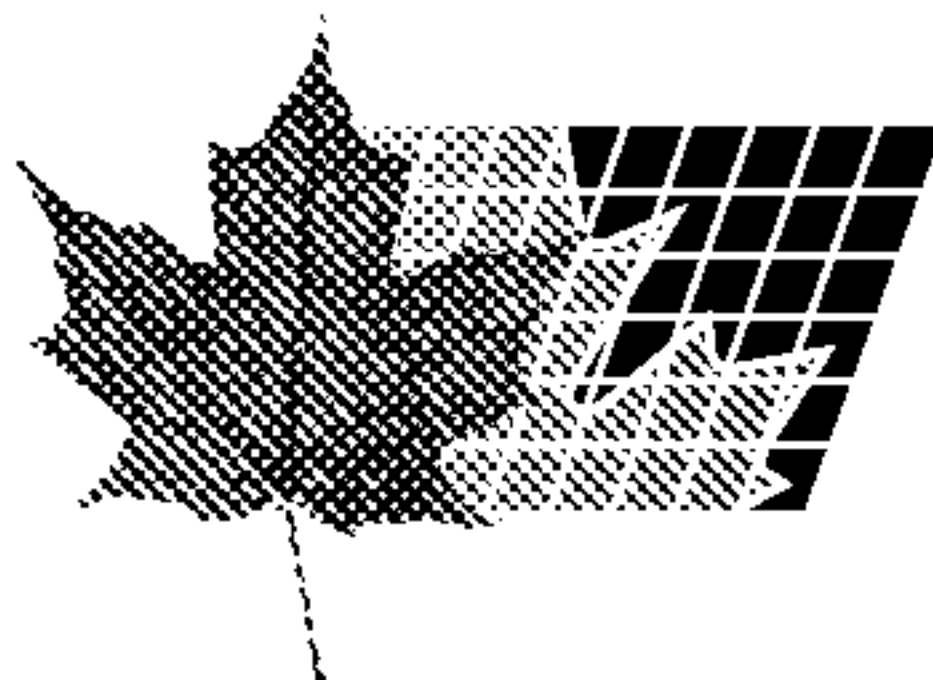




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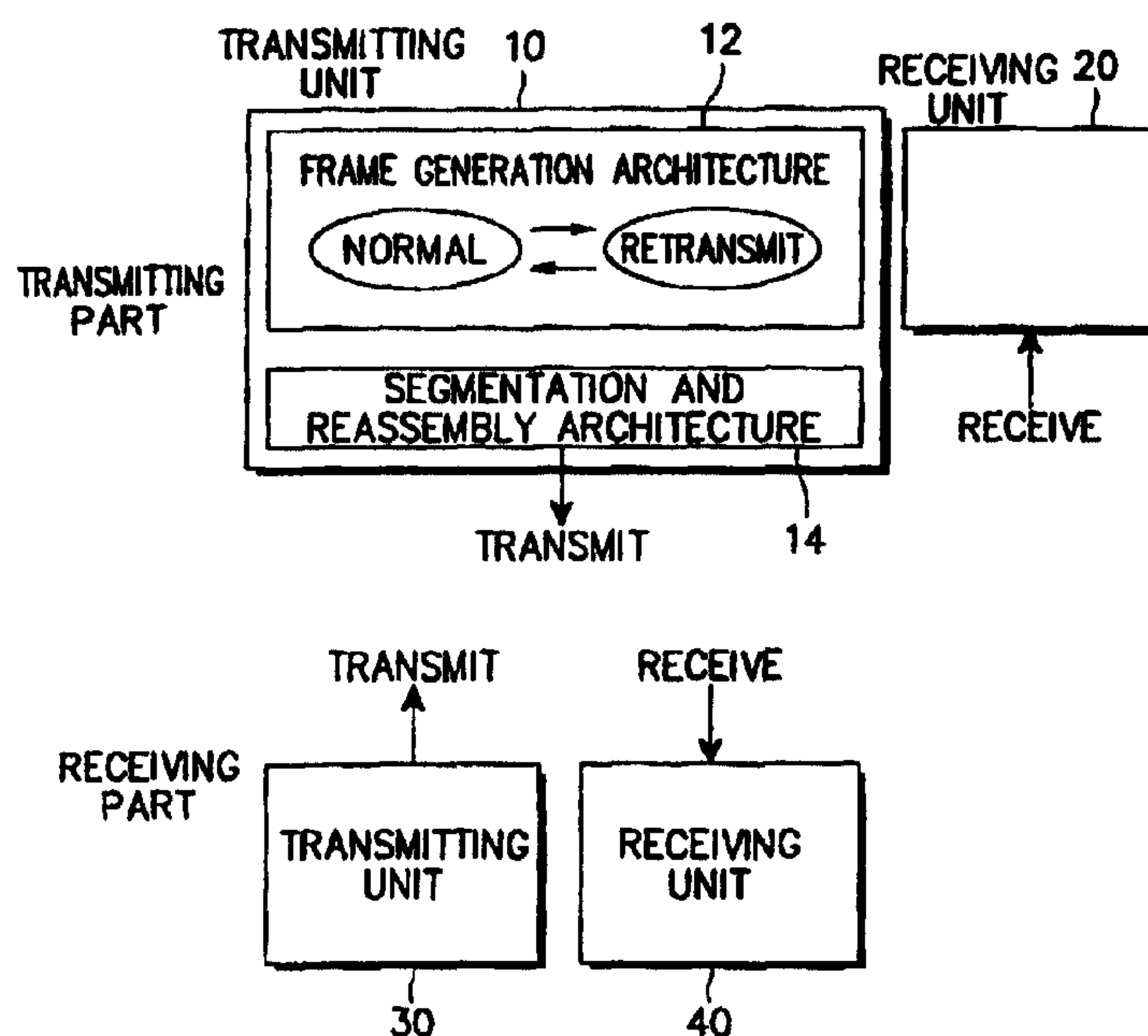
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(54) **PROCEDE SERVANT A METTRE EN APPLICATION UN  
PROTOCOLE DE LIAISON RADIO POUR UNE  
TRANSMISSION DE DONNEES EFFICACE**

(54) **METHOD FOR IMPLEMENTING RADIO LINK PROTOCOL FOR  
EFFICIENT DATA TRANSMISSION**



(57) Procédé servant à mettre en application un protocole de liaison radio conçu pour réaliser une transmission de données efficace dans des environnements radio. On utilise ce protocole avec un procédé de réservation de nombres de séquences proposé pour des systèmes de communications mobiles conçus pour fournir des services basés sur des paquets de données, de façon à faire face au problème posé par la transmission de données exempte de vitesses de transmission variables.

(57) A method for implementing a radio link protocol adapted for efficient data transmission in radio environments. The radio link protocol proposed by the invention is used along with a sequence number reservation method proposed for mobile communication systems adapted to provide packet data services, so that the radio link protocol can support data transmission problem free with varying transmission rates.

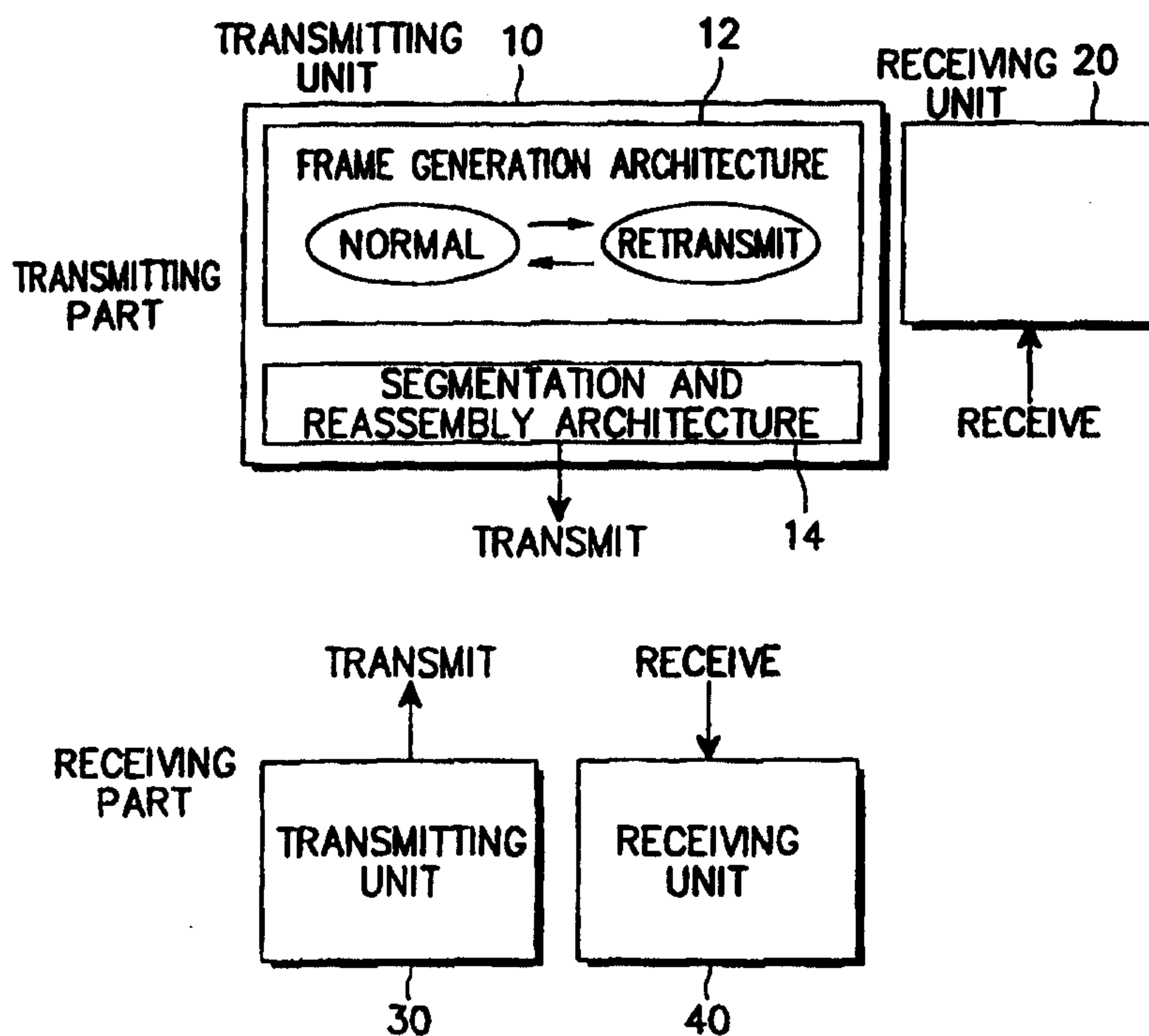
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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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**(54) Title:** METHOD FOR IMPLEMENTING RADIO LINK PROTOCOL FOR EFFICIENT DATA TRANSMISSION**(57) Abstract**

A method for implementing a radio link protocol adapted for efficient data transmission in radio environments. The radio link protocol proposed by the invention is used along with a sequence number reservation method proposed for mobile communication systems adapted to provide packet data services, so that the radio link protocol can support data transmission problem free with varying transmission rates.



**METHOD FOR IMPLEMENTING RADIO LINK  
PROTOCOL FOR EFFICIENT DATA TRANSMISSION**

**BACKGROUND OF THE INVENTION**

**1. Field of the Invention**

5       The present invention relates to a code division multiple access (CDMA) communication system, and more particularly, to a method for implementing a radio link protocol adapted for efficient data transmission in radio environments.

**2. Description of the Related Art**

Generally, CDMA mobile communication systems have been developed from  
10 the IS-95 standard which is mainly associated with the transmission of voice to the IMT-2000 standard to be adapted for transmission of high-rate data as well as voice. In accordance with the IMT-2000 standard, services such as transmission of voice and video and search for data over the Internet can be provided. The maximum data transmission rate in the IS-95 standard is defined by 9.6 Kbps or 14.4 Kbps because the  
15 IS-95 standard is mainly adapted for transmission of voice. In the IMT-2000 standard, however, data can be transmitted at a maximum rate of 2 Mbps. In other words, in accordance with the IMT-2000 standard, it is possible to transmit data in an amount corresponding to 256 times or more than that of the IS-95 at one time.

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In order to prevent data damage occurring in radio environments, CDMA mobile communication systems use a radio link protocol. In such a radio link protocol, data transmission is performed at a rate of 9.6 Kbps or 14.4 Kbps, in frames of 20 ms in length. Recently, a radio link protocol of Type 2 has been proposed.

5       The radio link protocol involves a data re-transmission procedure. That is, sequence numbers are allocated to successive frames each having a length of 20 ms, respectively, in order to re-transmit data frames lost during transmission in radio environments. Each sequence number, which is used in the radio link protocol, has a length of 8 bits. Accordingly, the maximum number of individual frames supported  
10 by the radio link protocol is 256.

In the data re-transmission procedure according to the radio link protocol, the data transmission rate may vary. When the data transmission rate in the data-retransmission procedure becomes higher than the previous transmission rate, a frame to be re-transmitted is transmitted along with another frame to be transmitted. Thus,  
15 a more efficient data transmission is achieved at a higher rate. On the other hand, when the data transmission rate in the data-retransmission procedure becomes lower than the previous transmission rate, the frame to be re-transmitted should be segmented into several frames in accordance with the lowered transmission rate.

Where the data re-transmission procedure according to the radio link protocol  
20 involves division of a frame into frames, the frame typically is segmented into a maximum of three frames. In this case, the frames, which are transmitted to a receiving part, are assembled again into the original frame in the receiving part so that they can be used in the same manner as the original frame.

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In the IMT-2000 standard, however, it is possible to obtain a transmission rate of up to 2 Mbps higher than the maximum transmission rate of 9.6 Kbps or 14.4 Kbps, which is supported by radio link protocol. In particular, a variety of transmission rates respectively required for a variety of services are defined in accordance with the IMT-2000. For this reason, an increased number of supportable transmission rates are used in the IMT-2000. However, the increased number of transmission rates not only imposes a burden on users utilizing specific services, but also adversely affects the performance of the entire system.

### SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide a sequence number generating method in a mobile communication system for implementing a radio link protocol capable of supporting data transmission without incurring problems during transmission rate variations, when a terminal is connected to the system via a radio channel having a variety of high transmission rates, such as 9.6 Kbps, 14.4 Kbps or more.

Another object of the invention is to provide a data re-transmission method in a mobile communication system using a sequence number generating method, in which data lost during a transmission thereof is effectively re-transmitted, while protecting the data already transmitted as much as possible.

Another object of the invention is to provide a sequence number generating method in a mobile communication system, in which data lost during a transmission thereof is effectively re-transmitted while protecting the data already transmitted as

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much as possible, when the transmission rate varies on a radio channel connecting a terminal to the system.

Another object of the present invention is to provide a sequence number generating method in a mobile communication system which is capable of optimizing  
5 the system for the transmission rate supported by a terminal connected to the system, thereby reducing additional burdens on the system while enhancing transmission efficiency.

Still another object of the present invention is to provide a new high rate transmission radio protocol for a mobile communication system which is capable of  
10 providing complete compatibility to terminals supporting the existing radio link protocol of Type 2.

In order to achieve the above objects, a packet data communication method is provided which utilizes an extended sequence number generation method different from those used in the existing radio link protocols.

15

### **BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic diagram illustrating a segment tree generated in accordance  
20 with a segment tree generation method proposed in the present invention;

Fig. 2 is a diagram illustrating an example in which the number of necessary sequence numbers for each node of a segment tree is derived in accordance with an embodiment of the present invention;

Fig. 3 is a diagram illustrating an example in which a segment tree bearing a sequence number associated with a frame bearing a sequence No: 7 is derived in accordance with a method for deriving a segment tree bearing a sequence number associated with a frame bearing a sequence No. r;

Fig. 4 is a diagram illustrating an example in which NAK entries contained in a NAK control frame are generated in accordance with the present invention, along with an example in which the region of a block to be transmitted is derived, based on NAK entries received, in accordance with the present invention;

Fig. 5 is a diagram illustrating a configuration for implementing a radio link protocol in accordance with an embodiment of the present invention;

Fig. 6a is a flow chart illustrating a procedure executed in the frame generation architecture of a receiving part shown in Fig. 5;

Fig. 6b is a flow chart illustrating a procedure executed in the segmentation and reassembly architecture of a transmitting part shown in Fig. 5;

Fig. 7a is a flow chart illustrating a procedure executed in the transmitting unit of the receiving part shown in Fig. 5;

Fig. 7b is a flow chart illustrating a procedure executed in the receiving unit of the receiving part shown in Fig. 5; and

Fig. 8 is a diagram for illustrating a minor transmission rate, and transmission rate set concept proposed in accordance with an embodiment of the present invention.

5

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Reference will now be made in greater detail to the preferred embodiments of the present invention.

In order to perform data communications efficiently in mobile communication systems, it is necessary to use a new sequence number generating method capable of preventing data loss in radio environments involving frequent transmission rate variations. The sequence number generating method made to satisfy such a requirement should also maintain compatibility with the above-mentioned existing radio link protocols. Table 1 contains transmission rates supported by the IMT-2000 standard along with the corresponding maximum frame sizes.

Table 1

Transmission Rate and Frame Size for IMT-2000 System

|    | Transmission Rate by<br>IMT-2000 System |            | Transmission Rate by<br>IMT-2000 System |            |
|----|-----------------------------------------|------------|-----------------------------------------|------------|
|    | Transmission Rate by<br>IMT-2000 System | Frame Size | Transmission Rate by<br>IMT-2000 System | Frame Size |
| 20 | 9.6Kbps                                 | 21bytes    | 14.4Kbps                                | 33bytes    |
|    | 19.2Kbps                                | 45bytes    | 28.8Kbps                                | 69bytes    |

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|   |            |           |            |           |
|---|------------|-----------|------------|-----------|
|   | 38.4Kbps   | 93bytes   | 57.6Kbps   | 141bytes  |
|   | 76.8Kbps   | 189bytes  | 115.2Kbps  | 285bytes  |
|   | 153.6Kbps  | 381bytes  | 230.4Kbps  | 573bytes  |
|   | 307.2Kbps  | 765bytes  | 460.8Kbps  | 1149bytes |
| 5 | 614.4Kbps  | 1533bytes | 921.6Kbps  | 2301bytes |
|   | 1036.8Kbps | 2589bytes | 1036.8Kbps | 2589bytes |
|   | 1228.8Kbps | 3069bytes | 1843.2Kbps | 4605bytes |
|   | 2073.8Kbps | 5181bytes | 2073.6Kbps | 5181bytes |
|   | 2457.8Kbps | 6141bytes |            |           |

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10 In order to prevent loss of data caused by a variation in transmission rate while supporting a variety of transmission rates as described above, it is necessary to transmit data where every frame transmitted at a high rate, in accordance with the radio link protocol, is segmented into several frames so that it is transmitted at a lower rate. In the above mentioned existing radio link protocol, a segmentation and reassembly

15 method has been proposed in which a frame is segmented into three frames, namely, blocks. However, this method is not optimal, taking into consideration the fact that there are at least 10 transmission rates supported by the existing radio link protocol. For some transmission rates, each frame must be segmented into several hundred blocks.

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In accordance with an embodiment of the present invention, unique sequence numbers are allocated to blocks segmented from a large radio link protocol frame, respectively, as opposed to the above mentioned segmentation and reassembly method, so that received data can be protected as much as possible, more so than the existing  
5 radio link protocol. In accordance with this method, it is also possible to re-transmit only a necessary portion of data.

In order to allocate unique sequence numbers to blocks segmented from a frame, it is necessary to prevent other blocks or frames from using those sequence numbers. To this end, it is required to reserve a desired maximum number of sequence numbers,  
10 when a large radio link protocol frame is generated, thereby preventing other blocks or frames from using those sequence numbers. Such a method will be referred to as a "sequence number reservation method" in the description of the present invention.

The sequence number reservation method is a method for allocating sequence numbers corresponding in number to a possible maximum number of blocks segmented  
15 from a large link protocol frame upon re-transmitting the large link protocol frame, in order to re-transmit lost blocks. When a radio link protocol frame assigned with a sequence No. S is generated, successive sequence numbers, which follow the sequence No. S and correspond in number to a possible maximum number of blocks segmented from the radio link protocol frame at the worst, are allocated for the S-th radio link  
20 protocol frame. For instance, when a frame assigned with a sequence No. 6 and able to be segmented into a maximum of three blocks is generated, sequence Nos. 6, 7, and 8 are reserved for that frame. In this case, accordingly, the next frame bears a sequence No. 9 and is allocated with sequence Nos. 9, 10, and 11.

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The maximum number of blocks required in the above procedure at the worst can be estimated as follows. The minimum number of blocks segmented from a frame for transmission of the frame when a variation in transmission rate occurs can be calculated using an expression of " $\langle L_{\text{OLD}}/L_{\text{NEW}} \rangle$ ". Here, " $L_{\text{OLD}}$ " represents the maximum length of data transmittable at the previous transmission rate, and " $L_{\text{NEW}}$ " represents the maximum length of data transmittable at the varied transmission rate. " $\langle x \rangle$ " is an integer not less than the value of " $x$ ". In order to achieve a re-transmission of data where a variation in transmission rate from the highest transmission rate occurs several times, that is, the case involving the worst transmission rate variation, it is necessary to segment a radio link protocol frame of the maximum size generated at the highest transmission rate into several blocks, which can be transmitted at the second higher transmission rate, and then to segment the blocks again into blocks of a smaller size which can be transmitted at the third higher transmission rate. This procedure should be repeated to carry out segmentation for generated blocks, thereby generating blocks of the smallest size at the lowest transmission rate. The number of blocks having the smallest size is the minimum number of blocks in the worst case.

The procedure for deriving the minimum number of blocks can be simplified using a tree structure. A tree, which is drawn in the procedure for deriving the minimum number of blocks, is referred to as "segment tree" in the description of the present invention. Such a segment tree can be drawn in accordance with the following procedure.

#### A. Method for Deriving Segment Tree

1) First, the maximum length of data which can be transmitted at each of N supportable transmission rates determined between the system and the terminal is

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derived. All values respectively derived for the N transmission rates are arranged in descending power. The arranged values are referred to as " $L_1$ ", " $L_2$ "....., and " $L_N$ ", respectively.

2) " $L_1$ ", which represents the maximum length of data which can be transmitted  
 5 at the highest transmission rate, is called a root node. Using the root node, accordingly, it is possible to transmit data having the maximum length " $L_1$ ". If "N" is more than 1, the following third procedure is repeatedly executed for " $L_2$ "....., and " $L_N$ ", respectively.

3) The following procedure is executed for all nodes previously derived. That is, it is assumed that one of the previously derived nodes is regarded as a node p, and  
 10 that the node p has a value of I. It is also assumed that the maximum length of data transmittable at the transmission rate currently taken into consideration corresponds to " $L_1$ ". In this case, the node p is added with son nodes including f " $L_1$ " nodes and (c - f) " $I \bmod L_1$ " nodes. Here, "c" corresponds to " $\lceil I/L_1 \rceil$ ", and "f" corresponds to " $\lfloor I/L_1 \rfloor$ ". It is noted that " $\lfloor x \rfloor$ " represents an integer not more than "x" whereas " $\lceil x \rceil$ "  
 15 represents an integer not less than "x". For example, if the values of I and  $L_1$  correspond to 7 and 3, respectively, the root node has, as its son nodes, two " $L_1$ " nodes, that is, two nodes having a value of 3, and one " $I \bmod L_1$ " node, that is, one node having a value of 1. Accordingly, the node p has three son nodes. "mod" represents a modulus operation, that is, an operation for deriving a modulo.

20 The nodes derived in the above procedure have a value of " $L_1$ " or " $I \bmod L_1$ ", respectively. Using the son nodes generated in the same manner as the nodes previously derived, it is possible to transmit data having a length corresponding to the value of each son node, that is, " $L_1$ " or " $I \bmod L_1$ ".

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This procedure for the addition of son nodes is executed for all nodes previously derived, respectively.

4) After the above mentioned third procedure is repeatedly executed for the remaining maximum lengths of data transmittable at the remaining supportable  
5 transmission rates, that is, " $L_2$ "....., and " $L_N$ ", the entire procedure is completed. The result obtained after the completion of this procedure is a segment tree to be derived. The number of leaf nodes included in this segment tree corresponds to the minimum number of blocks which can be transmitted in the worst case associated with transmission rates supportable between the terminal and the system.

10 The above mentioned term "N supportable transmission rates" determined between the system and the terminal means a set of transmission rates supportable for the current services and selected from all transmission rates supportable in the IMT-2000 system in accordance with an agreement between the terminal and the system. For instance, where a terminal having a limited performance requests services, it can  
15 determine, together with the system, to use three transmission rates of, for example, 9.6 Kbps, 19.2 Kbps, and 38.4 Kbps. In this case, the three transmission rates of 9.6 Kbps, 19.2 Kbps, and 38.4 Kbps are referred to as "three supportable transmission rates determined between the terminal and the system". Fig. 1 illustrates a segment tree derived by executing the above procedure for the case which the above mentioned three  
20 transmission rates are supportable between the terminal and the system.

Now, the procedure for deriving the segment tree for the three transmission rates will be described. First, the maximum data length of 93 bytes transmittable at 38.4 Kbps is determined as a root node. With regard to the maximum data length of 45

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bytes transmittable at 19.2 Kbps, the root node is then added with two 45-byte nodes and one "93 mod 45", namely, 3-byte, node, as son nodes thereof, because the values of  $c$  and  $f$  correspond to 3 and 2, respectively. With regard to the maximum data length of 21 bytes transmittable at 9.6 Kbps, the above procedure is repeated for the three  
5 additional nodes, respectively. As a result, each of the first and second nodes, that is, two 45-byte nodes, have two 21-byte nodes and one 3-byte node as son nodes thereof. The last node, namely, the 3-byte node has one son node of 3 bytes because the values of  $c$  and  $f$  correspond to 1 and 0, respectively, so that the value of "3 mod 2" is 1.

In the case three transmission rates of 9.6 Kbps, 19.2 Kbps, and 38.4 Kbps are  
10 supported by the terminal and system, at least seven blocks would be generated in the worst case. This means that it is impossible to support data transmission without any problem irrespective of any transmission rate variation unless there are seven sequence numbers reserved for blocks. Fig. 2 shows the number of sequence numbers for each node of the segment tree derived in the case of Fig. 1.

15 As shown in Fig. 2, the root node, which can transmit data at a maximum rate of 93 bytes, has seven leaf nodes. Accordingly, it can be found that seven sequence numbers are necessary for the root node. When data of 93 bytes, which has been transmitted at 38.4 Kbps, is to be re-transmitted at 19.2 Kbps, it must be segmented into three blocks respectively, having sizes of 45 bytes, 45 bytes, and 3 bytes. To each of  
20 these blocks, one or more of the seven sequence numbers allocated to the root node must be allocated again. In this case, three sequence numbers are allocated to each of the first and second blocks, because each of those blocks having a size of 45 bytes has three leaf nodes, whereas one sequence number is allocated to the third block, because that block having a size of 3 bytes has one leaf node. Accordingly, it is possible to

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transmit data of 93 bytes using the allocated sequence numbers even when the transmission rate is lowered from 19.2 Kbps to 9.6 Kbps. Practically, the segmentation is carried out for the blocks of 45 bytes when the transmission rate is lowered from 19.2 Kbps to 9.6 Kbps. That is, the block of 3 bytes is transmitted, as it is, without being segmented into blocks of a smaller size, even though each of the blocks having a size of 45 bytes is transmitted after being segmented into three blocks, namely two 21-byte blocks and one 3-byte block. Table 2 describes blocks derived using the segment tree of Fig. 2 for each of the possible transmission rates when a frame, which bears a sequence No. 7 and has been transmitted at 38.4 Kbps, is to be re-transmitted, along with the number of sequence numbers allocated to each of the blocks, and the sequence number of each block. Fig. 3 also shows a segment tree along with the sequence numbers of blocks.

Table 2

|    | Transmission Rate | Blocks  | Number of Allocated<br>Sequence Numbers |  | Allocated Sequence No. |
|----|-------------------|---------|-----------------------------------------|--|------------------------|
|    |                   |         |                                         |  |                        |
| 15 | 38.4Kbps          | 93bytes | 7                                       |  | 7                      |
|    | 19.2Kbps          | 45bytes | 3                                       |  | 7                      |
|    |                   | 45bytes | 3                                       |  | 10                     |
|    |                   | 3bytes  | 1                                       |  | 13                     |
|    | 9.6Kbps           | 21bytes | 1                                       |  | 7                      |

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|         |   |    |
|---------|---|----|
| 21bytes | 1 | 8  |
| 3bytes  | 1 | 9  |
| 21bytes | 1 | 10 |
| 21bytes | 1 | 11 |
| 3bytes  | 1 | 12 |
| 3bytes  | 1 | 13 |

---

Fig. 3 illustrates sequence numbers allocated to nodes derived for a root node having a sequence No. 7, based on the segment tree of Fig. 2, respectively. The procedure for deriving a segment tree allocated with sequence numbers will now be described.

5      B. Procedure for Deriving a Segment Tree Allocated with Sequence Numbers for a Frame Bearing a Sequence No. r

1) First, a segment tree stored with the number of necessary sequence numbers for each node thereof is derived. The number of necessary sequence numbers for a node of the segment tree corresponds to the number of leaf nodes in a sub-tree which  
10 has a root node corresponding to the node of the segment tree. In other words, the number of necessary sequence numbers for a node corresponds to the number of leaf nodes having a relation with the node, such that the node is an ancestor node for those leaf nodes. Fig. 2 shows the number of necessary sequence numbers derived for each node of the segment tree shown in Fig. 1.

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2) It is then assumed that the sequence No. assigned to the root node is  $r$ , and that the root node is designated by "p".

3) It is then assumed that the leftmost one of son nodes of the node  $p$  is designated by "q". Thereafter, the sequence No.  $r$  of the node  $p$  is allocated to the node  
5 q as a sequence number for the node  $q$ . If the node  $p$  is a leaf node of the segment tree, then the procedure for deriving the segment tree allocated with sequence numbers is complete.

4) A value obtained by adding the number of necessary sequence numbers stored in the node  $q$  to the sequence number of the node  $q$  is allocated to a node next  
10 to and on the right of the node  $q$ . That is, when it is assumed that the sequence number of the node  $q$  is  $r$ , and that the number of necessary sequence numbers for the node  $q$  is  $a$ , the node next to and on the right of the node  $q$  is allocated with a sequence number of " $r + a$ ".

5) If there is no node on the right of the node  $q$ , this fifth procedure is then  
15 skipped. However, if there is a node on the right of the node  $q$ , this node is designated again by "q". In this case, the above mentioned fourth procedure is executed.

6) The leftmost son node of the node  $p$  is designated again by "p". For this node  $p$ , the third through fifth procedures are executed.

As is apparent from the segment tree of Fig. 3 bearing the sequence numbers,  
20 the leaf nodes of the segment tree bear successive sequence numbers, respectively. Referring to Fig. 3, it is also apparent that nodes other than leaf nodes are allocated

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with sequence numbers, respectively, starting from the leftmost one thereof, in such a fashion that a value obtained by adding the number of necessary sequence numbers in a node to the sequence number of the node is allocated to a node next to and on the right of the node, as a sequence number of the next node. Fig. 3 also shows that each  
5 leftmost node of the segment tree has the same sequence number as the root node.

Where the receiving part requests a re-transmission of a frame bearing a sequence No. R, it can generate a segment tree bearing sequence numbers for the r-th frame, as shown in Fig. 4. It is also possible to prepare a table like Table 2. Accordingly, it is possible to estimate the number of blocks to be received, the size of  
10 those blocks, and the sequence numbers allocated to those blocks in association with each of the different transmission rates. Therefore, both the transmitting and receiving parts can find which blocks were lost during a re-transmission of blocks. This means that it is possible to request a re-transmission for those lost blocks. Thus, a great improvement in re-transmission efficiency is achieved. Since all blocks are  
15 distinguished from one another in the same fashion as frames, it is unnecessary to define a new format for those blocks. It is also possible to process blocks in the same manner as frames, thereby allowing the entire protocol to be simplified.

Where a new frame is transmitted from the transmitting part, sequence numbers, which correspond in number to a multiple of the number of leaf nodes in a segment tree  
20 derived, are allocated for the frame, as is apparent from the above mentioned procedure. In the above mentioned case in which three transmission rates of 9.6 Kbps, 19.2 Kbps, and 38.4 Kbps are supported, the number of leaf nodes in the segment tree is 7. Accordingly, a sequence No. 0 is allocated to a first frame. 7 sequence numbers starting from the sequence No. 0, that is, sequence Nos. 0, 1, 2, 3, 4, 5, and 6, are

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reserved for the frame. A sequence No. 7 is allocated to a new frame next to the first frame. For this frame, accordingly, sequence Nos. 7, 8, 9, 10, 11, 12, and 13 are reserved. These procedures may be executed as follows:

C. Procedure for Allocating Sequence Numbers to a New Frame

- 5        1) It is first assumed that a variable stored with successive sequence numbers is designated by "S", and the value stored in the sequence number variable S corresponds to "s". Thereafter, a segment tree is derived in accordance with the above mentioned segment tree deriving method. It is then assumed that the number of leaf nodes of the derived segment node corresponds to "I".
- 10       2) When a new frame is generated, the transmitting part allocates the value s stored in the sequence number variable S to the new frame as a sequence number for the new frame. Thereafter, the transmitting part increases the value s of the sequence number variable S by the number of leaf nodes of the derived segment tree, I, in order to reserve necessary sequence numbers for the frame. To a new frame to be  
15 subsequently generated, therefore, a sequence number of "s + I" will be allocated.

As is apparent from the above procedure, the transmitting part always increases the value s of the sequence number variable S by the number of leaf nodes of the segment tree, irrespective of the transmission rate. Accordingly, every frame newly generated will have sequence numbers corresponding in number to a multiple of the  
20 number of leaf nodes of the segment tree. This concept is referred to as a "regular sequence number generation method" in the description of the present invention. In accordance with this regular sequence number generation method, both the transmitting

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and receiving parts can operate in an easier manner because sequence numbers newly generated increase regularly in number.

Where loss of blocks occur during a re-transmission of those blocks, the receiving part requests a re-transmission of lost blocks using NAK entries as in the existing radio link protocol. Since the sequence number allocated to each block is a unique means for distinguishing the block from other blocks, the receiving part records the sequence numbers of blocks in NAK entries, respectively, in order to request a re-transmission of necessary blocks to the transmitting part, as in the case using the existing radio link protocol. In accordance with the present invention, the sequence number of a parent node is identical to the leftmost son node of the parent node, as shown in Fig. 3. When this sequence number is recorded in a NAK entry at the receiving part, the transmitting part can not determine whether the request for a block re-transmission based on the sequence number is associated with the parent node or the son node. Such a phenomenon is referred to as a "NAK entry vagueness".

Such a NAK entry vagueness may be solved by allocating different sequence numbers for all nodes of the segment tree, respectively. In this case, however, there is a problem in that a great increase in the number of necessary sequence numbers occurs. In accordance with the present invention, therefore, a method for recording sequence numbers of leaf nodes in NAK entries is used in place of the above mentioned method, in order to solve the NAK entry vagueness. Since the leaf nodes of the segment tree have different sequence numbers, respectively, they can be distinguished from one another in any case. A higher-rank node can be generated by combining leaf nodes associated with the higher-rank node. In this regard, desired NAK entries can be generated using sequence numbers of leaf nodes of the segment tree, that is, blocks

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having the smallest size, respectively. Fig. 4 illustrates an example for solving the NAK entry vagueness using such a NAK entry preparation method.

Referring to Fig. 4, NAK entries are shown which are made at the receiving part to receive a block again. For example, the first block bearing a sequence No. 7, which  
5 was lost in the process of a re-transmission for an associated frame, namely, the frame bearing a sequence No. 7, at 19.2 Kbps, in a configuration supporting three transmission rates of 9.6 Kbps, 19.2 Kbps, and 38.4 Kbps is shown. The block bearing a sequence No. 7 for 19.2 Kbps corresponds to a first 45-byte portion of the 93-byte block associated with 38.4 Kbps. The 93-byte block has three blocks bearing  
10 respective sequence Nos. 7, 8, and 9 and corresponding to leaf nodes of the segment tree. For this 93-byte block, the sequence Nos. 7, 8 and 9 respectively allocated to the smallest blocks are sent to the transmitting part while being respectively carried in NAK entries, in order to solve the above mentioned NAK entry vagueness. When the transmitting part receives the NAK entries carrying the sequence Nos. 7, 8, and 9, it  
15 conducts a re-transmission operation at the current transmission rate in accordance with a most appropriate method. That is, if the current transmission rate is 19.2 Kbps, the 45-byte block bearing the sequence No. 7 and including the smallest blocks respectively bearing the sequence Nos. 7, 8 and 9 is then re-transmitted. Where the current transmission rate is 9.6 Kbps, two 21-byte blocks respectively bearing the  
20 sequence No. 7 and 8 and one 3-byte block bearing the sequence No. 9 are sequentially re-transmitted. Now, the NAK entry preparation method executed at the receiving part and the re-transmission method executed at the transmitting part will be described.

#### D. NAK Entry Preparation Method

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- 1) It is first assumed that the block to be requested to the transmitting part for a re-transmission thereof is "p", and that the sequence number allocated to that block is "s". If the block p to be re-transmitted corresponds to a frame first transmitted, this block is then rendered to be the root node of the segment tree. Where the block p to be re-transmitted is a block already requested for a re-transmission thereof, this block is rendered to be a leaf node of the segment tree because the receiving part requests a re-transmission only for leaf nodes of the segment tree. In this regard, the receiving part knows the position of the block, to be requested for a re-transmission thereof, on the segment tree.
- 2) The number of sequence numbers allocated to the block p is then derived from the segment tree. Since the number of necessary sequence numbers for each node is stored in the segment tree, as mentioned above, and the transmitting part conducts a data transmission while maintaining a redundancy for sequence numbers corresponding to the number of necessary sequence numbers for each node, it is possible to derive the number of sequence numbers allocated to the block p using the segment tree. It is assumed that the derived number of allocated sequence numbers is "a".
- 3) NAK entries starting from a NAK entry corresponding to the sequence No. s allocated to the block p are additionally generated in a number a. That is, sequence Nos. s, s+1, s+2, ....., and s+a+1 are additionally generated as NAK entries.

In the above procedure, it is important that the sequence numbers of leaf nodes of the segment tree are added to NAK entries, respectively. This is because the number

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of sequence numbers stored in the block p corresponds to the number of leaf nodes, as apparent from the above mentioned segment tree.

When a block or frame to be re-transmitted is generated, the receiving part generates an associated NAK entry or entries using the above mentioned NAK entry  
5 preparation method. After completing the generation of NAK entries for all blocks or frames to be received again, the receiving part stores the generated NAK entries in a NAK list. Subsequently, the receiving part generates a NAK control frame using the NAK entries and sends the NAK control frame to the transmitting part.

In response to the NAK control frame, the transmitting part re-transmits the  
10 block requested by the receiving part using the recorded NAK entries. First, the transmitting part determines which frame is associated with the block requested by the receiving part, based on the sequence number allocated to the requested block and stored in the NAK entry associated with the requested block. Where the sequence number stored in the NAK entry is s, and the number of leaf nodes of the segment tree  
15 is I, the sequence number of the frame including the block designated by the NAK entry corresponds to a value of " $\lceil s/I \rceil$ " (here, " $\lceil x \rceil$ " is an integer not more than the value of x) because every frame has a sequence number corresponding to a multiple of the number of leaf nodes of the segment tree.

Thereafter, a segment tree bearing the above mentioned sequence number of the  
20 requested block is derived, based on the sequence number of the frame determined in the above procedure, in accordance with the above mentioned method adapted to derive a segment tree bearing sequence numbers. Referring to the derived segment tree, the

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position of the leaf node, on the segment tree, designated by the sequence number stored in the NAK entry can be found.

Now, the re-transmission frame generation method executed at the transmitting part will be described.

#### 5 E. Re-Transmission Frame Generation Method

1) Once the transmitting part receives a NAK control frame, it puts all NAK entries contained in the received NAK control frame into a re-transmission queue in an appropriate order.

2) The transmitting part then extracts the foremost one of the NAK entries from  
10 the re-transmission queue. Using the extracted NAK entry, the transmitting part searches for the block bearing the sequence number corresponding to that of the NAK entry. That is, the sequence number of a frame, to which the block bearing the sequence number of the NAK entry belongs, is derived using the above mentioned method. Based on the sequence number of the derived frame, a segment tree bearing  
15 the sequence number of the block is then derived. Referring to the derived segment tree, the block bearing the above mentioned sequence number can be found from the leaf nodes of the segment tree. It is assumed that the derived frame is designated by "F", and the derived node bearing the sequence number of the NAK entry is designated by "p".

20 3) If the node p does not correspond to a node meeting the current transmission rate, and the node p has the same sequence number as the parent node of the node p,

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it is then determined whether or not there are brother nodes of the node p in the re-transmission queue. Here, "brother nodes" are nodes belonging to the same parent node. When it is determined that all brother nodes of the node p are in the re-transmission queue, that is, it is determined that the block requested by the receiving  
5 part is a parent node of the node p, this parent node of the node p is designated by "p". For this new node p, the above mentioned third procedure is executed again.

If any one of the brother nodes of the node p are not existing in the re-transmission queue, it is then determined that the block requested by the receiving part corresponds to the node p. In this case, accordingly, the following procedure is  
10 executed.

Where the node p is a node meeting the current transmission rate or has a sequence number different from that of the parent node of the node p, the following procedure is executed.

4) Based on the information about the derived segment tree and node p, a region,  
15 where the node occupies the frame F, is derived. After deriving the region, a re-transmission frame having the derived region is generated. When the derived region corresponds to the end portion of the frame F, the END field of the re-transmission frame is set to "1". In this case, NAK entries respectively associated with empty regions of the frame F are completely deleted from the re-transmission queue. If the  
20 derived region does not correspond to the end portion of the frame F, the END field of the re-transmission frame is set to "0". After completing the above procedure, the entire re-transmission frame generation procedure is completed.

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The node meeting the current transmission rate in the above mentioned re-transmission frame generation method includes all nodes existing at a level, on the segment tree, corresponding to the current transmission rate. The root node of the segment tree corresponds to the transmission rate selected, as allowing a transmission  
5 of the maximum length of data, from supportable transmission rates determined between the terminal and the system. The son nodes of the root node correspond to the transmission rate selected, as allowing a transmission of the second longer length of data, from the supportable transmission rates determined between the terminal and the system. Accordingly, nodes arranged on the L-th layer starting from the root node  
10 correspond to the transmission rate selected, as allowing a transmission of the "L+1"-th longer length of data, from the supportable transmission rates determined between the terminal and the system. It is noted that the root node is arranged on the 0-th layer starting from the root node, and that son nodes of the root node are arranged on the first layer starting from the root node.

15 In this regard, when the length of data transmittable at the current transmission rate corresponds to the "L+1"-th higher one of supportable transmission rates supported between the terminal and the system, the nodes meeting the current transmission rate are nodes arranged on the L-th layer starting from the root node.

In the above procedure, it is important that if the region associated with a block  
20 to be re-transmitted corresponds to the end portion of the frame F, the END field of the re-transmission frame is then set to "1", and if not, it is set to "0". This is adapted to prevent the generation of empty blocks occurring when the frame consists of only data having a small length. For example, it is assumed that the terminal and the system have determined to support 9.6 Kbps, 19.2 Kbps, and 38.4 Kbps. It is also assumed that a

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frame, which bears a sequence No. 7 and has a data length of only 50 bytes is transmitted. Where the frame bearing the sequence No. 7 is lost, the receiving part sends to the transmitting part a NAK control frame having NAK entries respectively bearing sequence Nos. 7, 8, 9, 10, 11, and 12 in order to receive again the frame. If the transmission rate is lowered to 19.2 Kbps at this time, then the frame bearing the sequence No. 7 should be segmented into three blocks having respective sizes of 45 bytes, 45 bytes, and 3 bytes, for its transmission. Practically, however, the transmission of the frame is completed by transmitting only the first block, bearing a sequence No. 7, of the frame and the second block, bearing a sequence No. 10, of the frame because the frame has a data length of only 50 bytes. In order to prevent an unnecessary transmission of the block, which bears a sequence No. 13 and is an empty block, accordingly, the END field of the frame associated with the second block bearing the sequence No. 10 is set to "1". Thereafter, the sequence No. 13, which is a NAK entry associated with the empty region of the frame bearing the sequence No. 7 is deleted from the re-transmission queue, as mentioned above. The phenomenon that empty blocks are generated in the transmission of frames having a small size is referred to as an "empty block re-transmission problem".

The following description is associated with the procedure for receiving and processing re-transmission blocks from the transmitting part by the receiving part.

#### 20 F. Method for Processing Re-Transmission Frame Received

1) When the receiving part receives a block re-transmitted from the transmitting part, it finds the data length and sequence number of the received block. Based on the sequence number of the block and through the above mentioned procedures, a segment

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tree bearing the sequence number of the block is derived. That is, a method is used in which a frame including the block is derived, based on the sequence number of the block, and then a segment tree bearing the sequence number of the block is derived, based on the sequence number of the derived frame. Referring to the derived segment  
5 tree, the sequence number of the block, and the size of the block, the node of the segment tree designated by the sequence number of the block can be derived. If there is no node of the segment tree corresponding to the size of the block, a leaf node of the segment tree bearing the sequence number of the block is becomes a node corresponding to the block.

10       2) The sequence numbers of all leaf nodes, on the segment tree, for which the node derived in the above first procedure serves as an ancestor node, are deleted from the NAK list.

3) If the END field of the block re-transmitted is 1, then those, higher than the sequence number of the re-transmitted block, of sequence numbers associated with all  
15 leaf nodes of the segment tree are deleted from the NAK list.

As apparent from the above mentioned received re-transmission frame processing method, unnecessary empty blocks are prevented from being requested again by deleting NAK entries associated with those empty blocks from the NAK list.

The radio link protocol of Type 2 conventionally used supports the segmentation  
20 and reassembly method. Accordingly, proposed in the present invention is a major transmission rate, minor transmission rate, and transmission rate set concept. Fig. 8 is a schematic view for illustrating the minor transmission rate, and transmission rate set

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concept. This concept will now be described in detail in conjunction with Fig. 8. In accordance with the concept of the present invention, supportable transmission rates are grouped into several transmission rate sets, for example, three sets A, B, and C. For each transmission rate set, one major transmission rate M and a plurality of minor  
5 transmission rates are provided. The major transmission rate M corresponds to the highest transmission rate in the associated transmission rate set whereas the remaining minor transmission rates m correspond to the transmission rates, lower than the major transmission rate M, in the associated transmission rate set.

In order to support the above mentioned radio link protocol of Type 2, in  
10 accordance with the present invention, the above mentioned transmission rate sets are configured for transmission rates supportable between the terminal and the system, and the following rule is applied for determination of a re-transmission method, depending upon the configured transmission rate sets and the current transmission rate.

G. Determination of Re-transmission method Depending upon the Transmission  
15 Rate Sets and the Current Transmission Rate

1) A block to be re-transmitted is created using the aforementioned sequence number reservation method and the segment tree on the basis of a major transmission rate of a transmission rate set to which a current transmission rate belongs.

2) If the current transmission rate is the major transmission rate, the block to be  
20 re-transmitted, which is generated by the use of the re-transmission method employing the sequence number reservation method and the segment tree, is transmitted as it is.

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3) If the current transmission rate is the sub-transmission rate, the block to be re-transmitted, which is created by the use of the re-transmission method employing the sequence number reservation method and the segment tree, is transmitted in a segmented manner using the segmentation and reassembly method which is defined by  
5 the existing radio link protocol of Type 2.

In other words, when assuming that the major transmission rates of the respective transmission rate sets with respect to the transmission rates which belong to the transmission rate set 1, that is, Rate Set 1 and to the transmission rate set 2, that is, Rate Set 2, which are currently defined by IS-95-B, are determined as 9.6 Kbps and  
10 14.4 Kbps, respectively, and the remaining transmission rates are determined as the sub-transmission rates, the radio link protocol of the present invention creates the blocks to be re-transmitted, on the basis of the respective major transmission rates, and if the current transmission rate is the sub-transmission rate with respect to the created blocks, by re-transmitting the blocks using the segmentation and reassembly method,  
15 reliable re-transmission can be accomplished even at the sub-transmission rates of the transmission rate set.

Also, because a terminal using the existing radio link protocol of Type 2 supports only one of respective transmission rate sets, only one major transmission rate which is supported by the terminal and system exists. Accordingly, since the segment  
20 tree becomes a tree which has only one root node, only one block is created by the segment tree. With respect to the created block, by using the segmentation and reassembly method of the radio link protocol of Type 2, it is possible to satisfactorily support the terminal which uses the existing radio link protocol of Type 2.

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A new high-rate transmission radio link protocol which is suggested by the present invention by organizing all the above described procedures, can be illustrated as shown in FIG. 5. FIG. 5 depicts both the transmitting part and the receiving part. The transmitting part and the receiving part have transmitting units 10 and 30 and receiving units 20 and 40. Operations of the transmitting part and the receiving part will be described hereinbelow in detail with reference to Figs. 6a, 6b, 7a and 7b.

FIG. 6a is a flow chart of an operation control which is performed at a frame generation architecture 12 of the transmitting part of FIG. 5. FIG. 6b is a flow chart of an operation control which is performed at a segmentation and reassembly architecture 14 of the transmitting part of FIG. 5. FIG. 7a is a flow chart of an operation control which is performed at the transmitting unit 30 of the receiving part of FIG. 5, and FIG. 7b is a flow chart of an operation control which is performed at the receiving unit 40 of the receiving part of FIG. 5.

First, a construction of the transmitting part and operations thereof will be described below. The transmitting unit 10 of the transmitting part comprises two architectures. First, a frame generation architecture 12. The frame generation architecture 12 functions to transmit data which are requested by a higher-rank architecture, to be transmitted and data which are requested by the receiving part, to be re-transmitted. The frame generation architecture 12 has two states. One is a normal state and the other is a re-transmission state. In the normal state, if a re-transmission queue which waits to be re-transmitted is empty, a new radio link protocol frame in which data requested by the higher-rank architecture, to be transmitted are loaded, is generated.

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In the re-transmission state, if the re-transmission queue is not empty, a re-transmission work is performed. The frame generation architecture 12 is in the normal state at an initial stage. The frame generation architecture 12 repeatedly performs work in which it allocates a sequence number to the new frame in conformity with a  
5 procedure for allocating a sequence number to a new frame and transmits the new frame. If the NAK control frame which is transmitted from the receiving part is received, the frame generation architecture 12 transits to the re-transmission state. In the re-transmission state, the frame generation architecture 12 continuously performs the aforementioned re-transmission frame generation method until it processes all the  
10 NAK entries. If the re-transmission queue is empty due to the fact that all the NAK entries are processed, the frame generation architecture 12 transits again to the normal state.

A second architecture of the transmitting unit 10 of the transmitting part is the segmentation and reassembly architecture 14. In the segmentation and reassembly  
15 architecture 14, it is determined whether data are to be transmitted, as they are, to the re-transmission frame which is generated in the frame generation architecture 12 in conformity with re-transmission method determination method which depends upon the preset transmission rate and a current transmission rate, or a segmentation and reassembly method is to be used.

20 On the other hand, in the case that the receiving part transmits the NAK control frame, the receiving unit 20 of the transmitting part receives the NAK control frame to inform the frame generation architecture 12 of the receipt of the NAK control frame.

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Hereinafter, processes which are performed at the transmitting unit 10 and the receiving unit 20 of the transmitting part, will be described in detail with reference to FIGS. 6a and 6b.

The frame generation architecture 12 of the transmitting part determines at step 100 of FIG. 6a whether the NAK control frame is received. If the NAK control frame is received, the program proceeds to step 102. In step 102, the frame generation architecture 12 transits to the re-transmission state, and then, the program proceeds to step 104. The frame generation architecture 12 of the transmitting part generates the re-transmission frame by performing the re-transmission frame generation method, and at step 106, transmits the re-transmission frame to the segmentation and reassembly architecture 14. Thereafter, at step 108, it is determined whether the re-transmission queue is empty. If the re-transmission queue is empty, the processes from step 104 on are repeated. If the re-transmission queue is not empty, the program is returned to step 100 to determine whether or not the NAK control frame is received. If the NAK control frame is not received, the program proceeds to step 110 to determine whether data are generated. If the data are generated, the frame generation architecture 12 proceeds to step 112 to transit to the normal state, and then, the program proceeds to step 114. The frame generation architecture 12 of the transmitting part, at step 114, generates a new frame which is in conformity with the transmission rate, allocates a sequence number to the newly generated frame, and then, at step 116, transmits the frame having the allocated sequence number to the segmentation and reassembly architecture 14.

The segmentation and reassembly architecture 14 of the transmitting part determines at step 150 of FIG. 6b whether the frame which is transmitted at step 106

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or step 116 by the frame generation architecture 12 of the transmitting part, is received. If the frame is received, the program proceeds to step 152 to determine whether the current transmission rate is a sub-transmission rate. If the current transmission rate is the sub-transmission rate, the program proceeds to step 154 to transmit the frame to the  
5 receiving part using the segmentation and reassembly method. Otherwise, if it is determined at step 152 that the current transmission rate is not the sub-transmission rate, the program proceeds to step 156 to transmit the frame as it is.

Next, a construction of the receiving part and operations thereof will be described below. The transmitting unit 30 of the receiving part functions to prepare the  
10 NAK entries for the re-transmission frame which is requested by the receiving unit 40 of the receiving part, according to the NAK entries preparing method, make the NAK control frame including the NAK entries, and transmit the NAK control frame to the receiving part. If the re-transmission does not occur until a predetermined period of time has lapsed, the transmitting unit 30 of the receiving part re-transmits the NAK  
15 control frame. If the re-transmission still does not occur even by this, the transmitting unit 30 of the receiving part informs the receiving part of the re-transmission failure.

The receiving unit 40 of the receiving part observes the frames newly transmitted thereto, and in the case where a missing frame exists, requests the transmitting unit 30 of the receiving part to re-transmit the missing frame. If the  
20 transmitting unit 30 informs the receiving part of re-transmission failure, the receiving part transmits remaining frames excluding the missing frame to the higher-rank architecture. If the re-transmitted frame is received by the receiving unit 40 of the receiving part, the receiving unit 40 processes the re-transmitted frame by the received

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re-transmitted frame processing method, and informs the transmitting unit 30 of the receiving part of the receipt of the re-transmitted frame.

Hereinafter, processes which are performed at the transmitting unit 30 and the receiving unit 40 of the receiving part, will be described in detail with reference to  
5 FIGS. 7a and 7b.

The receiving unit 40 of the receiving part determines at step 250 of FIG. 7b whether the frame is received. If the frame is received, the program proceeds to step 252 to determine whether the received frame is a re-transmitted frame. If the frame is a re-transmitted frame, the program proceeds to step 254. The receiving unit 40 of the  
10 receiving part informs the transmitting unit 30 of the receiving part to cause the NAK entries to be deleted from the NAK list at step 254. If it is determined at step 252 that the received frame is not the re-transmitted frame, the program proceeds to step 256 to determine whether a missing frame exists among the received frames. If a missing frame exists, the program proceeds to step 258 to request the transmitting unit 30 of the  
15 receiving part to re-transmit the missing frame. If a missing frame does not exist, the program proceeds to step 260 where the receiving unit 40 processes the received frames.

On the other hand, the transmitting unit 40 of the receiving part determines at step 200 of FIG. 7a whether the receiving unit 40 of the receiving part requests the re-  
20 transmission. If the re-transmission is requested, the program proceeds to step 202 of FIG. 7a to prepare the NAK entries using the NAK entry preparing method. Thereafter, the transmitting unit 40 of the receiving part transmits at step 204 of FIG. 7a the NAK control frame including the NAK entries to the receiving part, and at the

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same time, turns on the re-transmission timer in step 208. Then, the transmitting unit 30 of the receiving part determines at step 210 whether time preset in the re-transmission timer is lapsed before data is received again. If the time has lapsed, the processes which are performed at steps 202 through 206 are performed at steps 212 through 216. Thereafter, the program proceeds to step 218 where the cancel timer turns on. Then, at step 220, it is determined whether time preset in the cancel timer is lapsed before data is received again. If the time is lapsed, the program proceeds to step 222 to delete the NAK entries from the NAK list.

FIG. 5 illustrates the entire procedures of the radio link protocol suggested by the present invention. It should be noted that the transmission rate between the terminal and the system must be determined before the radio link protocol suggested by the present invention is used, and the radio link protocol must be operated after making the segment tree.

As described above, due to the fact that, when a radio link protocol is used in an IMT-2000 system having diverse transmission rates, an extended sequence number generation method, a segment tree, an end field, and various transmission and re-transmission procedures are suggested by the present invention. Accordingly, many advantages are provided in that it is possible to support many kinds of terminals in an efficient and effective way.

While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiment, but, on the contrary, it is

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intended to cover various modifications within the spirit and scope of the appended claims.

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**CLAIMS:**

1. A method for allocating sequence numbers to frames, to be transmitted, in a code division multiple access mobile communication system comprising the steps of:  
segmenting each one of the frames, where each one of the frames has a data size  
5 allowing transmission at a maximum one of a plurality of data transmission rates, into  
a plurality of frames transmittable at a minimum one of the data transmission rates;  
determining sequence numbers, based on the number of the segmented frames;  
and  
allocating the sequence numbers to successive frames being transmitted at a  
10 selected one of the data transmission rates, respectively.
2. The method recited in claim 1, wherein the number of the sequence numbers allocated to the successive frames corresponds to a multiple of the number of the segmented frames.
3. The method recited in claim 2, further comprising the steps of:  
15 identifying, in response to a request for a re-transmission of a frame, the selected  
data transmission rate and whether or not the frame to be re-transmitted corresponds  
to one of the transmitted frames, and determining a current data transmission rate  
associated with the re-transmission of the frame;  
allocating the frame with a corresponding sequence number, based on the  
20 determined current data transmission rate; and  
transmitting the frame at the current transmission rate.

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4. A method for re-transmitting frames in a code division multiple access mobile communication system comprising the steps of:

segmenting each one of the frames, where each one of the frames has a data size allowing transmission at a maximum one of a plurality of data transmission rates, into  
5 a plurality of frames transmittable at a minimum one of the data transmission rates, and allocating sequence numbers to the segmented frames, respectively;

identifying, in response to a request for a re-transmission of a frame, whether or not the frame to be re-transmitted corresponds to one of the frames already transmitted, along with a data transmission rate at which the frames were transmitted,  
10 thereby searching for the frame to be re-transmitted;

determining a current data transmission rate associated with the re-transmission of the frame; and

transmitting data of the frame, to be re-transmitted, at the current data transmission rate.

15 5. The method recited in claim 4, wherein the request for a frame re-transmission is made when there is a lost frame generated during the transmission of the frames, and the request is carried out using a sequence number allocated to the lost frame.

6. The method recited in accordance with claim 4, wherein the step of  
20 transmitting data of the frame to be re-transmitted comprises the steps of:

segmenting the frame to be retransmitted into a plurality of frames meeting the current data transmission rate if the current data transmission rate is lower than the data transmission rate at which the frames were transmitted; and

sequentially re-transmitting the segmented frames.

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7. The method recited in claim 4, further comprising the following steps after the step of allocating sequence numbers to the segmented frames:

allocating successive frames to be transmitted with sequence numbers corresponding in number to a multiple of the number of segmented frames,  
5 respectively; and

transmitting the successive frames at a selected one of the data transmission rates.

8. The method recited in claim 6, further comprising the step of:

inserting, into a last one of the segmented frames, information about the last  
10 frame.

9. A method for implementing a radio link protocol adapted for a data transmission method in a mobile communication system comprising the steps of:

sorting transmission rates into transmission rate sets adapted to support the radio link protocol of Type 2, and sorting the transmission rates in each of the transmission  
15 rate sets in such a fashion that the maximum one of the transmission rates is set to a major transmission rate while the remaining ones of the transmission rates are set to a minor transmission rate, respectively;

creating segments of a frame to be re-transmitted in accordance with a re-transmission procedure determining method depending on the transmission rate sets  
20 and a current transmission rate; and

transmitting the frame in accordance with a segmentation and reassembly method selected on the basis of whether the current transmission rate corresponds to the minor transmission rate or the major transmission rate.

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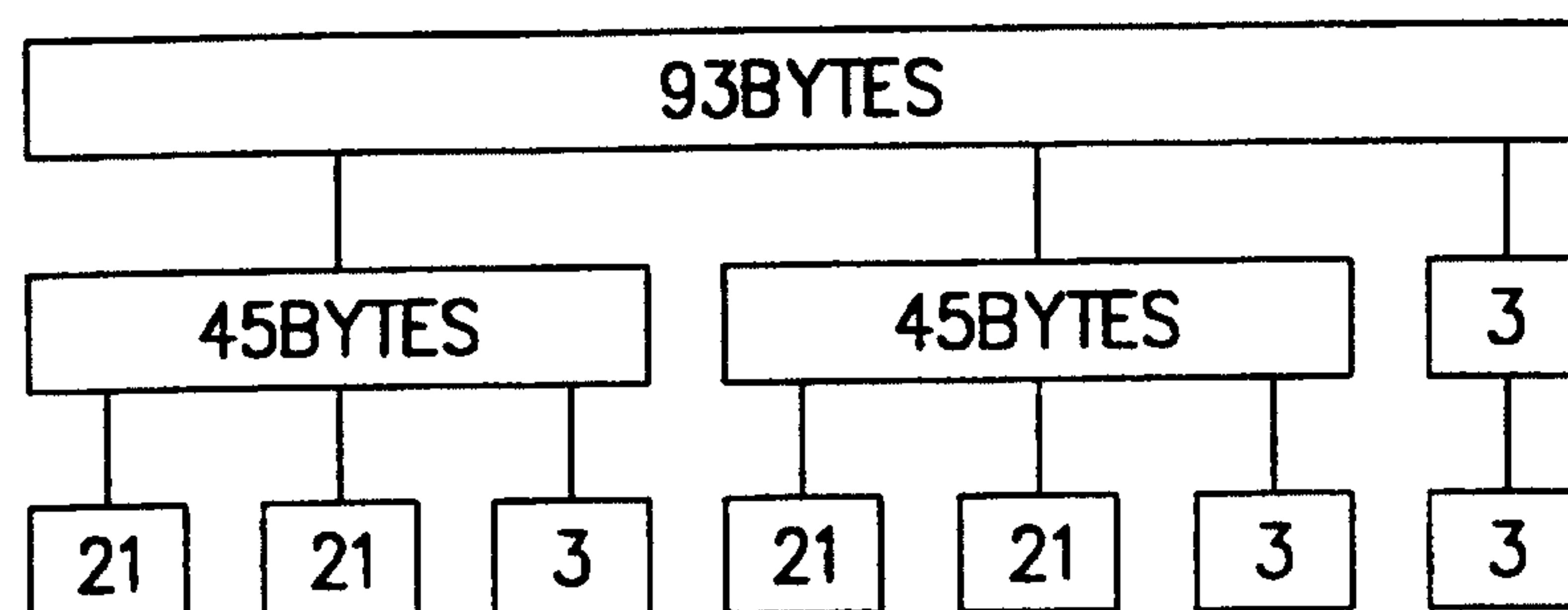


FIG. 1

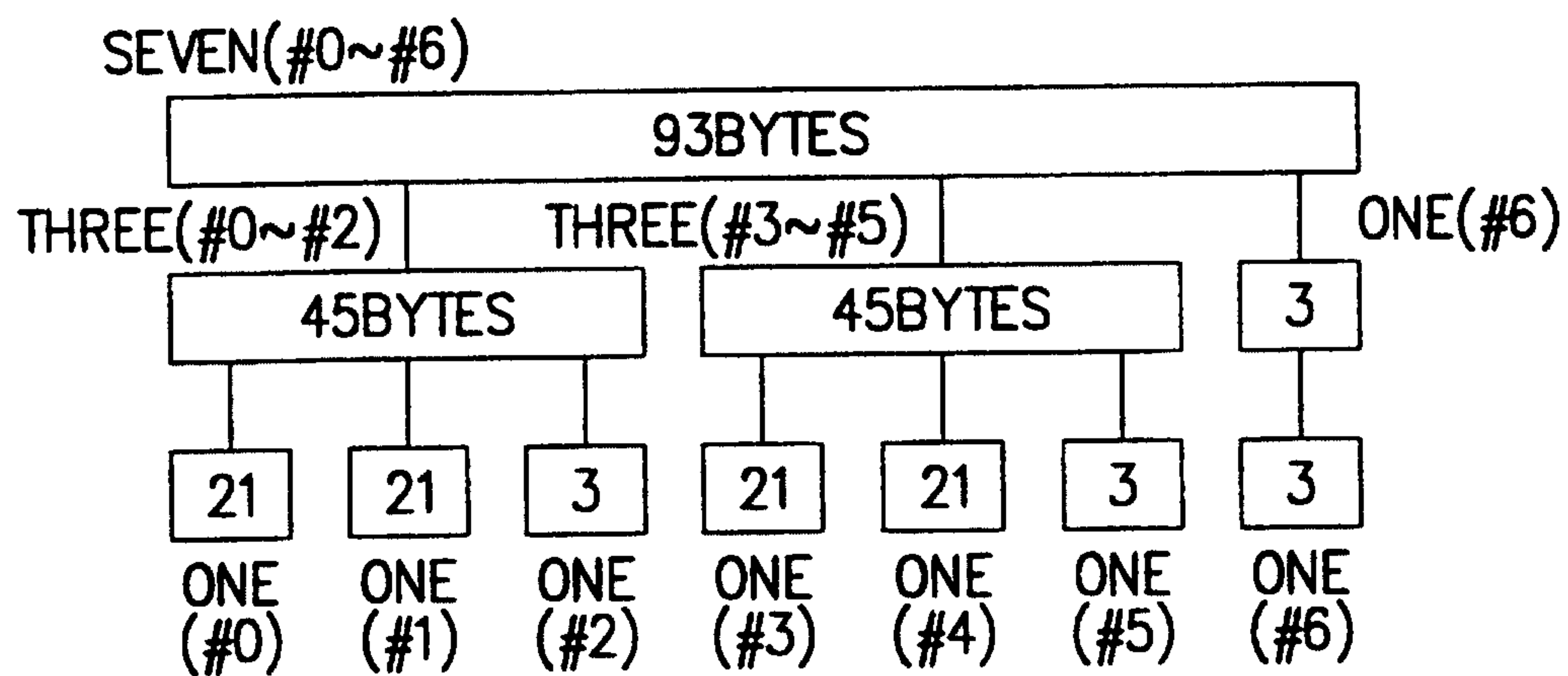


FIG. 2

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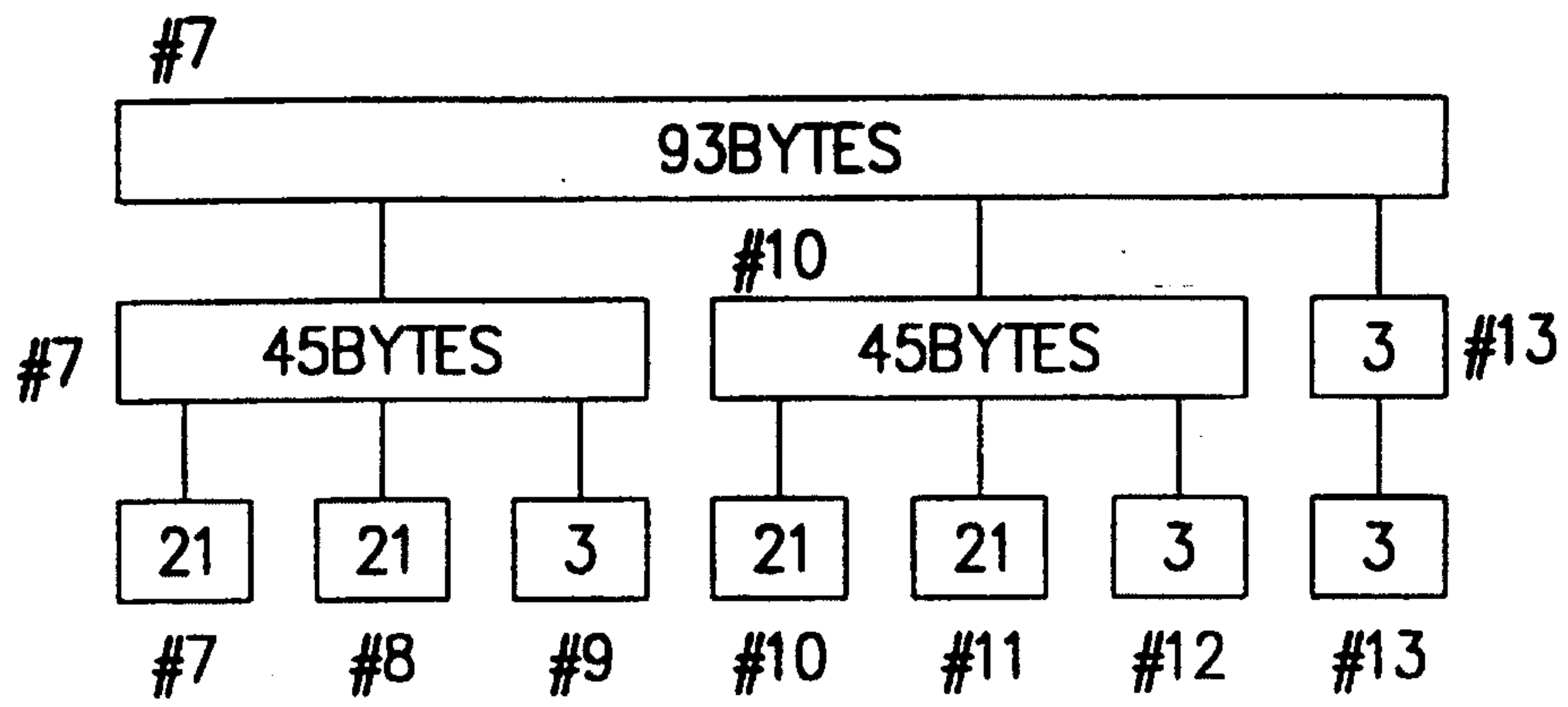


FIG. 3

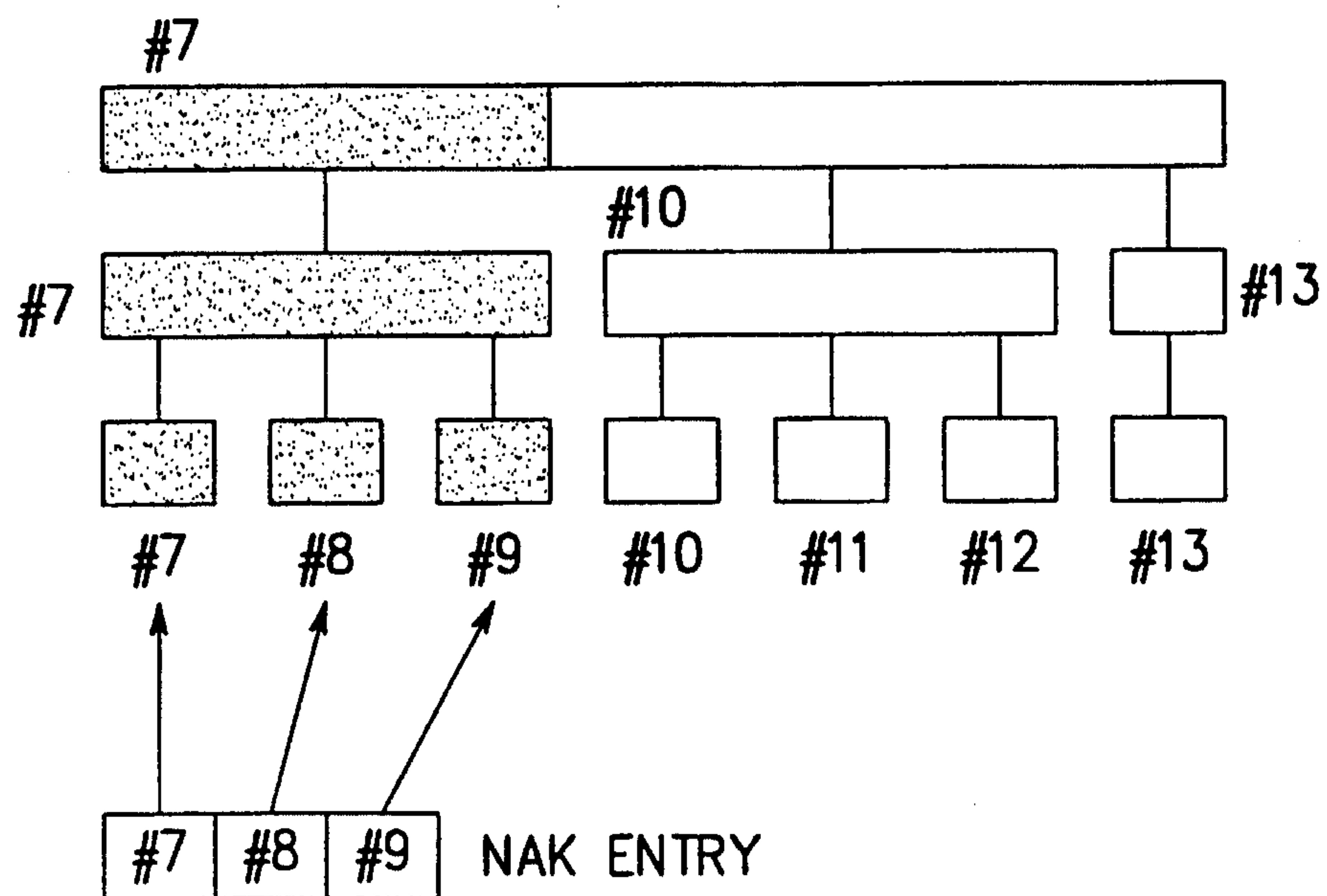


FIG. 4

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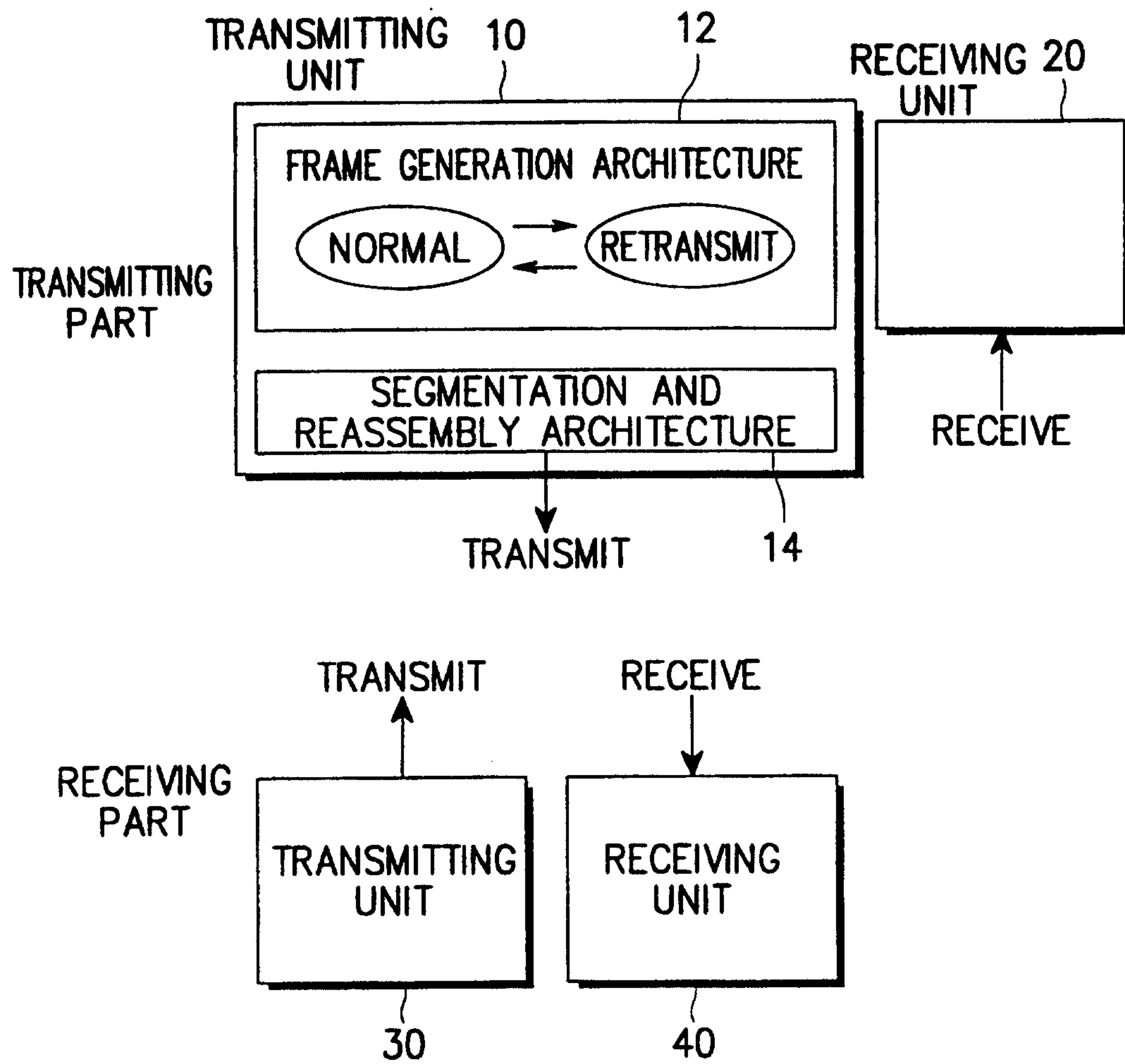


FIG. 5

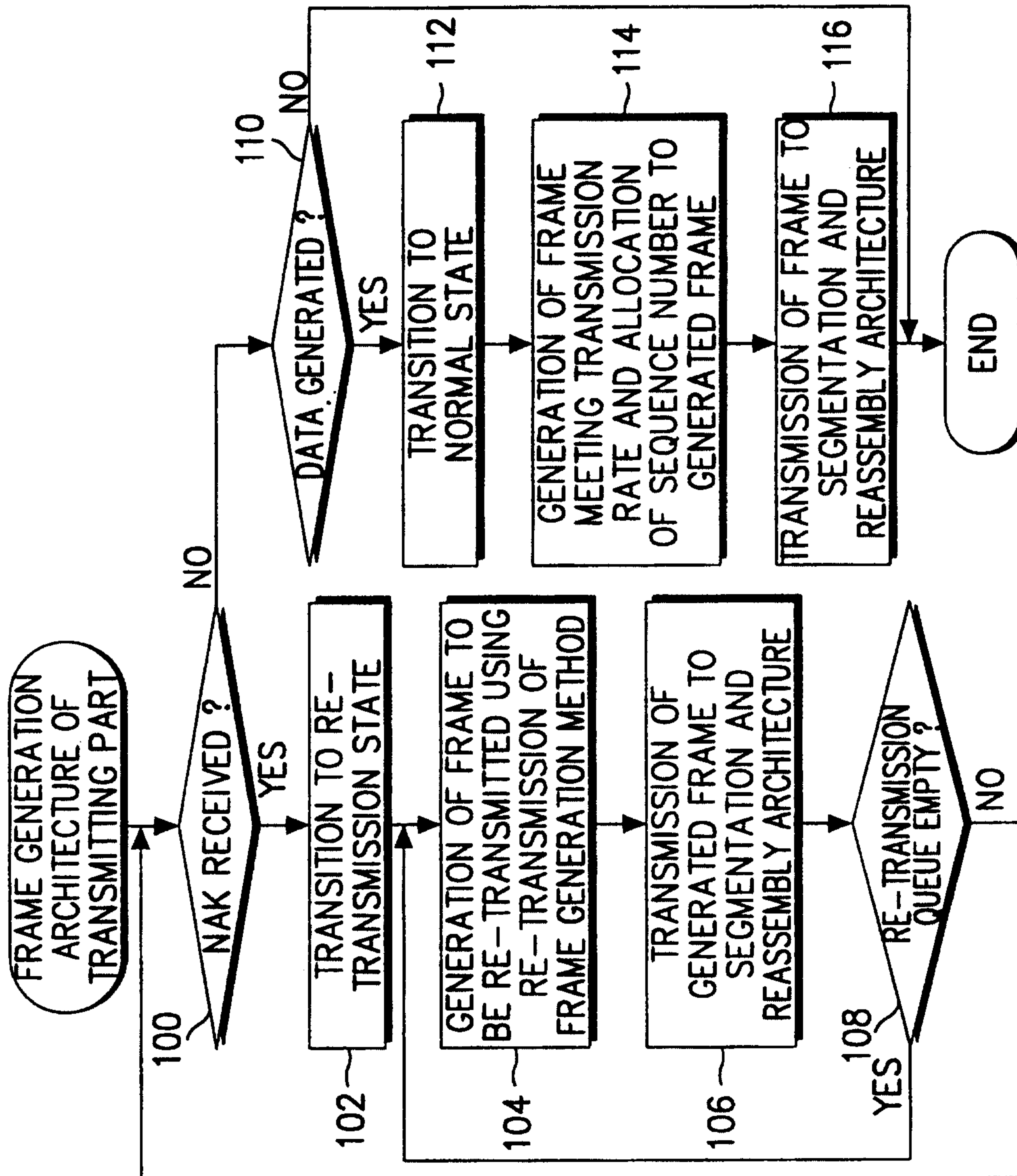


FIG. 6A

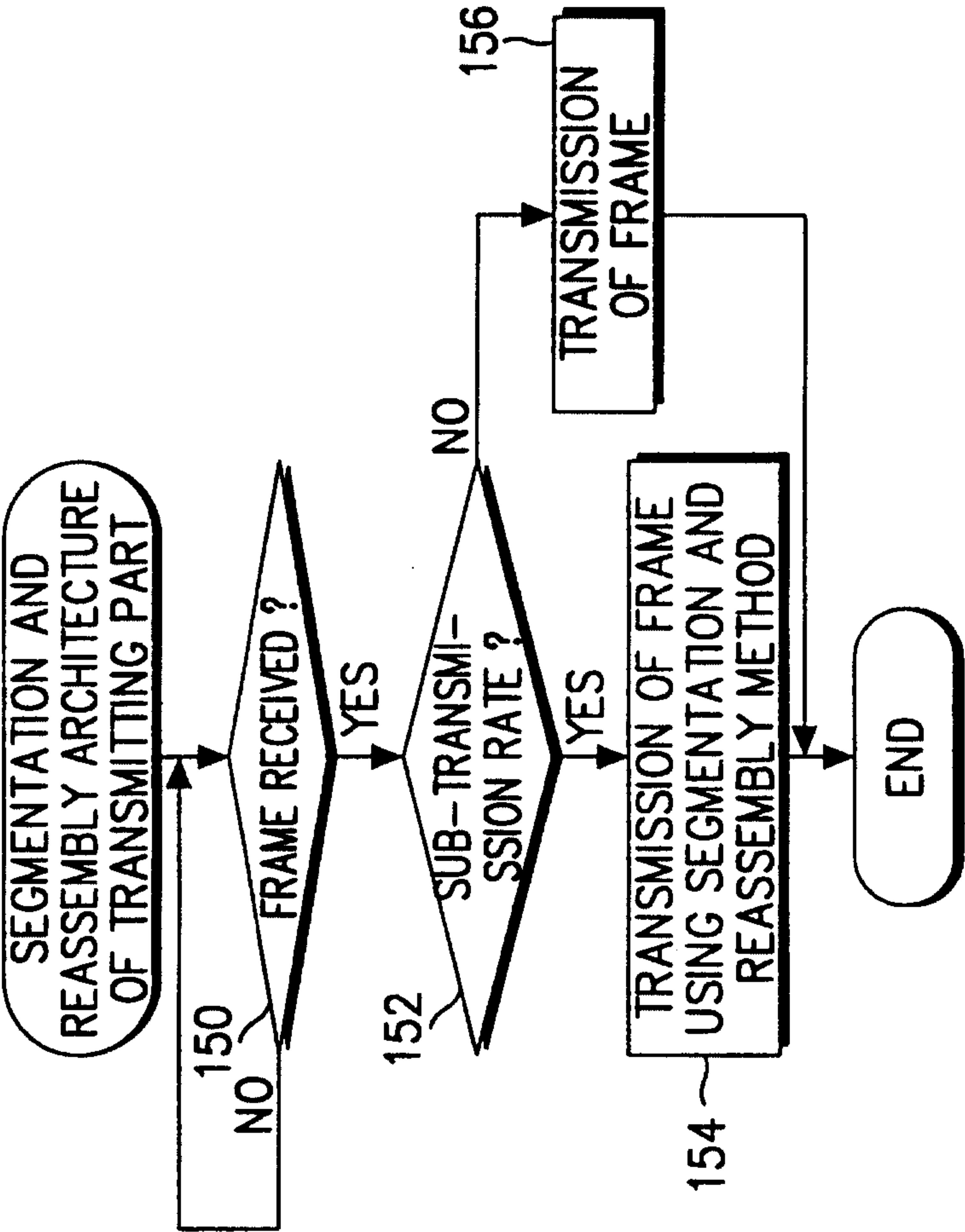


FIG. 6B

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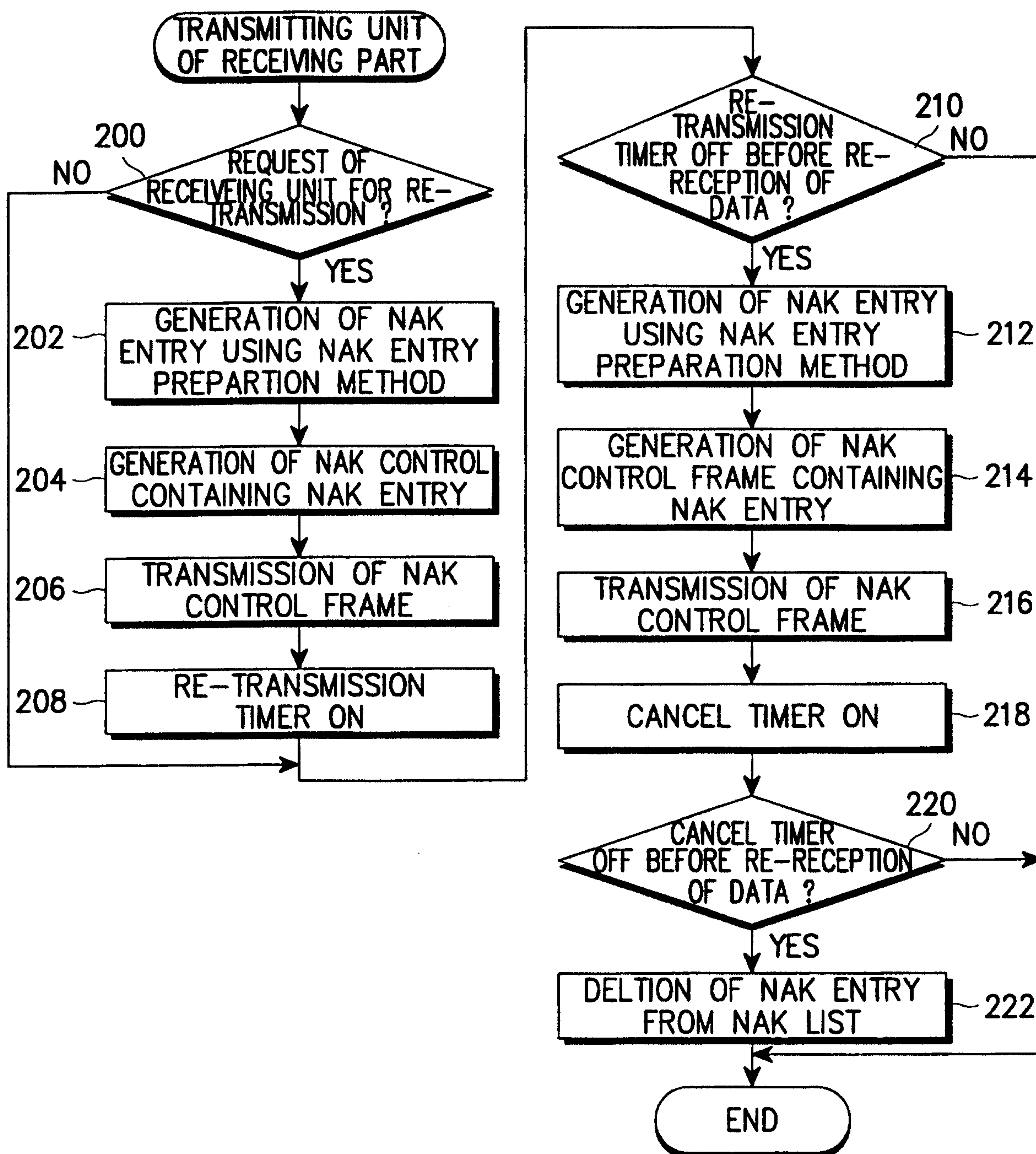


FIG. 7A

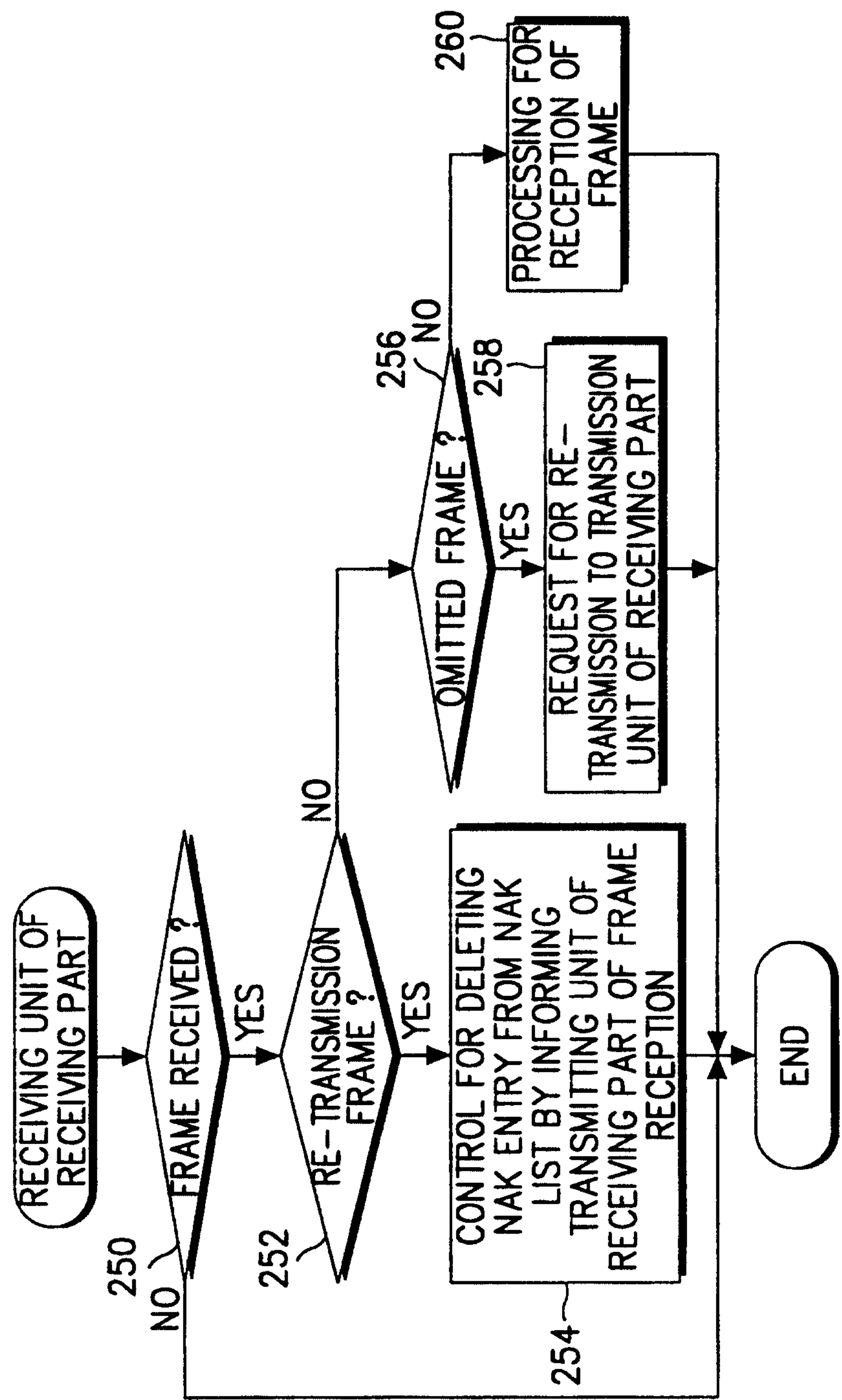


FIG. 7B

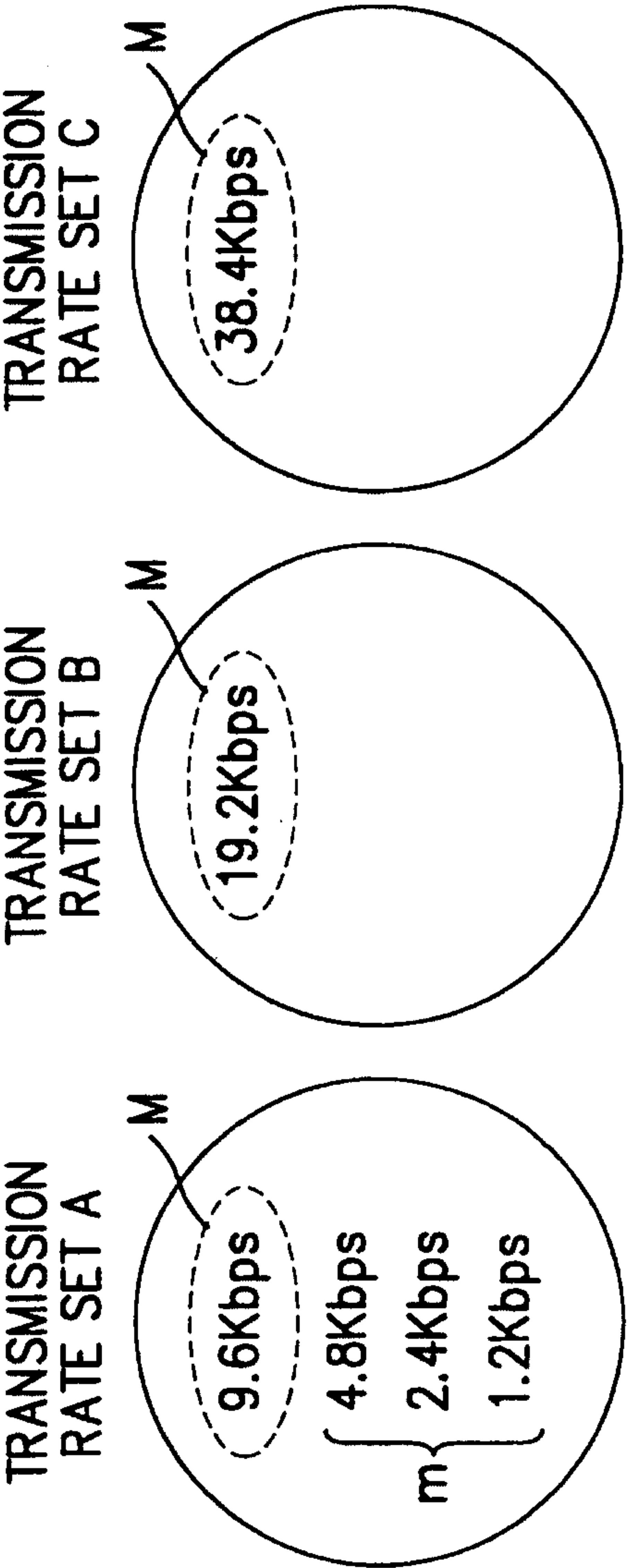


FIG. 8

