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An agency of Industry Canada

CA 2370191 A1 2001/08/23

(21) 2 370 191

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2001/02/12
(87) Date publication PCT/PCT Publication Date: 2001/08/23
(85) Entrée phase nationale/National Entry: 2001/10/11
(86) N° demande PCT/PCT Application No.: US 2001/004501
(87) N° publication PCT/PCT Publication No.: 2001/062024
(30) Priorité/Priority: 2000/02/14 (09/504,651) US

(51) Cl.Int.^{7}/Int.Cl.^{7} H04Q 7/24, H04L 12/66, H04B 3/46, H04Q 7/00

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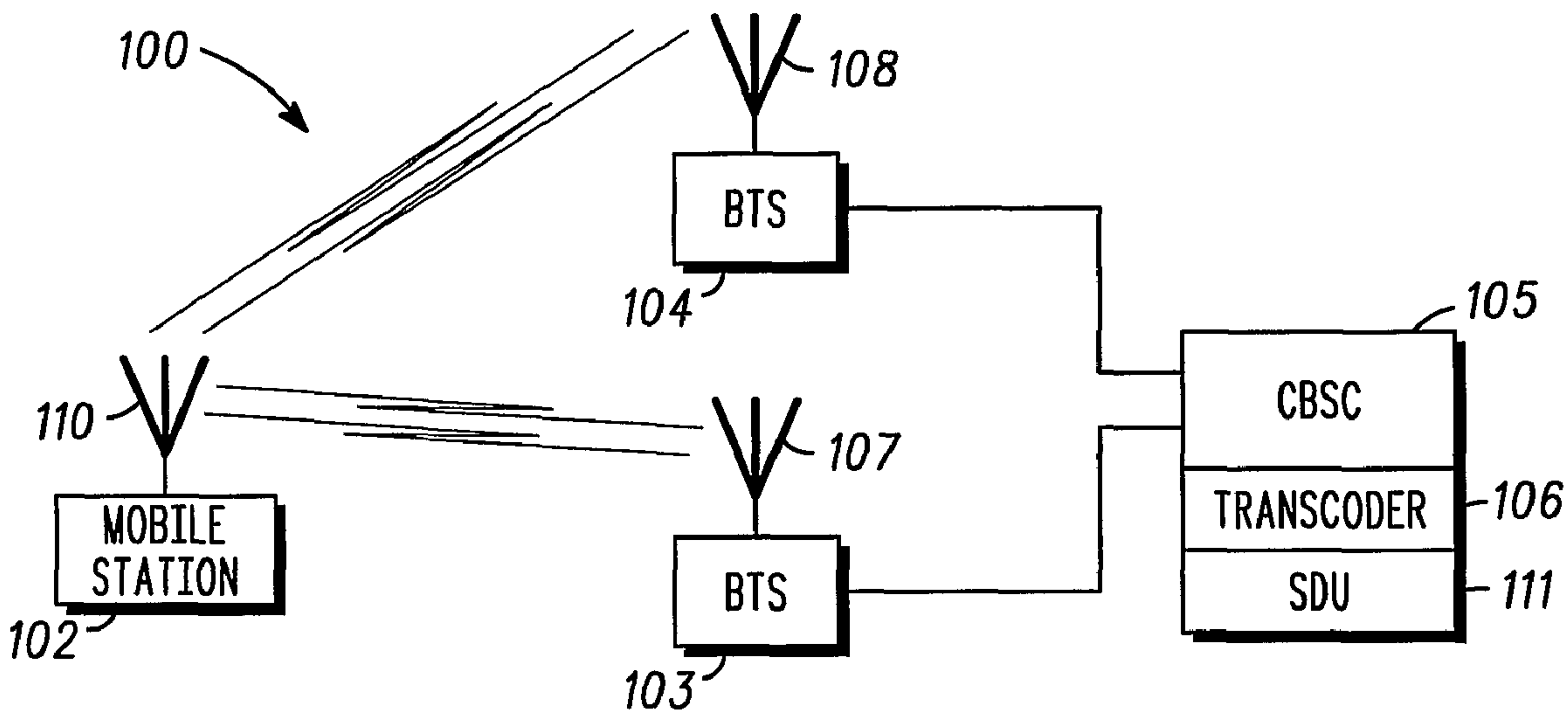
(54) Titre : PROCEDE DE MODIFICATION DYNAMIQUE DE DEBIT PAR L'INTERMEDIAIRE D'UNE SIGNALISATION DE COUCHE MOYENNE DE CANAL D'ACCES

(54) Title: METHOD OF DYNAMIC RATE SWITCHING VIA MEDIUM ACCESS CHANNEL LAYER SIGNALING



(57) Abrégé/Abstract:
A method and system (100) for dynamic rate switching (105) via medium access channel layer signaling is disclosed, wherein data rates for high data rate channels are automatically shifted up or down based on a predetermined metric. In a preferred embodiment, data rates are automatically shifted up or down based on transmit channel gain required to maintain a required signal to noise ratio.

CA 02370191 2001-10-11

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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 August 2001 (23.08.2001)

PCT

(10) International Publication Number
WO 01/62024 A1

(51) International Patent Classification[7]: H04Q 7/24, 7/00, H04L 12/66, H04B 3/46

(21) International Application Number: PCT/US01/04501

(22) International Filing Date: 12 February 2001 (12.02.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/504,651 14 February 2000 (14.02.2000) US

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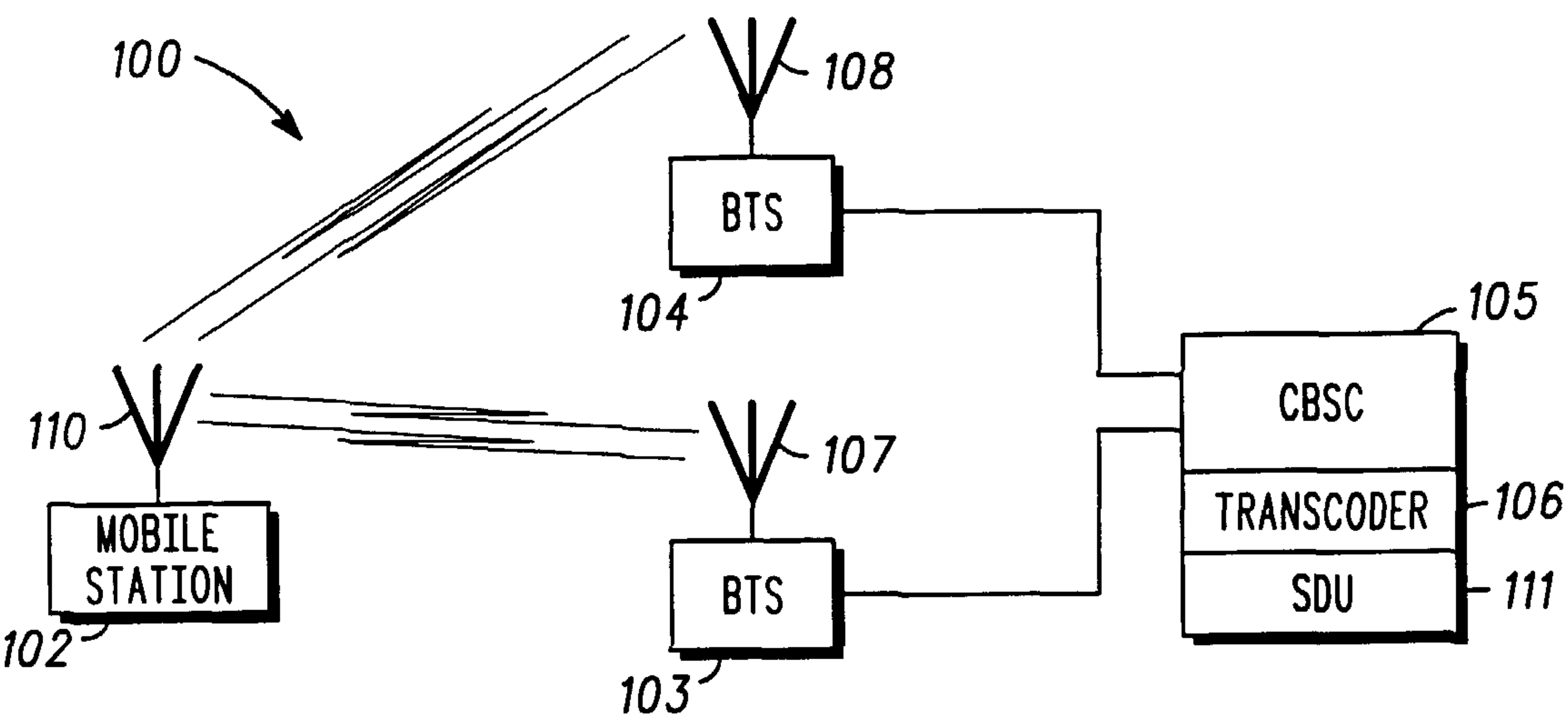
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** METHOD OF DYNAMIC RATE SWITCHING VIA MEDIUM ACCESS CHANNEL LAYER SIGNALING



(57) **Abstract:** A method and system (100) for dynamic rate switching (105) via medium access channel layer signaling is disclosed, wherein data rates for high data rate channels are automatically shifted up or down based on a predetermined metric. In a preferred embodiment, data rates are automatically shifted up or down based on transmit channel gain required to maintain a required signal to noise ratio.

WO 01/62024 A1

METHOD OF DYNAMIC RATE SWITCHING VIA MEDIUM ACCESS CHANNEL LAYER SIGNALING

Field of the Invention

The present invention is related in general to communication systems, and, more particularly, to an improved method and system for dynamic rate switching via medium access channel layer signaling.

Background of the Invention

Standards bodies such as the International Standards Organization (ISO) have adopted a layered approach for the reference model of a communication subsystem. The complete communication subsystem is broken down into a number of layers, each of which performs a well-defined function in the context of the overall communication subsystem. It operates according to a defined protocol by exchanging messages, both user data and additional control information, with a corresponding peer layer in a remote system. Each layer has a well-defined interface between itself and the layer immediately above and below. Consequently, the implementation of a particular protocol layer is independent of all other layers. The function of each layer is specified formally as a protocol that defines the set of rules and conventions used by the layer to communicate with a similar peer layer in another (remote) system. Each layer provides a defined set of services to the layer immediately above. It also uses the services provided by the layer immediately below it to transport the message units associated with the protocol to the remote peer layer.

Communication systems, such as Code Division Multiple Access (CDMA) systems, communicate messages between infrastructure equipment and subscriber or mobile units. As used herein, a forward message refers to a message generated by cellular infrastructure equipment and transmitted for reception by a mobile communication unit, and a reverse message refers to a message generated by a mobile communication unit, such as a mobile cellular phone.

At the most basic level, cdma2000 provides protocols and services that correspond to the bottom two layers of the ISO/OSI Reference Model (i.e., Layer 1 -- the Physical Layer, and Layer 2 -- the Link Layer) according to the general structure specified by the ITU for IMT-2000 systems. In cdma2000, a generalized multi-media service model is supported. This allows a combination of voice, packet data, and circuit data services to be operating concurrently (within the limitations of the air interface system capacity). Cdma2000 also includes a Quality of Service (QOS) control mechanism to balance the varying QOS requirements of multiple concurrent services.

One problem associated with the combination of voice, packet data, and circuit data services operating concurrently is the ability to maintain a high data rate connection at a required fixed error rate over a channel of varying quality. In addition, maximizing system capacity when high data rate channels are active presents another problem. Consequently, a need exists for a method and system for dynamic rate switching via medium access channel layer signaling, wherein data rates for high data rate channels are automatically shifted up or down based on a predetermined metric.

Brief Description of the Drawings

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 depicts a communication system in accordance with the method and system of the present invention;

FIG. 2 illustrates a block diagram of a communication system layer structure in accordance with the method and system of the present invention;

FIG. 3 illustrates a packet data gateway medium access control initiated rate shift transaction in accordance with the method and system of the present invention;

FIG. 4 illustrates a subscriber unit medium access control initiated rate shift transaction in accordance with the method and system of the present invention;

FIG. 5 illustrates an example of rate shifting in accordance with the method and system of the present invention;

FIG. 6 illustrates a functional flow diagram depicting the process of base transceiver station transmit rate control in accordance with the method and system of the present invention;

FIG. 7 illustrates a functional flow diagram depicting the process of base transceiver station receive rate control in accordance with the method and system of the present invention;

FIG. 8 illustrates a block diagram of the channel gain as determined by power control in accordance with the method and system of the present invention; and

FIG. 9 illustrates data frames being transmitted at different rates.

Detailed Description of the Invention

FIG. 1 depicts a communication system **100** in accordance with the preferred embodiment of the present invention. System **100** includes a mobile station **102**, a first base transceiver station **104**, a second base transceiver station **103**, and a Centralized Base Station Controller (CBSC) **105**. CBSC **105** includes a transcoder **106**, and a selection distribution unit **111**. System **100** preferably includes a plurality of mobile stations and base transceiver stations, but only one mobile station and two base transceiver stations are depicted in **FIG. 1** for clarity. In a preferred embodiment, system **100** is a Code Division Multiple Access (CDMA) system. System **100** may also be any communication system that transmits signaling messages and requires accurate delivery and receipt by mobile stations.

First base station **104** includes a transceiver **108** that includes a transmitter and a receiver. Second base station **103** includes a transceiver **107** that includes a transmitter and a receiver. Transceivers **107** and **108** transmit, over-the-air, RF signals to be received by mobile unit **102**. The transmission is well known in the art, and will not be described further in this application. Signals transmitted from base stations **103** and **104** to mobile unit **102** are referred to herein as forward traffic frames, or as forward link messages. Transceivers **107** and **108** receive messages from mobile unit **102**, as is well known in the art. Such messages are referred to herein as reverse link messages.

Mobile unit **102** is preferably a cellular telephone unit that is capable of communicating with base transceiver stations **103** and **104**. In a preferred embodiment, mobile unit **102** is a digital cellular CDMA telephone. Mobile unit **102** may also be a wireless data terminal or a videophone. Mobile unit **102** includes a transceiver **110** that includes a transmitter and a receiver, as is well known in the art. Mobile unit **102** communicates with base stations **103** and **104** by transmitting messages by the transceiver **110** located therein on a reverse link, and by receiving messages generated by base stations **103** and **104** at transceiver **110** located therein on the forward link.

In the preferred embodiment of the present invention, BTSs **103** and **104** act as the central location for managing power control in system **100**. In an alternate embodiment of the present invention, CBSC **105** manages power control in system **100**.

FIG. 2 illustrates a block diagram of a communication system layer structure **200** in accordance with the method and system of the present invention. In the preferred embodiment, **FIG. 2** illustrates a block diagram of IS-95 and cdma2000 layer structure. However, it will be appreciated by those skilled in the art that other communication systems, such as CDMAOne, UMTS, and ARIB, have similar layer structures. As shown in **FIG. 2**, IS-95 has a layered structure providing voice, packet data, simple circuit data, and simultaneous voice and packet data services. It should be noted that the term "IS-95" includes any of the standards that are predecessors to cdma2000, i.e. IS-95-A, and TIA/EIA-95-B. At the most basic level, cdma2000 provides protocols and services that correspond to the bottom two layers of the ISO/OSI Reference Model (i.e., Layer 1 – the Physical Layer **202**, and Layer 2 – the Link Layer **204**) according to the general structure specified by the ITU for IMT-2000 systems. Layer 2 **204** is further subdivided into the Link Access Control (LAC) sublayer **206** and the Medium Access Control (MAC) sublayer **208**. In addition, a Quality of service (QOS) control mechanism **210** is included to balance the varying QOS requirements of multiple concurrent services. Applications and upper layer protocols corresponding to OSI Layers 3 through 7 utilize the services provided by the cdma2000 LAC services. Examples include signaling services, voice services, packet data applications, and circuit data applications.

The design of the cdma2000 LAC and MAC sublayers **206, 208** is motivated by many factors, among those being: the need to support a wide range of upper layer services; the requirement to provide for high efficiency and low latency for data services operating over a wide performance range; support for advanced QOS delivery of circuit and packet data services; and the demand for advanced multi-media services that support multiple concurrent voice, packet data, and circuit data services, each with varying QOS requirements. The cdma2000 MAC sublayer **208** provides two important functions: (1) best effort delivery - reasonably reliable transmission over the radio link with a Radio Link Protocol (RLP) **212** that provides a best effort level of reliability; and (2) multiplexing and QOS control - enforcement of negotiated QOS levels by mediating conflicting requests from competing services and by the appropriate prioritization of access requests.

The Packet Data Gateway (PDG) MAC, which in one embodiment is CBSC **105**, controls data rate shifting. Either the PDG MAC or the subscriber unit MAC may initiate a rate shift. If the BTS requires a Forward Supplemental Channel (F-SCH) rate switch, the PDG MAC will direct the subscriber unit to shift it's receive rate. If the subscriber unit requires a Reverse Supplemental Channel (R-SCH) rate switch, it will send a request to the PDG MAC, which will then direct the subscriber unit to switch (resources and loading permitting).

In the preferred embodiment, supplemental channel transmit gain is used as a metric for determining whether to shift data rates. The transmit channel gain is a function of power control, thus it provides a reliable and fast metric of channel quality. However, it will be appreciated by those skilled in the art that other channel quality metrics may be used without departing from the spirit and scope of the present invention. When the supplemental channel transmit gain exceeds a rate dependent threshold, the physical layer **202** will indicate the event to the MAC **208**, which in turn will initiate a rate shift down via Dedicated Control Channel (DCCH) **214**. Likewise, when the gain falls below another rate dependent threshold, a rate shift up can be initiated. In the preferred embodiment, three rates are available for the SCH: 460.8 kbps, 153.6 kbps, and 76.8 kbps. In addition, rate shifts will preferably increment one rate per shift. As will be appreciated by those skilled in the art, rate shifting based on F-SCH transmit power should provide an increase in system capacity or range. If the gain necessary to achieve a required signal-to-noise ratio E_b/N_0 exceeds the threshold, shifting to a lower rate will result in transmit power reduction and capacity increase.

Placing the decision making on the network side of the link, (i.e., PDG MAC) allows for more intelligent rate shifting based on loading, QOS, etc. **FIG. 3** illustrates a PDG MAC initiated rate shift transaction in accordance with the method and system of the present invention. To implement a rate shift down on the forward link, if at a given rate R, the BTS detects the SCH gain has exceeded the nominal value for that rate, G_{nom} (R), it will indicate the event to the PDG MAC. If resource availability and loading allow, the PDG MAC will, beginning on the next 20 millisecond frame boundary, send a rate shift SHIFT(RATE) command over the DCCH on the 0 millisecond and 5 millisecond sub-boundary of every 20 millisecond frame until an acknowledgment message SHIFT_ACK(RATE) is received. The MAC layer **208** will also set the F-SCH transmitter to the new rate on the 20 millisecond boundary following the first SHIFT(RATE) frame transmission. RATE is the next lowest rate.

If the SHIFT(RATE) frame arrives without error, the subscriber unit MAC will have approximately 10 to 15 millisecond to set up the F-SCH receiver to the new rate. That is, under ideal conditions, no frames are lost due to the rate shift. Also, by not waiting for a SHIFT_ACK before changing the F-SCH transmit rate, a seamless rate shift can occur if the SHIFT(RATE) frame was received at the subscriber unit but the SHIFT_ACK was lost.

To implement a rate shift up on the forward link, if at a given rate R, the gain falls below a rate dependent threshold, G_{up} (R), the BTS will indicate the event to the PDG. Following the same procedure described above for implementing a rate shift down on the forward link, the PDG MAC directs the subscriber unit to switch to the next higher rate.

FIG. 4 illustrates a subscriber unit MAC initiated rate shift transaction in accordance with the method and system of the present invention. To implement a subscriber unit initiated rate shift down on the reverse link, if at a given rate R, the subscriber unit physical layer detects that the R-SCH power control derived transmit gain has exceeded the nominal value for that rate, G_{nom} (R), it will indicate the event to the subscriber unit MAC. The subscriber unit MAC thereafter sends a rate shift request, SHIFT_REQ(RATE), to the PDG MAC. The subscriber unit continues to send SHIFT_REQ(RATE) until a response, or rate shift acknowledgment message SHIFT(RATE), is received. If the PDG grants the downshift, it will set RATE equal to the next lowest rate, otherwise it will set RATE equal to the current rate. The PDG will then send the SHIFT(RATE) using the procedure described above for implementing a rate shift down on the forward link.

Alternately, the PDG may initiate a rate shift down on the reverse link. To implement a PDG initiated rate shift down on the reverse link, the PDG directs the subscriber unit to shift down if the R-SCH fixed error rate exceeds a predetermined limit. This allows a rate shift to occur if the subscriber unit does not request a rate shift due to excess gain. In this case, the PDG MAC sends the SHIFT(RATE) using the procedure described above for implementing a rate shift down on the forward link.

To implement a rate shift up on the reverse link, if at a given rate R, the R-SCH transmit gain falls below a rate dependent threshold, G_{up} (R), the subscriber unit physical layer indicates the event to the subscriber unit MAC. The subscriber unit MAC will then send a rate shift request, SHIFT_REQ(RATE), to the PDG MAC. The subscriber unit will continue to send SHIFT_REQ(RATE) until a response, SHIFT(RATE) is received. If the PDG grants the up shift, it will set RATE equal to the next highest rate, otherwise it will set RATE equal to the current rate. The PDG will then send the SHIFT(RATE) using the procedure described above for implementing a rate shift down on the forward link.

When the PDG MAC initiates a rate shift, it assumes that the subscriber unit MAC received the command and switches to the new rate on schedule. If the subscriber unit received the command, but the SHIFT_ACK frame is lost, both sides of the link will still be running at the same rate. The PDG media access channel will continue sending the SHIFT(RATE) command. If the DCCH is reliable, the command will reach the subscriber unit in a short time, in which case the SHIFT_ACK is retransmitted. If the DCCH is unreliable and the SHIFT_ACK never arrived, the media access channel will initiate a call tear down after a time out period. Note that in this case, the SHIFT(RATE) most likely never reached the subscriber unit, meaning the DCCH is not operational and the call should be terminated.

When the PDG MAC initiates a rate switch, it assumes that the subscriber unit MAC received the command and switches to the rate on schedule. If the SHIFT(RATE) frame is lost over the DCCH, the subscriber unit will not switch to the new rate. This will result in frame erasers, as both ends of the link are running different rates. The media access channel will continue to send a SHIFT(RATE) command over the DCCH. If the DCCH is reliable, the subscriber unit will receive the command and switch its F-SCH receiver to the new rate. Packets lost during the rate mismatch will be recovered via retransmitted procedures. If the DCCH link is such that the SHIFT(RATE) is never reached at the subscriber unit, no SHIFT_ACK will be received. After a timeout period, the media access channel will assume the DCCH is lost and initiate a call tear down.

In the preferred embodiment, no subscriber unit initiated rate shift occurs if the SHIFT_REQ(RATE) is not received. Either the SHIFT_REQ(RATE) will eventually be received, resulting in a rate shift, or the DCCH is so unreliable as to cause an eventual call tear down.

The following describes gain thresholds used in the preferred embodiment to determine rate-switching events. However, it will be appreciated by those skilled in the art that other gain thresholds may be used without departing from the spirit and scope of the present invention. The forward link gain thresholds are rate dependent in order to increase system (RF) capacity and maintain a desired QOS. It may also be possible for the PDG to dynamically adjust a threshold to fine tune the system such that maximum RF capacity is approached. On the reverse link, the gain threshold is not rate dependent but is selected so as to avoid power amplifier saturation on the mobile. Also, it may be desirable to lower this threshold, while in a power save mode (i.e., shift to a lower rate to conserve battery life) if the current rate can not be maintained below some lower power threshold.

The gain threshold for a shift down, G_{down}, at a given rate R kbps, is based on the nominal required gain at that rate relative to the gain at 9600 bps.

$$G_{down}(R) = G_{nom}(R) = G_{9.6}\sqrt{\frac{R}{9.6}}$$

When the link is at a rate R other than full rate (460.8 kbps), a rate shift up gain threshold, $G_{up}(R)$, exists. If the required transmit gain at a given rate R is G(R), the required gain at the new (higher) rate, R_{up}, is:

$$G(R_{up}) = G(R) \times \sqrt{\frac{R_{up}}{R}}$$

The criteria for a rate shift up is that the required gain at the new (higher) rate is less than the nominal gain at that rate by some margin.

$$G_{up}(R) \times \sqrt{\frac{R_{up}}{R}} < G_{nom}(R_{up}) - \text{Delta}$$

Where Delta is some margin.

Therefore, the gain threshold, $G_{up}(R)$, to shift from rate R up to Rate R_{up} is:

$$G_{up}(R) = [G_{nom}(R_{up}) - \text{Delta}] \times \sqrt{\frac{R}{R_{up}}}$$

FIG. 5 illustrates an example of rate shifting events in accordance with the method and system of the present invention.

FIG. 6 illustrates a functional flow diagram depicting the process of base transceiver station transmit rate control in accordance with the method and system of the present invention. As depicted in **FIG. 6**, at block **602**, the medium access channel checks for needed rate change at the end of a data frame. At block

604, a determination is made whether the metric is below the shift up line **702** in **FIG. 7**. If the metric is below the shift up line **702**, then at block **606**, the shift up flag is set and the rate is shifted up. Thereafter, at block **608**, a shift rate DCCH message is sent, and flow reverts to block **602**. If the metric is not below the shift up line **702**, then a determination is made at block **610** whether the shift up flag is set. If the shift up flag is set, then flow proceeds to block **608** and continues as described above. If the shift up flag is not set, then a determination is made at block **612** whether the metric is above the shift down line **704** of **FIG. 7**. If the metric is above the shift down line **704**, then at block **614**, the shift down flag is set and the rate is shifted down. Thereafter at block **616**, a shift rate DCCH message is sent, and flow reverts to block **602**. If the metric is not above the shift down line **704**, then at block **618**, a determination is made whether the shift down flag is set. If the shift down flag is set, then flow proceeds to block **616** as described above. If the shift down flag is not set, then flow reverts to block **602**.

FIG. 8 illustrates a functional flow diagram depicting the process of base transceiver station receive rate control in accordance with the method and system of the present invention. As depicted in **FIG. 8**, at block **802**, the medium access control checks received DCCH messages. At block **804**, a determination is made whether or not a shift rate message has been received. If a shift rate message is present, then at block **806**, the shift rate flag is set and the rate shift is set to take effect at the next data frame boundary. Thereafter, flow reverts back to block **802**. If a shift rate message is not present, then at block **808**, a determination is made whether a shift rate acknowledgment has been received. If a shift rate acknowledgment has been received, then at block **810**, the shift rate flag is reset. If a shift rate acknowledgment has not been received, then flow reverts back to block **802**.

FIG. 9 illustrates data frames being transmitted at different rates, wherein a full rate 20 millisecond data frame includes four parts (i.e. quantum 1 through quantum 4). A retransmitted half rate includes two 20 millisecond frames, each including two parts (i.e. frame 1 - quantum 1 and quantum 2; frame 2 - quantum 3 and quantum 4). A retransmitted quarter rate includes four 20 millisecond frames, each including one part (i.e. frame 1 - quantum 1; frame 2, quantum 2; etc.). It should be noted that in the preferred embodiment, control channel frame DCCH should be less than or equal to the data frame size.

When a rate shift occurs and there are outstanding NACKed frames that were initially transmitted at the old rate but must be retransmitted at the new rate, the subscriber unit radio link protocol would have to back V(R) (next expected frame) to V(N) (next expected in sequence frame) and inform the PDG radio link protocol to start new rate frames at V(S) equals the subscriber unit's V(R) (i.e., back up to the last frame received in sequence by the subscriber unit). For example, if prior to the rate switch, frames 0, 1, 2, 4 were received by the subscriber unit, and the rate is switched before frame 3 is present, the receiver sets V(R) = V (N) = 3 and includes V(R) in the SHIFT_ACK packet. The PDG radio link protocol then starts transmitting at the new rate from packet 3. If this is not done, packet sequence order is not preserved.

The rate-switching algorithm assumes an atomic packet size equal to that of the lowest rate packet. The SCH rates available are 460.8, 153.6, and 76.8 kbps. Therefore, the atomic packet size P should be that of 76.8 kbps. Then at 153.6 kbps, 2P packets are sent in a 20 millisecond frame while at 460.8 kbps, 6P packets are sent. Using this scheme, rate switches should be transparent to the radio link protocol.

The foregoing description of a preferred embodiment of the invention has been presented for the purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment was chosen and described to provide the best illustration of the principles of the invention and its practical application, and to enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

Claims

What is claimed is:

1. A method for dynamic rate switching in a communication system adapted to provide protocols and services that correspond to a first, physical layer and a second, link layer, the link layer including a medium access channel sublayer, the method comprising the steps of:

in the physical layer, determining whether, at a given data rate, a link quality metric is within a predetermined range having an upper threshold and a lower threshold;

in response to the step of determining, indicating to the link layer that one of the upper threshold and the lower threshold has been crossed; and

in the link layer, initiating data rate shifting via a control channel.

2. The method for dynamic rate switching according to claim 1, wherein the step of initiating data rate shifting includes rate shifting based on the power control derived transmit channel gain necessary to maintain a predetermined signal to noise ratio.

3. The method for dynamic rate switching according to claim 2, wherein when one of the upper threshold and the lower threshold has been crossed, periodically sending a rate shift command over the control channel until an acknowledgment message is received.

4. The method for dynamic rate switching according to claim **3**, including the step of, in the medium access channel sublayer, setting up a transmitter to the new data rate

5. The method for dynamic rate switching according to claim **4**, including the step of determining whether the rate shift command has arrived without error.

6. The method for dynamic rate switching according to claim **5**, including the step of setting up a receiver to the new data rate if the rate shift command arrived without error.

7. The method for dynamic rate switching according to claim **5**, including the step of initiating a call tear down if the rate shift command has not arrived without error within a predetermined timeout period.

8. The method for dynamic rate switching according to claim **6**, including the step of determining whether the acknowledgment message has been received.

9. The method for dynamic rate switching according to claim **8**, including the step of initiating a call tear down if the acknowledgment message has not been received within a predetermined timeout period.

10. The method for dynamic rate switching according to claim **9**, including the step of determining whether the metric is outside the predetermined range in a reverse link.

11. The method for dynamic rate switching according to claim **10**, wherein when the metric is determined to be outside the predetermined range in the reverse link, including the steps of

receiving a rate shift request from a subscriber unit medium access channel;

sending a rate shift acknowledgment message to the subscriber unit medium access channel;

determining whether to grant the rate shift request; and

setting the data rate equal to one of the current data rate, a next lowest data rate, and a next highest data rate.

12. A system for dynamic rate switching in a communication system adapted to provide protocols and services that correspond to a first, physical layer and a second, link layer, the link layer including a medium access channel sublayer, the system comprising:

in the physical layer, means for determining whether, at a given data rate, a link quality metric is within a predetermined range having an upper threshold and a lower threshold;

in response to the means for determining, means for indicating to the link layer that one of the upper threshold and the lower threshold has been crossed; and

in the link layer, means for initiating data rate shifting via a control channel.

13. The system for dynamic rate switching according to claim **12**, wherein the means for initiating data rate shifting includes means for rate shifting based on power control derived transmit channel gain necessary to maintain a predetermined signal to noise ratio.

14. The system for dynamic rate switching according to claim **13**, wherein when one of the upper threshold and the lower threshold has been crossed, periodically sending a rate shift command over the control channel until an acknowledgment message is received.

15. The system for dynamic rate switching according to claim **14**, including, in the medium access channel sublayer, means for setting up a transmitter to the new data rate

16. The system for dynamic rate switching according to claim **15**, including means for determining whether the rate shift command has arrived without error.

17. The system for dynamic rate switching according to claim **16**, including means for setting up a receiver to the new data rate if the rate shift command arrived without error.

18. The system for dynamic rate switching according to claim **16**, including means for initiating a call tear down if the rate shift command has not arrived without error within a predetermined timeout period.

19. The system for dynamic rate switching according to claim **17**, including means for determining whether the acknowledgment message has been received.

20. The system for dynamic rate switching according to claim **18**, including means for initiating a call tear down if the acknowledgment message has not been received within a predetermined timeout period.

21. The system for dynamic rate switching according to claim **19**, including means for determining whether the link quality metric is outside the predetermined range in a reverse link.

22. The system for dynamic rate switching according to claim **20**, wherein when the link quality metric is determined to be outside the predetermined range in the reverse link, including

means for receiving a rate shift request from a subscriber unit medium access channel;

means for sending a rate shift acknowledgment message to the subscriber unit medium access channel;

means for determining whether to grant the rate shift request; and

means for setting the data rate equal to one of the current data rate, a next lowest data rate, and a next highest data rate.

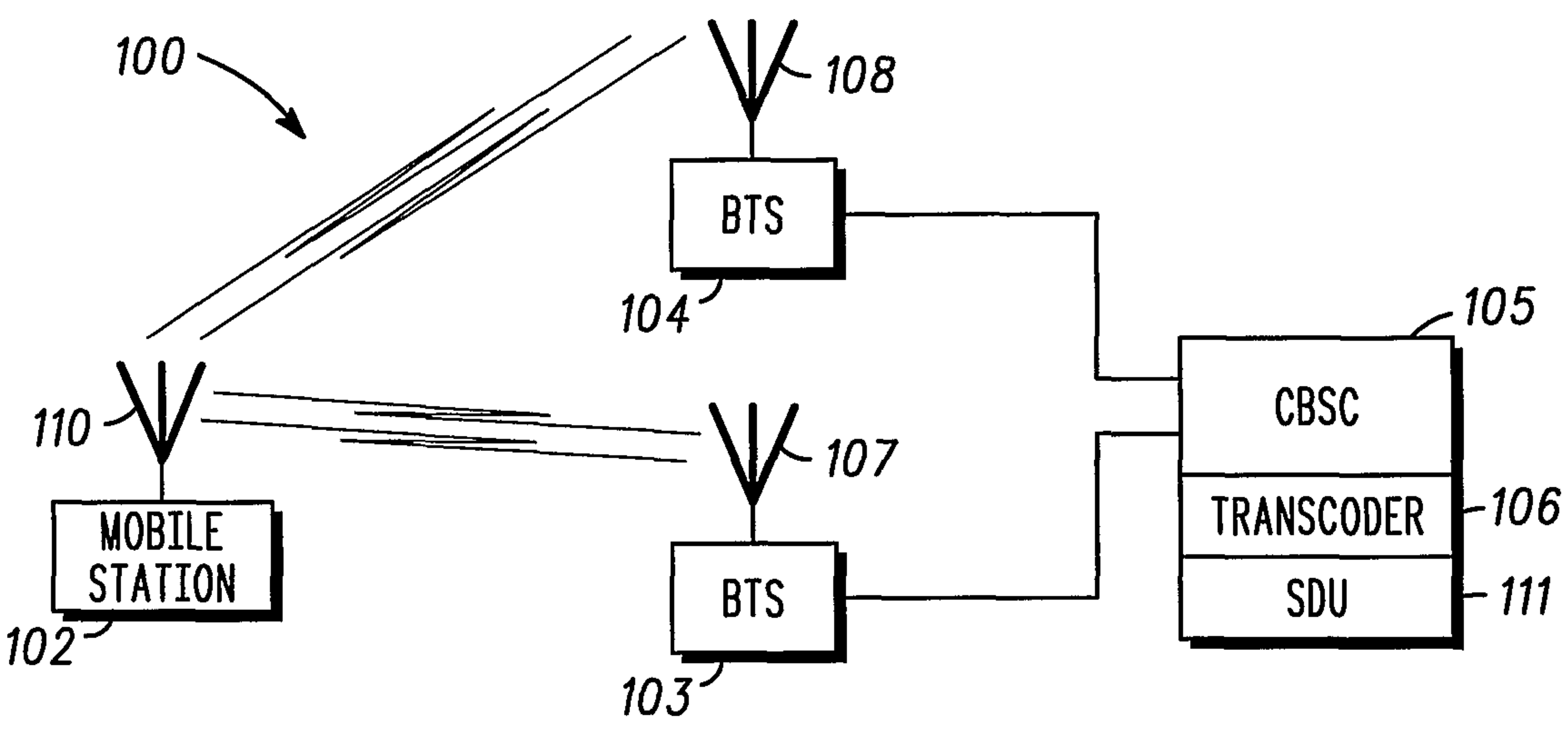

100
108
BTS
104
105
CBSC
110
107
TRANSCODER
106
MOBILE STATION
BTS
SDU
111
102
103

FIG. 1

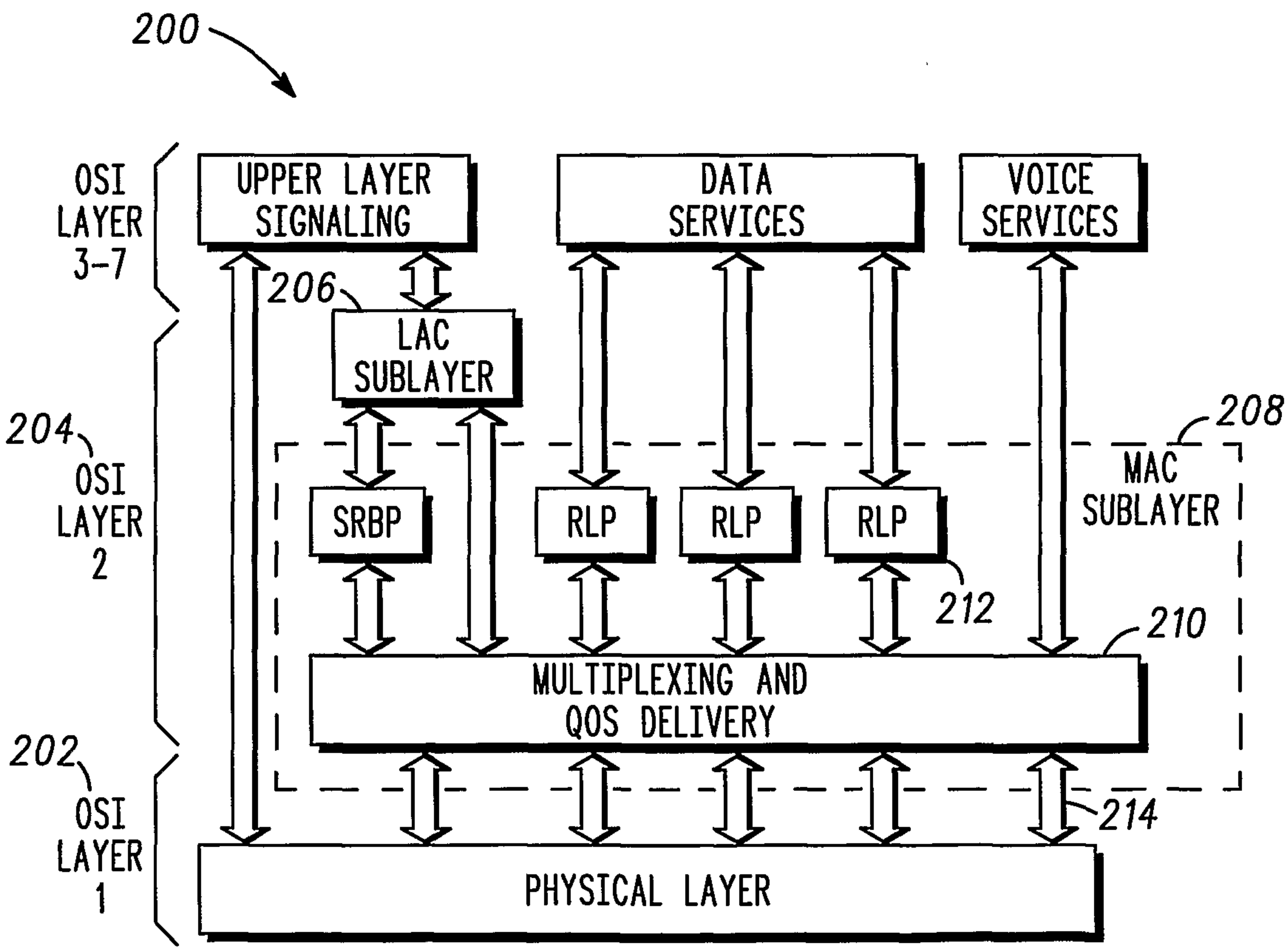

200
OSI LAYER 3-7
UPPER LAYER SIGNALING
DATA SERVICES
VOICE SERVICES
206
LAC SUBLAYER
204
OSI LAYER 2
208
MAC SUBLAYER
SRBP
RLP
RLP
RLP
212
210
MULTIPLEXING AND QOS DELIVERY
202
OSI LAYER 1
214
PHYSICAL LAYER

FIG. 2

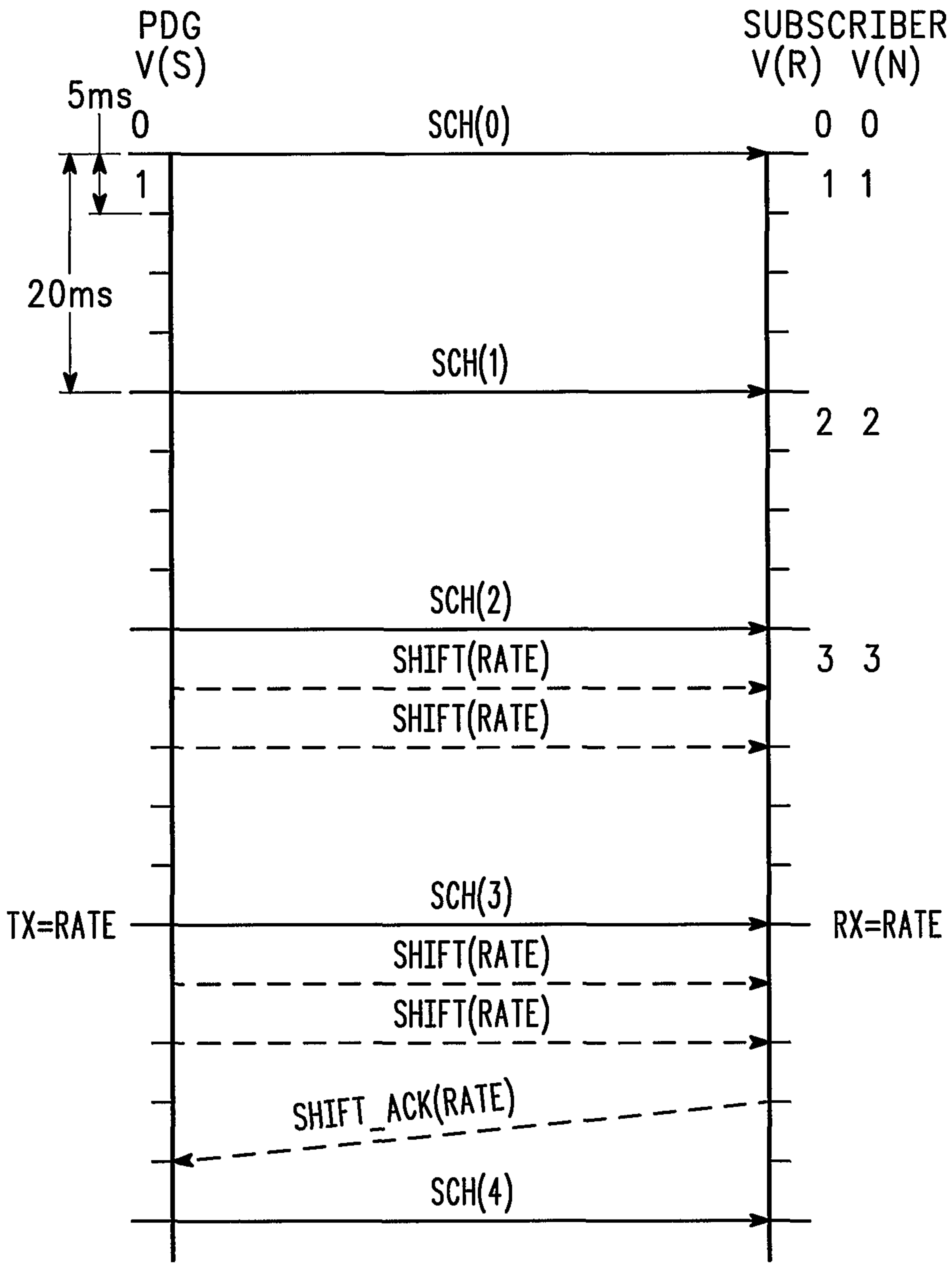

PDG
V(S)
5ms
0
1
20ms
SUBSCRIBER
V(R) V(N)
0 0
1 1
2 2
3 3
SCH(0)
SCH(1)
SCH(2)
SHIFT(RATE)
SHIFT(RATE)
TX=RATE
SCH(3)
RX=RATE
SHIFT(RATE)
SHIFT(RATE)
SHIFT_ACK(RATE)
SCH(4)

FIG. 3

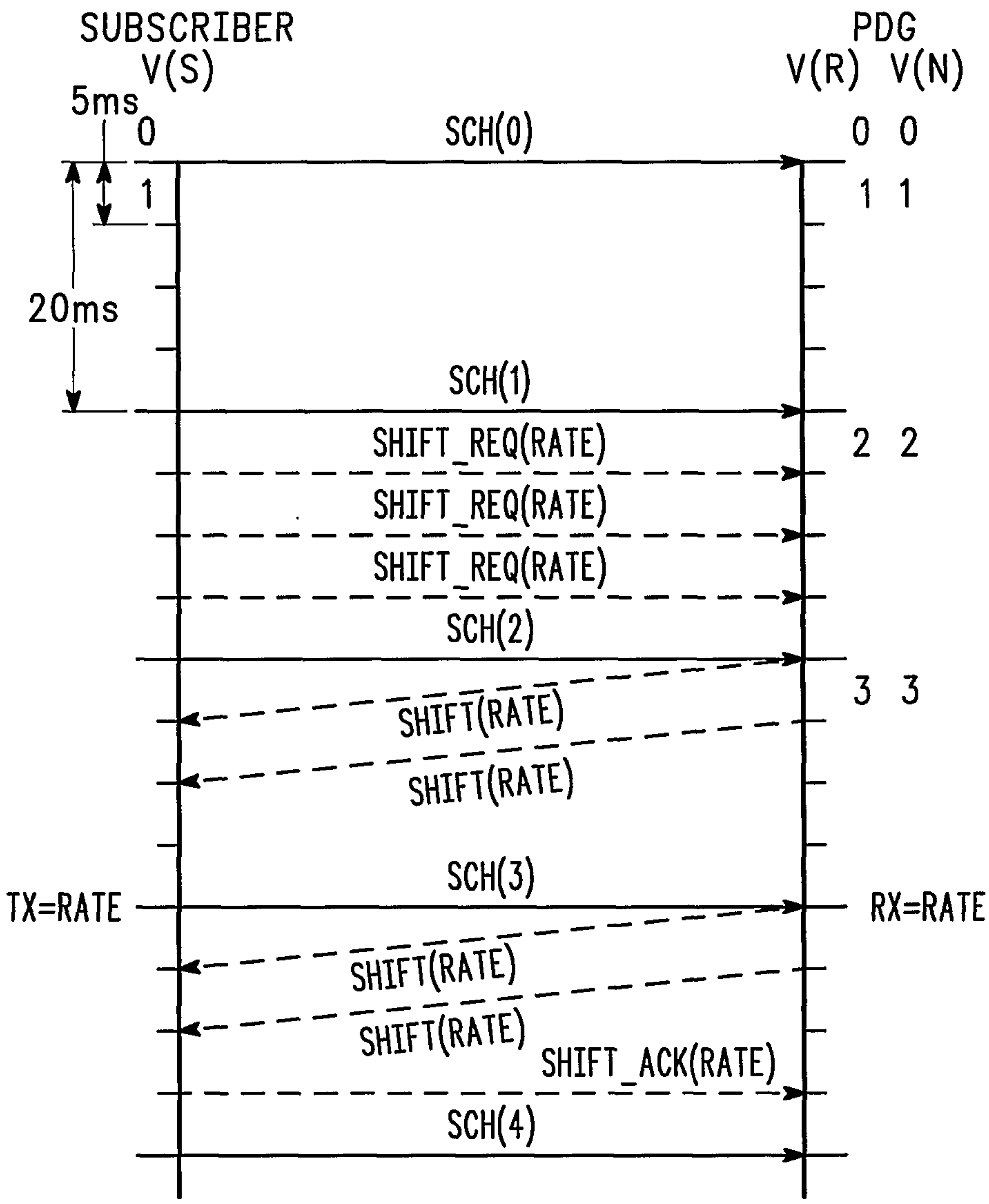

SUBSCRIBER
V(S)
5ms
0
1
20ms
PDG
V(R) V(N)
0 0
1 1
2 2
3 3
SCH(0)
SCH(1)
SHIFT_REQ(RATE)
SHIFT_REQ(RATE)
SHIFT_REQ(RATE)
SCH(2)
SHIFT(RATE)
SHIFT(RATE)
SCH(3)
TX=RATE
RX=RATE
SHIFT(RATE)
SHIFT(RATE)
SHIFT_ACK(RATE)
SCH(4)

FIG. 4

FIG. 5

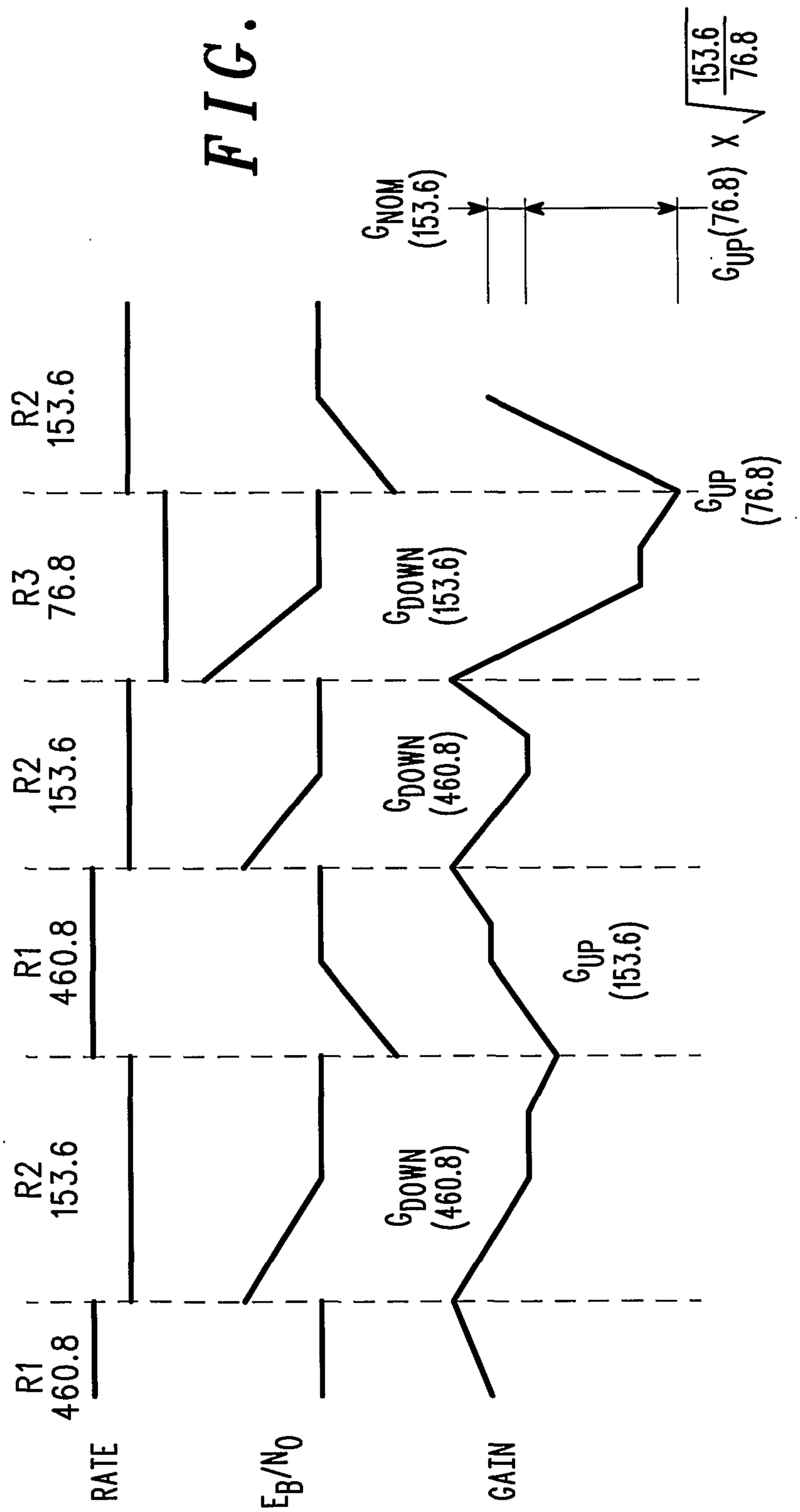
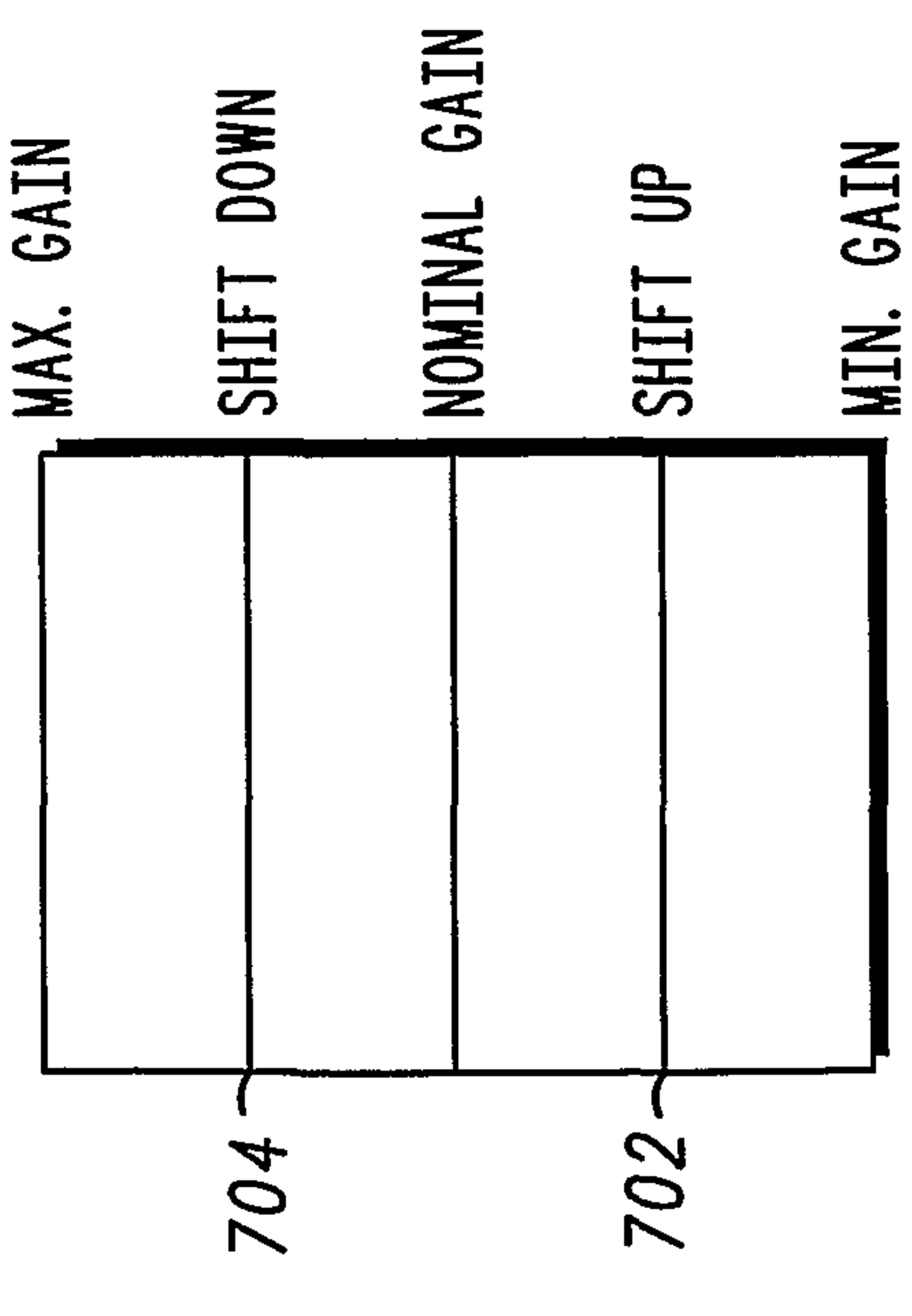

RATE
E_B/N_O
GAIN
R1 460.8
R2 153.6
R1 460.8
R2 153.6
R3 76.8
R2 153.6
G_DOWN (460.8)
G_UP (153.6)
G_DOWN (460.8)
G_DOWN (153.6)
G_UP (76.8)
G_NOM (153.6)
G_UP(76.8)
G_UP(76.8) X √(153.6/76.8)

FIG. 7


MAX. GAIN
SHIFT DOWN
NOMINAL GAIN
SHIFT UP
MIN. GAIN
704
702

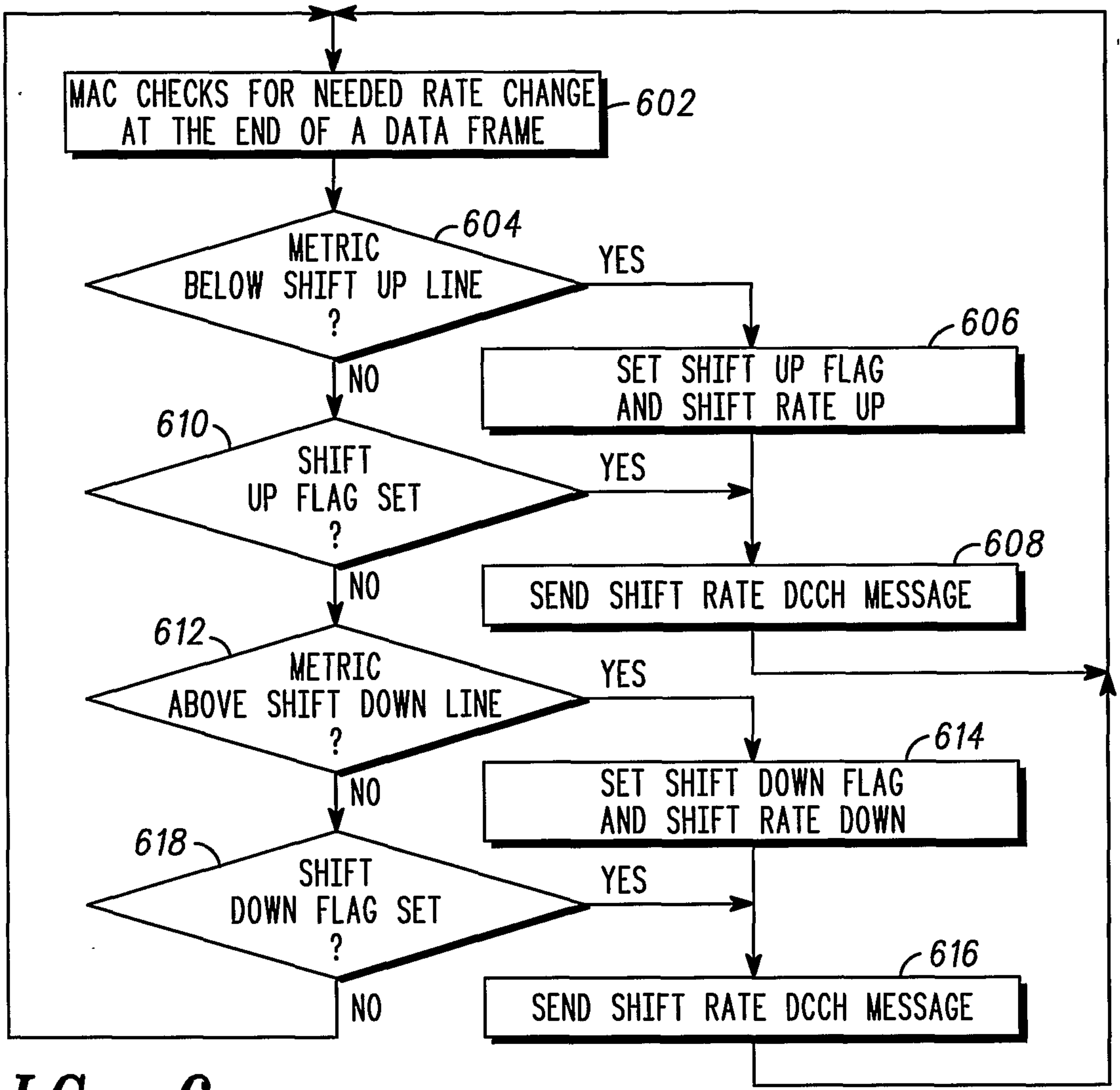

MAC CHECKS FOR NEEDED RATE CHANGE AT THE END OF A DATA FRAME
602
METRIC BELOW SHIFT UP LINE ?
604
YES
NO
SET SHIFT UP FLAG AND SHIFT RATE UP
606
SHIFT UP FLAG SET ?
610
YES
NO
SEND SHIFT RATE DCCH MESSAGE
608
METRIC ABOVE SHIFT DOWN LINE ?
612
YES
NO
SET SHIFT DOWN FLAG AND SHIFT RATE DOWN
614
SHIFT DOWN FLAG SET ?
618
YES
NO
SEND SHIFT RATE DCCH MESSAGE
616

FIG. 6

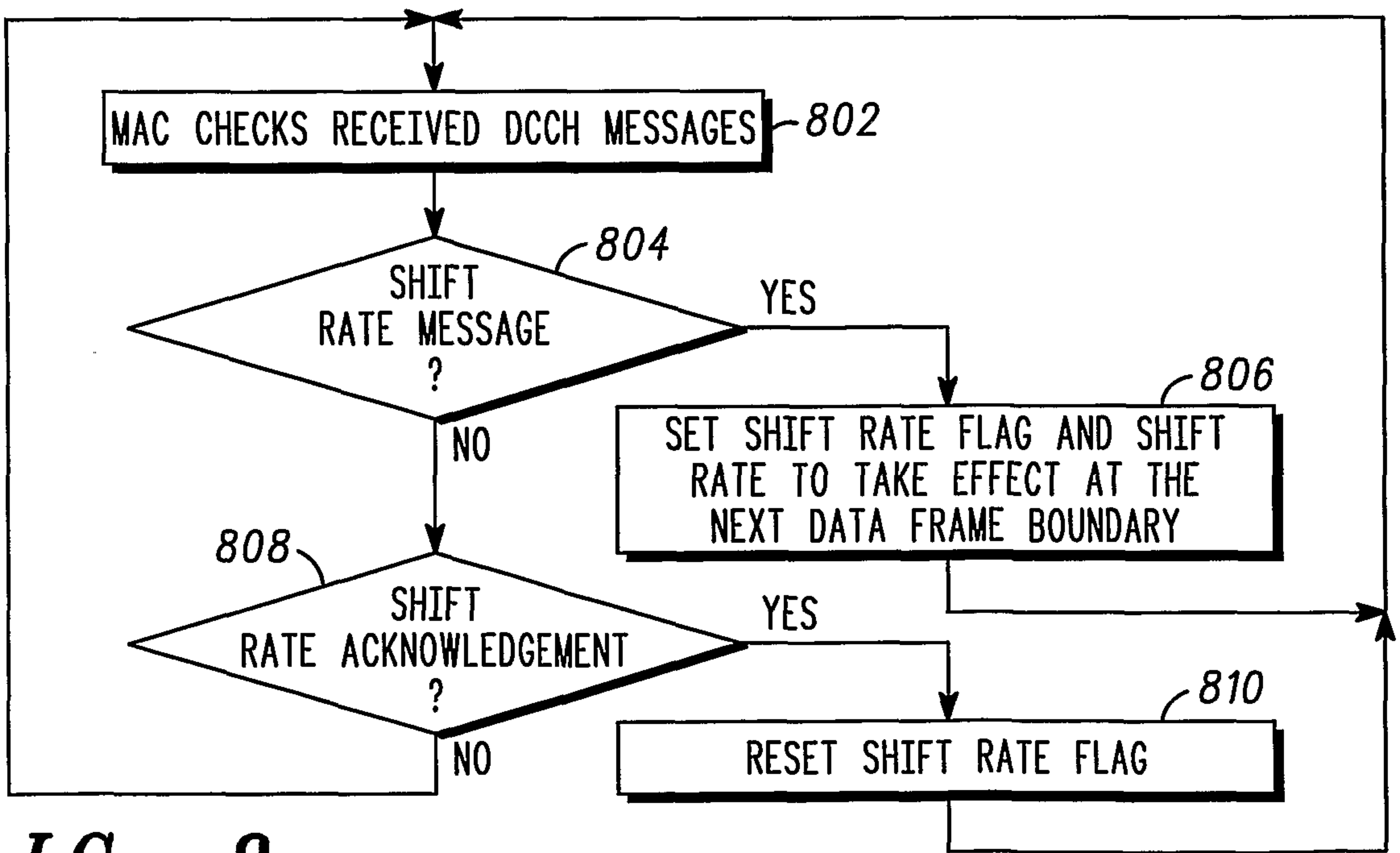

MAC CHECKS RECEIVED DCCH MESSAGES
802
SHIFT RATE MESSAGE ?
804
YES
NO
SET SHIFT RATE FLAG AND SHIFT RATE TO TAKE EFFECT AT THE NEXT DATA FRAME BOUNDARY
806
SHIFT RATE ACKNOWLEDGEMENT ?
808
YES
NO
RESET SHIFT RATE FLAG
810

FIG. 8

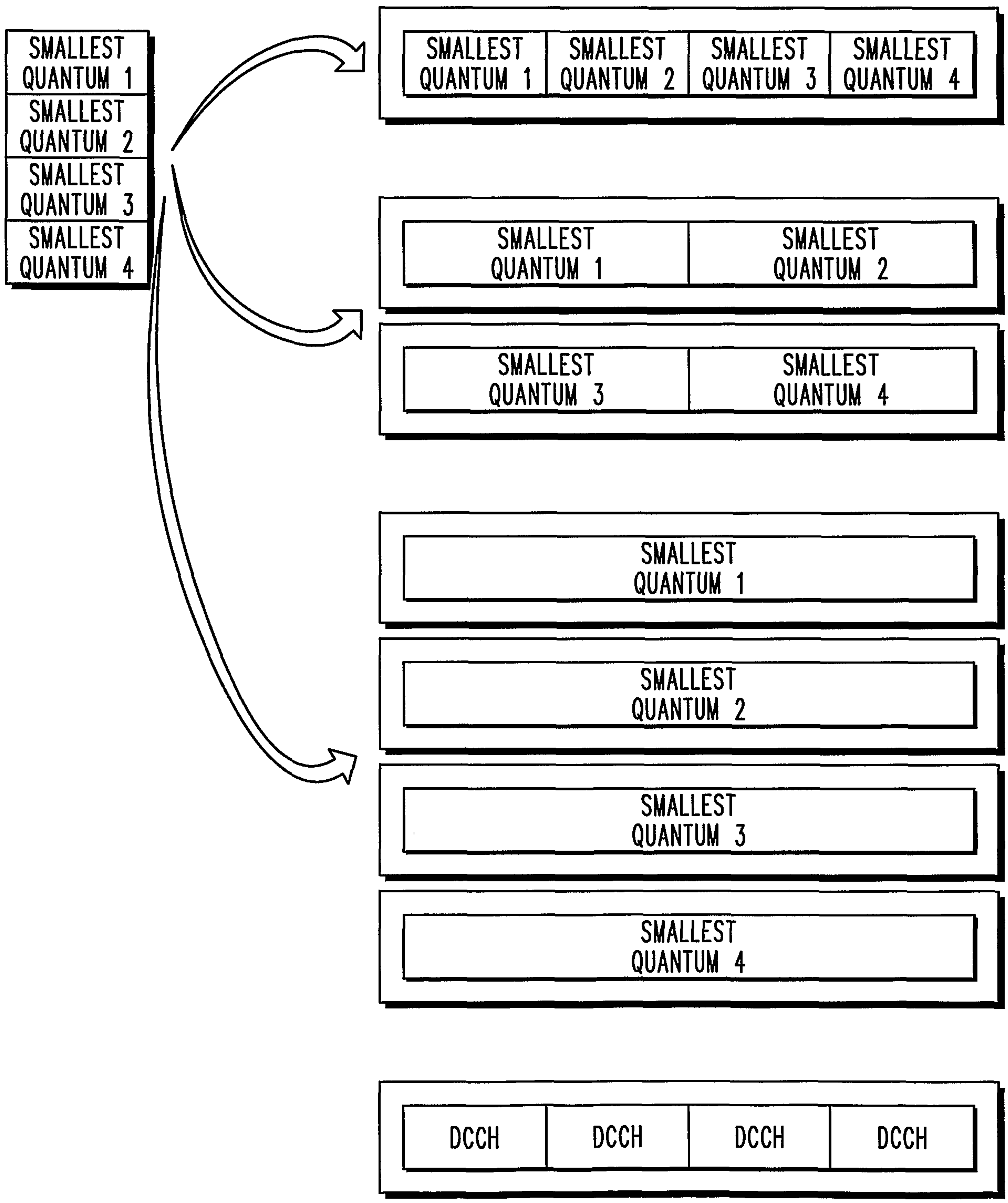
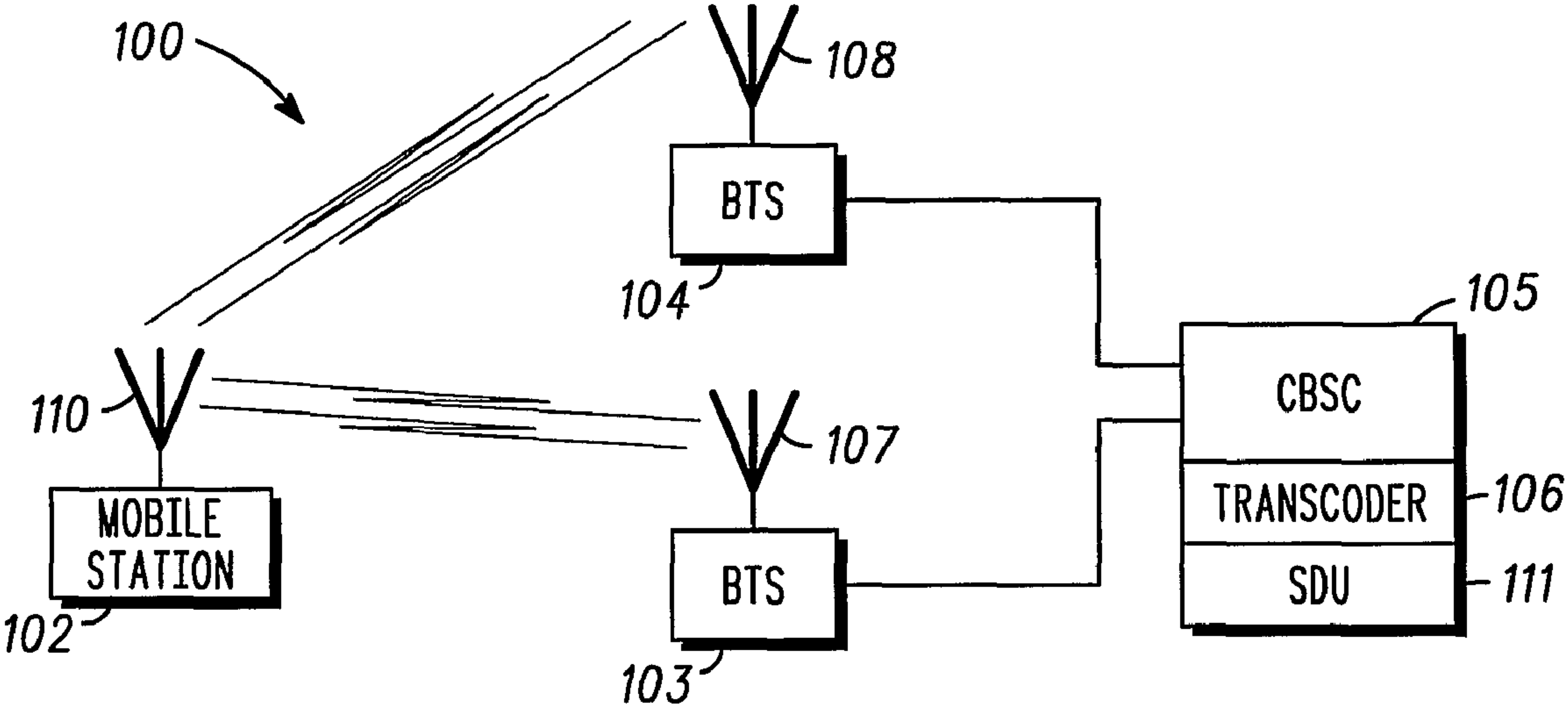

SMALLEST QUANTUM 1
SMALLEST QUANTUM 2
SMALLEST QUANTUM 3
SMALLEST QUANTUM 4
SMALLEST QUANTUM 1
SMALLEST QUANTUM 2
SMALLEST QUANTUM 3
SMALLEST QUANTUM 4
SMALLEST QUANTUM 1
SMALLEST QUANTUM 2
SMALLEST QUANTUM 3
SMALLEST QUANTUM 4
SMALLEST QUANTUM 1
SMALLEST QUANTUM 2
SMALLEST QUANTUM 3
SMALLEST QUANTUM 4
DCCH
DCCH
DCCH
DCCH

FIG. 9


100
108
BTS
104
105
CBSC
110
107
TRANSCODER
106
MOBILE
STATION
BTS
SDU
111
102
103