• • •
918
919
• • •
2049
2050
2051
2052
• • •
FURTHER PREVIOUS TIME POINT
RLC TRANSMISSION WINDOW (TRANSMITTABLE)(SIZE=2048)
(PROHIBITION OF TRANSMISSION)
PREVIOUS TIME POINT
RLC TRANSMISSION WINDOW (TRANSMITTABLE)
(PROHIBITION OF TRANSMISSION)
CERTAIN TIME POINT
RLC TRANSMISSION WINDOW (TRANSMITTABLE)
(PROHIBITION OF TRANSMISSION)
TRANSMITTED DATA SEGMENTED BY TSN
12
13
14
15
• • •
29
30
PREVIOUS TIME POINT
MAC TRANSMISSION WINDOW (TRANSMITTABLE)(SIZE=16)
(PROHIBITION OF TRANSMISSION)
CERTAIN TIME POINT
MAC TRANSMISSION WINDOW (TRANSMITTABLE)
(PROHIBITION OF TRANSMISSION)

FIG.5A



APPLICATION／PDCP
RLC／ARQ
(SN MISSING → RETRANS-MISSION REQUEST)
MAC
(CRC−NG → RETRANS-MISSION REQUEST)
ISD
ISD

FIG.5B



APPLICATION／PDCP
RLC／ARQ
SN MISSING → DETERMINE WHETHER RETRANSMISSION IS NEEDED
→ RETRANSMISSION REQUEST
MAC
(CRC−NG → RETRANS-MISSION REQUEST)
ISD
OSD

FIG.6

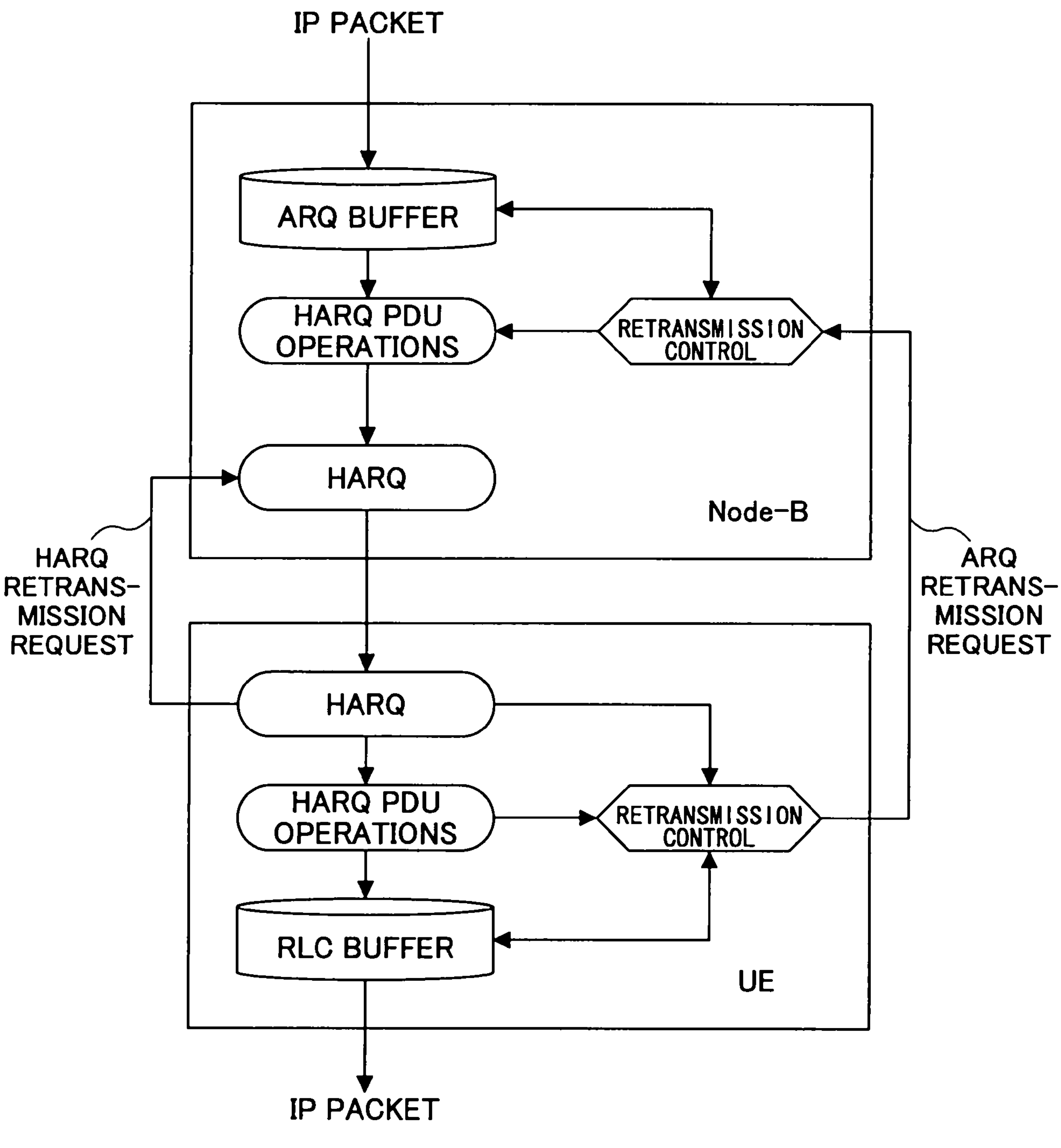
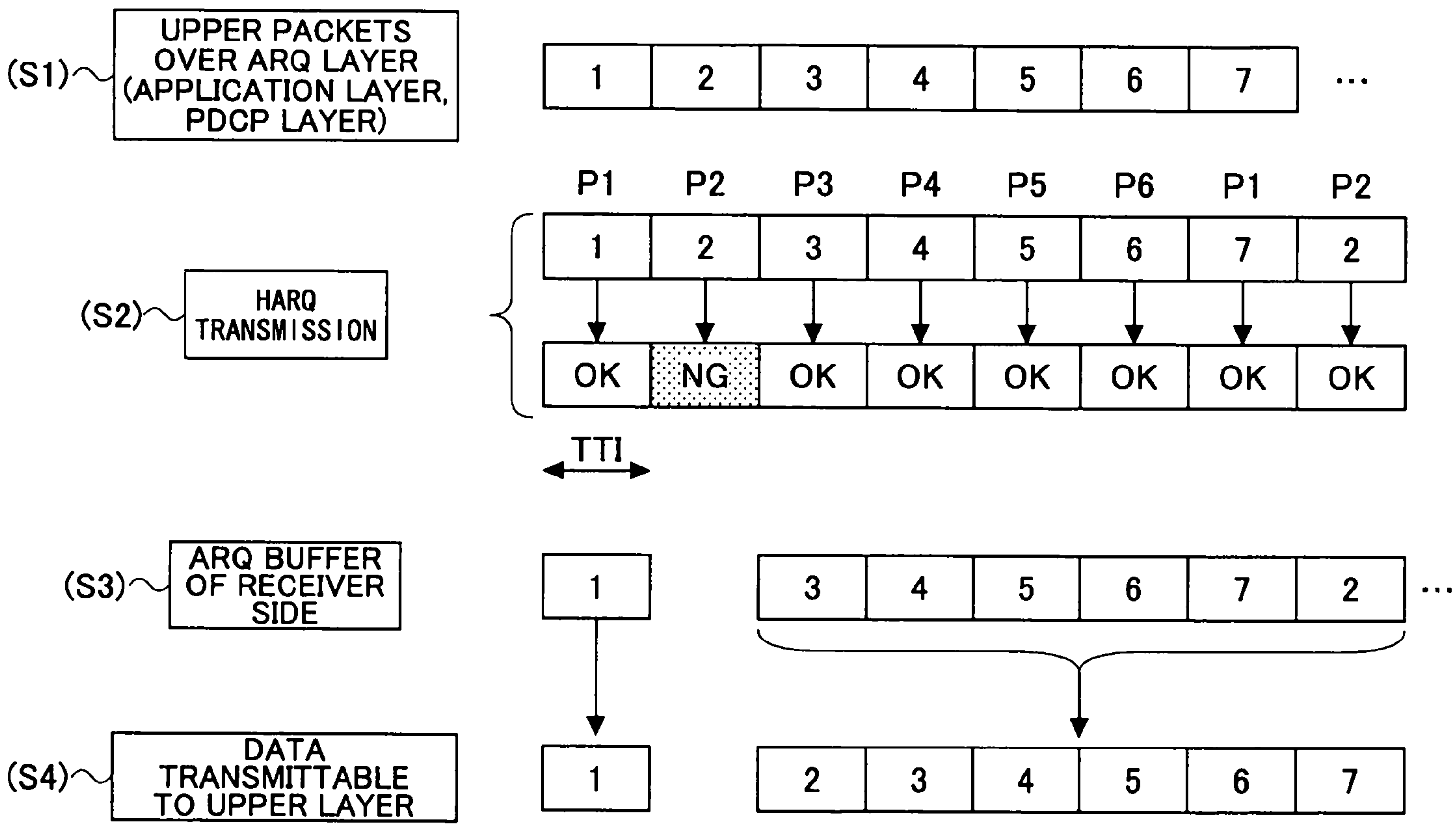
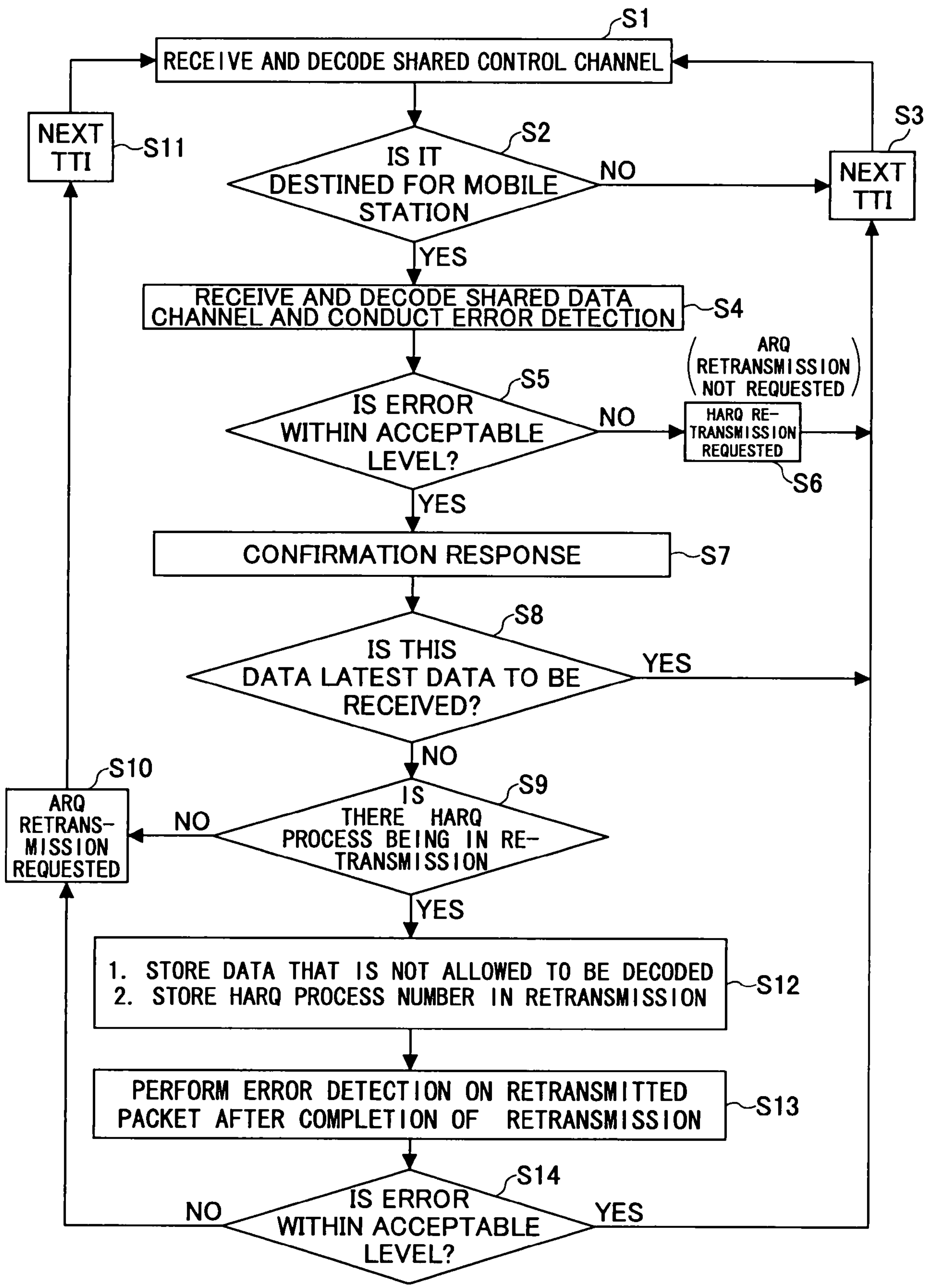

IP PACKET
ARQ BUFFER
HARQ PDU
OPERATIONS
RETRANSMISSION
CONTROL
HARQ
Node-B
HARQ
RETRANS-
MISSION
REQUEST
ARQ
RETRANS-
MISSION
REQUEST
HARQ
HARQ PDU
OPERATIONS
RETRANSMISSION
CONTROL
RLC BUFFER
UE
IP PACKET

FIG.7



(S1)
UPPER PACKETS OVER ARQ LAYER (APPLICATION LAYER, PDCP LAYER)
1 2 3 4 5 6 7 ...
P1 P2 P3 P4 P5 P6 P1 P2
(S2)
HARQ TRANSMISSION
1 2 3 4 5 6 7 2
OK NG OK OK OK OK OK OK
TTI
(S3)
ARQ BUFFER OF RECEIVER SIDE
1
3 4 5 6 7 2 ...
(S4)
DATA TRANSMITTABLE TO UPPER LAYER
1
2 3 4 5 6 7

FIG.8



S1
RECEIVE AND DECODE SHARED CONTROL CHANNEL
S2
IS IT DESTINED FOR MOBILE STATION
NO
S3
NEXT TTI
YES
RECEIVE AND DECODE SHARED DATA CHANNEL AND CONDUCT ERROR DETECTION
S4
S5
IS ERROR WITHIN ACCEPTABLE LEVEL?
NO
(ARQ RETRANSMISSION NOT REQUESTED)
HARQ RE-TRANSMISSION REQUESTED
S6
YES
CONFIRMATION RESPONSE
S7
S8
IS THIS DATA LATEST DATA TO BE RECEIVED?
YES
NO
S9
IS THERE HARQ PROCESS BEING IN RE-TRANSMISSION
NO
S10
ARQ RETRANS-MISSION REQUESTED
NEXT TTI
S11
YES
1. STORE DATA THAT IS NOT ALLOWED TO BE DECODED
2. STORE HARQ PROCESS NUMBER IN RETRANSMISSION
S12
PERFORM ERROR DETECTION ON RETRANSMITTED PACKET AFTER COMPLETION OF RETRANSMISSION
S13
S14
IS ERROR WITHIN ACCEPTABLE LEVEL?
NO
YES