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(54) Title: A METHOD AND AN APPARATUS FOR IMPROVING STABILITY AND CAPACITY IN CDMA MEDIUM DATA RATE SYSTEMS

(57) Abstract: A novel method and apparatus for achieving optimum capacity and stability in IS-95-B based medium data rate systems. Each user served by a base station is allocated a constant portion of available transmission power. A data are transmitted to each user at this allocated transmission power and a data rate is varied in accordance with the user's channel condition. This strategy removes the variation in transmission power when a user switches between a maximum and minimum rate, thus increasing stability and capacity of the system. The capacity is further increased by allocating a constant portion of a total available transmission power of a base station is allocated to a power for data transmission power for data transmission on a fundamental forward channel and a power for transmission on supplemental forward channels. Each user is allocated one fundamental channel. Rate of transmission of data to a user is varied by allocating supplemental forward channels based on the RF conditions of a communication link and the required data rate of each of the user. The allocation is controlled by a scheduling method. In another aspect of the invention the base station, transmitting on a fixed power is allowed to gradually adjust this fixed power to allow changes in a long term data throughput.

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A METHOD AND AN APPARATUS FOR IMPROVING STABILITY AND CAPACITY IN CDMA MEDIUM DATA RATE SYSTEMS

BACKGROUND OF THE INVENTION

I. Field of the Invention

The current invention relates to communications. More particularly, the present invention relates to method and apparatus for managing Medium Data Rate (MDR) radio frequency power in a CDMA communication system in order to improve the system's capacity and stability.

II. Description of the Related Art

The use of code division multiple access (CDMA) modulation techniques is one of several techniques for facilitating communications in which a large number of system users are present. Although other techniques such as time division multiple access (TDMA), frequency division multiple access (FDMA), and AM modulation schemes such as amplitude companded single sideband (ACSSB) are known, CDMA has significant advantages over these other techniques. The use of CDMA techniques in a multiple access communication system is disclosed in U.S. Patent No. 4,901,307, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS," and assigned to the assignee of the present invention and incorporated by reference herein. The use of CDMA techniques in a multiple access communication system is further disclosed in U.S. Patent No. 5,103,459, entitled "SYSTEM AND METHOD FOR GENERATING SIGNAL WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM", assigned to the assignee of the present invention and incorporated by reference herein. The CDMA system can be designed to conform to the "TIA/EIA/IS-95 Mobile

Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System", hereinafter referred to as the IS-95 standard.

The CDMA system is a spread spectrum communication system. The benefits of spread spectrum communication are well known in the art and can be appreciated by reference to the above-cited references. CDMA, by its inherent nature of being a wideband signal, offers a form of frequency diversity by spreading the signal energy over a wide bandwidth. Therefore, frequency selective fading affects only a small part of the CDMA signal bandwidth. Space or path diversity is obtained by providing multiple signal paths through simultaneous links to a mobile user or remote station through two or more base stations. Furthermore, path diversity may be obtained by exploiting the multipath environment through spread spectrum processing by allowing signals arriving with different propagation delays to be received and processed separately. Examples of path diversity are illustrated in U.S. Patent No. 5,101,501 entitled "METHOD AND SYSTEM FOR PROVIDING A SOFT HANDOFF IN COMMUNICATIONS IN A CDMA CELLULAR TELEPHONE SYSTEM," and U.S. Patent No. 5,109,390 entitled "DIVERSITY RECEIVER IN A CDMA CELLULAR TELEPHONE SYSTEM," both assigned to the assignee of the present invention and incorporated by reference herein.

Code division multiple access communications systems have been standardized in the United States in Telecommunications Industry Association TIA/EIA/IS-95-B, entitled "MOBILE STATION-BASE STATION COMPATIBILITY STANDARD FOR DUAL-MODE WIDEBAND SPREAD SPECTRUM CELLULAR SYSTEMS", incorporated by reference herein, and hereinafter referred to as IS-95-B.

EIA/TIA IS-95-A with TSB-74 and ANSI J-STD-008 (IS-95-A) introduced standardized CDMA communication networks carrying basic rate voice and data traffic. EIA/TIA IS-95-B (IS-95-B) augmented this basic capability with support for MDR by allowing a base station to communicate with a mobile station using up to 8 parallel forward and up to 8 parallel reverse links. The description of a set of procedures used in the transmission of packet data in an

IS-95-B system. Telecommunications Industry Association Interim Standard TIA/EIA/IS-707-A, entitled "DATA SERVICE OPTIONS FOR SPREAD SPECTRUM SYSTEMS", hereinafter referred to as IS-707.

Radio Link Protocol (RLP) is described in TIA/EIA/IS-707-A.8, entitled "DATA SERVICE OPTIONS FOR SPREAD SPECTRUM SYSTEMS: RADIO LINK PROTOCOL TYPE 2", hereinafter referred to as RLP2, and incorporated herein by reference. RLP2 incorporates an error control protocol with frame retransmission procedures over the IS-95-B framing layer. RLP is of a class of error control protocols known as NAK-based ARQ protocols, which are well known in the art. The IS-707 RLP, facilitates the transmission of a byte-stream, rather than a series of voice frames, through an IS-95-B communication system.

Several protocol layers typically reside above the RLP layer. IP datagrams, for example, are typically converted into a Point-To-Point Protocol (PPP) byte stream before being presented as a byte stream to the RLP protocol layer. As the RLP layer ignores the protocol and framing of higher protocol layers, the stream of data transported by RLP is said to be a "featureless byte stream".

RLP was originally designed to satisfy the requirements of sending large datagrams through an IS-95 channel with wireline reliability. For example, if an IP datagram of 500 bytes were to be simply sent in IS-95-B frames carrying 20 bytes each, the IP datagram would fill 25 consecutive IS-95 frames. Without some kind of error control layer, all 25 of these RLP frames would have to be received without error in order for the IP datagram to be useful to higher protocol layers. On an IS-95 channel having a 1% frame error rate, the effective error rate of the IP datagram delivery would be $(1 - (0.99)^{25})$, or 22%. This is a very high error rate compared to most networks used to carry Internet Protocol traffic. RLP was designed as a link layer protocol that would decrease the error rate of IP traffic to be comparable to the error rate typical of a 10Base2 ethernet channel.

The International Telecommunications Union recently requested the submission of proposed methods for providing high rate data and high-quality speech services over wireless communication channels. A first of these proposals was issued by the Telecommunications Industry Association, entitled "The cdma2000 ITU-R RTT Candidate Submission. The Telecommunications Industry Association is currently developing the cdma2000 proposal as interim standard TIA/EIA/IS-2000, and hereinafter referred to as cdma2000. A second of these proposals was issued by the European Telecommunications Standards Institute (ETSI), entitled "The ETSI UMTS Terrestrial Radio Access (UTRA) ITU-R RTT Candidate Submission", also known as "wideband CDMA" and hereinafter referred to as W-CDMA. A third proposal was submitted by U.S. TG 8/1 entitled "The UWC-136 Candidate Submission", hereinafter referred to as EDGE. The contents of these submissions is public record and is well known in the art.

RLP2 was designed for use with IS-95-B. A new RLP designed for use with cdma2000 is described in TIA/EIA/IS-707-A-1.10, entitled "DATA SERVICE OPTIONS FOR SPREAD SPECTRUM SYSTEMS: RADIO LINK PROTOCOL TYPE 3", hereinafter referred to as RLP3E, and incorporated herein by reference.

The IS-95-A voice systems rely on the large number of uncorrelated users per cell per carrier and on the well-behaved Markov voice statistics for both radio-frequency (RF) capacity and RF stability. The large number of uncorrelated well-behaved users result in a forward link RF transmit power distribution that is predictably stationary and has a log-normal distribution. Without this forward link RF power predictability, forward link power control and mobile assisted handoff would likely become unstable.

Unfortunately packet data traffic is not as well behaved. Data traffic often comes in bursts, resulting in relatively long periods of maximum rate transmission followed by relatively long periods of minimum rate transmission. With the advent of medium data rate in IS-95-B, these effects become even more pronounced. The multiple links of a medium rate user are correlated. Unlike uncorrelated voice links, the data links switch between maximum rate and minimum rate as well as power control together. This makes the forward link

RF transmit power distribution decidedly non-stationary and non-log-normal, and, consequently, potentially unstable.

Therefore, there exists a need to address the issue of network stability and capacity, without changing the IS-95-B air interface standard, when MDR is used.

SUMMARY OF THE INVENTION

The present invention is directed to a novel method and apparatus for achieving optimum capacity and stability in IS-95-B based medium data rate systems. In accordance with the present invention, a constant portion of a total available transmission power of a base station is allocated to each user. A data are transmitted to each user at this allocated transmission power and a data rate is varied in accordance with the user's channel condition.

In accordance with another aspect of the present invention, a constant portion of a total available transmission power of a base station is allocated to a power for data transmission on a fundamental forward channel and a power for transmission on supplemental forward channels. Each user is allocated one fundamental channel. Rate of transmission of data to a user is varied by allocating supplemental forward channels based on the RF conditions of a communication link and the required data rate of each of the user.

In another aspect of the invention the base station, transmitting on a fixed power is allowed to gradually adjust this fixed power to allow changes in a long term data throughput.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

FIG. 1 is a histogram illustrating a power allocation to a user.

FIG. 2 is a histogram illustrating a power allocation to a base station.

FIG. 3 shows an exemplary embodiment of a terrestrial wireless communication system.

FIG. 4 shows an exemplary embodiment of a base station in accordance with one embodiment.

FIGS. 5A-D show exemplary embodiments of a flowchart in accordance with one embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 illustrates an embodiment of the present invention that uses a data transmission at constant power level per user, and variable a data rate, depending on the user's RF link condition. This is a viable option because unlike voice service, which require a guaranteed minimum bandwidth and maximum delay, packet data users have less stringent Grade of Service (GoS) requirements. In accordance with one embodiment, a packet data call, in addition to being granted one or more forward code channels, is also granted a fixed total power. **FIG. 1a** shows a total power allocated for transmission at medium data rate $\mathbf{P}_{TMDR}$. This power satisfies Equation 1:

$$P_{TMDR} = \sum_{i=1}^{N} P_{TUi} , \qquad (1)$$

where P_{TUi} is a total power allocated to user i, and N is number of users.

FIG. 1b shows allocation of the total power P_{TMDR} between a power available for fundamental forward channel P_{FU} and a power available for M supplemental forward channels P_{SU}. The allocation is executed in a manner satisfying the following equation:

$$P_{TU_i} = P_{FU_i} + \sum_{j=1}^{M_i} P_{SU_{i,j}} \qquad (2)$$

where P_{TU_i} is the total power for user i, and M_i is number of supplemental forward channels for user i.

The call is initiated by the user on the fundamental forward channel at a low enough data rate to ensure that the fundamental forward channel power control variation does not exceed the allocated user power $\mathbf{P}_{FU}$. The power level of a supplemental forward channel $\mathbf{P}_{SU}$ is then set based on the fundamental channel power $\mathbf{P}_{FU}$. Equation (2) is then utilized to determine the maximum number of supplemental channels that can be used. Because the forward channel power control acts only on the fundamental forward channel, Equation (2) and the maximum number of supplemental channels is used to adjust the power level of a supplemental forward channel $\mathbf{P}_{SU}$. If no data are transmitted on supplemental forward channels (because there is not enough power or because all data can be transmitted on the fundamental forward channel), then an empty supplemental forward channel, with enough power to ensure that Equation (2) is satisfied, is transmitted. If the demanded transmitted data rate requires power in excess of the total user power $\mathbf{P}_{TU}$, a low enough data rate is transmitted to keep the required power below the total power. The low data rate is achieved first by using fewer supplemental forward channels, then by using a less than full rate fundamental forward channel. The Radio Link Protocol (RLP) sequence numbers allow the mobile station to determine whether supplemental forward channel erasures are the result of packets being erased or packets not being sent.

Transmitting with "constant user power" reduces the base station transmit power variations caused by power control and data activity. However, because the method requires the user to transmit waste power when it has no data to transmit, it is not efficient. The greater the difference between the minimum and maximum user data rate, the greater the potential inefficiency. Therefore, in another embodiment of the present invention, the base station allows for time sharing of the forward link medium data rate power P_{TMDR}. The base station assigns a unique fundamental forward channel to each medium rate packet data user. Next, the base station assigns a number from zero to maximum number of allocable supplemental forward channel(s) to each of the medium rate packet data users. In one embodiment, the maximum number of allocable supplemental forward channels per user is seven. The supplemental forward channel(s) may be assigned to multiple users at the same time. The base station schedules the use of the supplemental forward channels by covering each frame of a supplemental forward channel by a particular user's long code. Consequently, all users not utilizing the particular long code will be unable to decode the frame of a supplemental channel intended for other users. **FIG. 2** illustrates power allocation in this situation. **FIG. 2a** shows a total power allocated for transmission of medium data rate $\mathbf{P}_{TMDR}$. This power satisfies Equation 3:

$$P_{TMDR} = \sum_{i=1}^{N} P_{TUi} = \sum_{i=1}^{N} P_{FU_i} + \sum_{i=1}^{N}\sum_{j=1}^{M_j} P_{SU_{i,j}}, \qquad (3)$$

where P_{Tui} is a total power allocated to user i, and N is number of users.

FIG. 2b shows an allocation of the total power for transmission of medium data rate $\mathbf{P}_{TMDR}$ between the supplemental and fundamental forward channels. Since N users were assumed, the power allocated to fundamental forward channels $\mathbf{P}_{TF}$ comprises a sum of the powers available for the fundamental forward channel P_{FU} for each user, thus:

$$P_{TF} = \sum_{i=1}^{N} P_{FUi}. \qquad (4)$$

This is illustrated by the right column of the histogram of **FIG. 2b**. The left column of the histogram of **FIG. 2b** illustrates the power allocated for the supplemental forward channels $\mathbf{P}_{TS}$. Note that in accordance with the principle of adjusting data rate to use available power, there is no predetermined allocation of the power $\mathbf{P}_{TS}$ for the supplemental forward channels CH_i among the N users. The M supplemental forward channels CH_i are available to all the users on an as-needed basis. Thus, as the demand on data rate for a particular user increases, the user is allocated additional channel(s) from the power for the supplemental forward channels $\mathbf{P}_{TS}$. However, a user cannot utilize more supplemental forward channels than were assigned to the user. Conversely, when the demand on data rate for a particular user decreases, the user is directed to release its supplemental forward channel(s) for the use of another user. The rate of allocation and deallocation must be selected so as not to disturb the power control. The power allocation among the users must satisfy equation (5):

$$P_{TMDR} = P_{TF} + P_{TS} . \qquad (5)$$

Transmitting with "constant user power" and "shared supplemental forward channels" reduces the base station transmit power variation due to per user power control and per user data activity. However, it does not eliminate short-term variations in transmission power due to changes in data activity and long-term variations in transmission power caused by changes in demand for data. In accordance with another embodiment of the present invention, the variation in transmission power due to changes in data activity is eliminated by the base station transmitting at a "fixed" power level by sending, on unused forward channels, power equal to the difference between power required for data transmission and the "fixed" power level. Because users may have different frame offsets, the extra power sent must be adjusted every power control group. For explanation of power control refer to the aforementioned IS-95 standard. The variations due to demand for data are mitigated by adjusting the "fixed" power level. Thus, when a demand for data decreases, the base station decreases the amount of "fixed" power allocated for the data services.

In one embodiment, the change in the "fixed" power happens gradually to prevent disturbing the power control method. In one embodiment of the invention, the "fixed" transmit power level is controlled by an outer power control loop. This outer power control loop adjusts the fixed transmit power level such that the fixed level does not saturate too often. An additional margin in such adjustment over the exact amount of "fixed" power allows for the arrival of new users into the base station.

FIG. 3 shows an exemplary embodiment of a terrestrial wireless communication system, represented by a base-station (BS) **302** and a remote-station (RS) **304**, communicating over a forward link **306**, carrying information from BS **302** to RS **304**, and a reverse link **308**, carrying information from RS **304** to BS **302**. Each link **306, 308** comprises one fundamental forward channel and at least one supplemental forward channel. The RS **304** can be any number of wireless communication devices including, but not being limited, to cellular phones, wireless local loop phones, personal digital assistant, and wireless modem.

FIG. 4 shows an exemplary embodiment of a transmitting station. The information to be transmitted is generated by a data source **402**, and is provided to a memory **404**. Memory **404** serves as a buffer, preventing data loss when data source **402** provides more data than can be transmitted. The data from the memory **404** is provided to a de-multiplexer **406**, which de-multiplexes the data in accordance with a signal **408** provided by control circuitry **410**. The de-multiplexed data are provided to channel elements **412a** through **412h**, that partition the data, CRC encode the data, and insert code tail bits as required by the system.

Channel elements **412a** through **412h** then convolutionally encode the data, CRC parity bits, and code tail bits, interleave the encoded data, scramble the interleaved data with a user's long pseudonoise (PN) sequence, and cover the scrambled data with a Walsh sequence. Channel elements **412a** through **412h** then provide the covered data to spreaders **414a** through **414h**, respectively, which spread the data with short in-phase pseudonoise (PN_I) and quadrature-phase pseudonoise (PN_Q) sequences. For more details refer to the aforementioned IS-95 standard. The spread data are then filtered in filters **416a** through **416h** and the filtered data are provided to gain stages **418a** through **418h**, which scale the data in response to signals **420a** through **420h** from control circuitry **410**. The control circuitry **410** can be any device capable of performing a function of producing signals **420a** through **420h.** Such device includes, e.g., a programmable logic array, application specific circuit, a digital signal processor, and the like. The scaled data are summed in summer **422**, and provided to a modulator **424,** which upconverts the data with in-phase and quadrature-phase sinusoids. The upconverted signal is provided to a gain stage **426** for scaling. The scaled signal is filtered and amplified in block **430.** The signal is transmitted over the forward channel **306** if the transmitting station is a BS, or reverse channel **308** if the transmitting station is a RS, through an antenna **432**.

A feedback signal from a receiving station (not shown) is received by an antenna **434,** and is provided to a receiver **436**. Receiver **436** filters, amplifies, downconverts, quadrature demodulates, and digitizes the received signal. The digitized signal is provided to a demodulator **438,** which despreads the data with the short PN_I and PN_Q sequences, and decovers the despread data with a user long PN sequence. The descrambled (or demodulated) data is provided to decoder **440,** which performs the inverse of the encoding performed within channel element **412**. The decoded data is provided to data sink **442**, and the control circuitry **410**.

Fig. 5 is a flowchart illustrating a process of accomplishing stability and capacity control in accordance with one embodiment.

The process starts in step **500,** in which a transmitting station is initialized into a state of readiness to provide services to users. The initialization process may include initial allocation of the total transmit power of the transmitting station. In accordance with one embodiment of the invention, the total transmit power is permanently allocated between voice services and data services. In another embodiment, the allocation of the total transmit power dynamically changes between voice services and data services. For the purposes of an explanation of the power allocation, it is assumed that the transmitting station supports several voice calls and several data users.

In step **502**, the transmitting station receives a request for data services, which is forwarded to step **504**. Step **504** represents an exemplary embodiment of a transmission scheduling method. Step **5042** makes a decision whether the request should be approved or not.

If the request is not approved, the request is forwarded for further transmission schedule processing in step **5044**. The re-scheduled request is forwarded to step **506**.

If the request is approved in step **5042**, the processing continues in step **506**.

Step **506** makes an inquiry whether a power sufficient to support additional user(s) is available. If the response is negative, the flow diagram enters step **508**.

In a variable power allocation embodiment, the function of step **508** is depicted in **Fig. 5a**. In step **50802**, an inquiry is made whether to reallocate power from voice services to data services. If the response is positive, a reallocation is carried out in step **50804**, and the flow continues in step **506** of **Fig. 5**. Referring back to **Fig. 5a**, if the response is negative, further inquiry is made in step **50806**, whether a maximum transmission power of the BS has been reached. If the response is positive, no power is available, and the request is forwarded to processing in step **50404**. If the response is negative, the BS will allocate portion of the total transmit power to the data services in step **50808**, and the flow continues in step **506** of **Fig. 5**.

In a permanent power allocation embodiment, the function of step **508** is depicted in **Fig. 5b**. Because no sharing with power allocated for voice services is allowed, inquiry is made in step **50810** whether a maximum transmission power of the BS has been reached. If the response is positive, no power is available, and the request is forwarded to processing in step **5044** of **Fig. 5**. Referring back to **Fig. 5b**, if the response is negative, the BS will allocate portion of the total transmit power to the data services in step **50812**, and the flow continues in step **506** of **Fig. 5**.

When the response to the sufficiency of power is positive in step **504**, the flow diagram enters step **510**.

Fig. 5c illustrates the function of step **510** in accordance with the embodiment of the present invention not incorporating the concept of supplemental forward channels sharing. As described with reference to **Figs. 1a, 1b**, data service user is allocated total user power P_{TU}, which comprises fundamental forward channel power P_{FU} and supplemental forward channel power P_{SU} in step **51002**. In step **51004**, a call is initiated on the fundamental forward channel at a low enough data rate to ensure that the fundamental forward channel forward power control variation does not exceed the allocated power $\mathbf{P_{FU}}$. Step **51006** performs a comparison of the requested data rate and the transmitted data rate. If the requested data rate is lower than or equal to the transmitted data rate, the power level of the empty supplemental forward channel $\mathbf{P_{SU}}$ is adjusted in step **51008** to ensure that total power $\mathbf{P_{TU}}$ is correct, i.e., Equation (1) is satisfied. When the requested data rate is higher than the transmitted data rate, additional supplemental forward channels are utilized in step **51010.** The power level of the supplemental forward channels $\mathbf{P_{SU}}$ is adjusted to ensure that total power $\mathbf{P_{TU}}$ is correct, i.e., Equation (1) is satisfied.

Fig. 5d illustrates the function of step **510** in accordance with an embodiment of the present invention incorporating the concept of supplemental forward channels sharing. As described in reference to **Fig. 2**, the data service user is allocated fundamental forward channel power P_{FU} in step **51012**. In step **51014**, a call is initiated on the fundamental forward channel at a low enough data rate to ensure that that the fundamental forward channel forward power control variation does not exceed the allocated power $\mathbf{P_{FU}}$. Step **51016** performs a comparison of the requested data rate and the transmitted data rate. If the requested data rate is lower or equal than the transmitted data rate, the power level of the supplemental forward channels $\mathbf{P_{SU}}$ is adjusted in step **51018**, to ensure that total power $\mathbf{P_{TU}}$ is correct, i.e., Equation (4) is satisfied.

When the requested data rate is higher than the transmitted data rate, additional supplemental forward channels are assigned from the pool of supplemental forward channels in step **51020.** The power level of the supplemental forward channels $\mathbf{P}_{SU}$ is adjusted to ensure that total power $\mathbf{P}_{TU}$ is correct, i.e., Equation (4) is satisfied.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

WHAT IS CLAIMED IS:

CLAIMS

1. A method for transmitting variable rate data in a communication system, comprising:

allocating a medium data rate transmission power among users of said communication system; and

transmitting data to at least one of said users over a radio-frequency link at said allocated transmission power.

2. The method of claim 1 wherein said medium rate data transmission power is an immutable allotment of a total transmission power.

3. The method of claim 1 wherein said medium rate data transmission power is a variable allotment of a total transmission power.

4. The method of claim 3 wherein said variable allotment is determined in accordance with demand for a data rate to be transmitted.

5. The method of claim 1 wherein allocating a medium data rate transmission power comprises:

apportioning said medium data rate transmission power between a first power pool for allocation to fundamental forward channels and a second power pool for allocation to supplemental forward channels; and

allocating at least a fundamental forward channel to each of said users.

6. The method of claim 5 wherein allocating at least one fundamental forward channel comprises:

allocating, from said first power pool, a first power required to support said fundamental forward channel;

determining a number of supplemental channels in accordance with a requested data rate and available power from said second power pool; and allocating, from said second power pool, a second power required to support said number of supplemental channels.

7. The method of claim 6 wherein determining a number of supplemental channels comprises:

initiating communication between a transmitting station and a receiving station on said fundamental forward channel at a data rate supportable by said first power;

determining a supplemental forward channel power in accordance with said first power; and

determining said number of supplemental forward channels in accordance with said determined supplemental forward channel power, said second power pool, and said requested rate.

8. The method of claim 7 wherein determining a number of supplemental channels is further carried out in accordance with maximum number of supplemental forward channels assigned to said user of said fundamental forward channel.

9. The method of claim 1 wherein allocating a medium rate data transmission power comprises:

apportioning an equal portion of said total medium data rate transmission power to each of said users;

apportioning said equal portion between a first power for a fundamental forward channel and a second power pool for allocation to supplemental forward channels; and

allocating said fundamental forward channel and at least one of said supplemental forward channels to each of said users.

10. The method of claim 9 wherein allocating at least one of said supplemental forward channels comprises:

determining number of supplemental forward channels in accordance with a requested data rate and available power in said second power pool;

allocating all power from said second power pool among said number of supplemental channels; and

allocating all power from said second power pool to one supplemental forward channel when said number equals zero.

11. The method of claim 10 wherein the step of determining number of said supplemental forward channels comprises the steps of:

initiating communication between a transmitting station and a receiving station on said fundamental forward channel at a data rate supportable by said first power;

determining a minimum supplemental forward channel power in accordance with said first power;

determining maximum number of supplemental forward channels in accordance with said minimum supplemental forward channel power and said second power pool;

determining said number of supplemental forward channels in accordance with said requested data rate and said maximum number of supplemental forward channels.

12. The method of claim 11 wherein determining maximum number of supplemental channels is further carried out in accordance with maximum number of supplemental forward channels assigned to said user of said fundamental forward channel.

13. The method of claim 1 wherein transmitting data comprises adjusting a rate of said data in accordance with said at least one user's channel condition.

14. The method of claim 1 wherein the step of transmitting data comprises the steps of:

adjusting a fundamental forward channel power in accordance with said at least one user's channel conditions; and

adjusting a supplemental forward channel power so that sum of said fundamental forward channel power and supplemental forward channel power equals said allocated transmission power.

15. An apparatus for transmitting variable rate data in a communication system, comprising:

a data source providing data to be transmitted;

a transmitter for transmitting said data; and

a control processor communicatively coupled to said transmitter configured to perform the functions of:

allocating a medium rate data transmission power among users of said communication system; and

causing said transmitter to transmit said data to at least one of said users over a radio-frequency link at said allocated transmission power.

16. The apparatus of claim 15 wherein the medium rate data transmission power is an immutable allotment of a total transmission power:

17. The apparatus of claim 15 wherein the medium data rate transmission power is a variable allotment of a total transmission power:

18. The apparatus of claim 17 wherein the control processor is further configured to perform the function of varying said variable allotment in accordance with demand for a data rate to be transmitted.

19. The apparatus of claim 15 wherein the control processor is configured to perform the function of allocating a medium data rate transmission power by performing the functions of:

apportioning said medium data rate transmission power between a first power pool for allocation to fundamental forward channels and a second power pool for allocation to supplemental forward channels; and

assigning at least a fundamental forward channel to each of said users.

20. The apparatus of claim 19 wherein the control processor is configured to perform the function of assigning at least one fundamental forward channel by performing the functions of:

allocating, from said first power pool, a first power required to support said fundamental forward channel;

determining a number of supplemental channels in accordance with a requested data rate and available power from said second power pool; and

allocating, from said second power pool, a second power required to support said number of supplemental channels.

21. The apparatus of claim 20 wherein wherein the control processor is configured to perform the function of determining a number of supplemental channels by performing the functions of:

initiating communication between a transmitting station and a receiving station on said fundamental forward channel at a data rate supportable by said first power;

determining a supplemental forward channel power in accordance with said first power; and

determining said number of supplemental forward channels in accordance with said determined supplemental forward channel power, said second power pool, and said requested rate.

22. The method of claim 21 wherein the control processor is configured to perform the function of determining a number of supplemental channels in accordance with maximum number of supplemental forward channels assigned to said user of said fundamental forward channel.

23. The apparatus of claim 15 wherein the control processor is configured to perform the function of allocating a medium data rate transmission power by:

apportioning equal portion of said total medium data rate transmission power to each of said users,

apportioning said equal portion between a first power for a fundamental forward channel and a second power for allocation to supplemental forward channels; and

allocating said fundamental forward channel and at least one of said supplemental forward channels to each of said users.

24. The apparatus of claim 23 wherein the control processor is configured to perform the function of allocating at least one supplemental forward channel by:

determining number of supplemental forward channels in accordance with a requested data rate and available power in said second power pool;

allocating all power from said second power pool among said number of supplemental channels; and

allocating all power from said second power pool to one supplemental forward channel when said number equals zero.

25. The apparatus of claim 24 wherein the control processor is configured to perform the function of determining number of said supplemental forward channels by:

initiating communication between a transmitting station and a receiving station on said fundamental forward channel at a data rate supportable by said first power;

determining a minimum supplemental forward channel power in accordance with said first power;

determining maximum number of supplemental forward channels in accordance with said minimum supplemental forward channel power and said second power pool;

determining said number of supplemental forward channels in accordance with said requested data rate and said maximum number of supplemental forward channels.

26. The apparatus of claim 11 wherein wherein the control processor is configured to perform the function of determining a number of supplemental channels in accordance with maximum number of supplemental forward channels assigned to said user of said fundamental forward channel.

27. The apparatus of claim 15 wherein the control processor is configured to perform the function of transmitting data by adjusting a rate of said data in accordance with said at least one user's channel condition.

28. The apparatus of claim 15 wherein the control processor is configured to perform the function of transmitting data by:

adjusting a fundamental forward channel power in accordance with said at least one user's channel conditions; and

adjusting a supplemental forward channel power so that sum of said fundamental forward channel power and supplemental forward channel power equals said allocated transmission power.

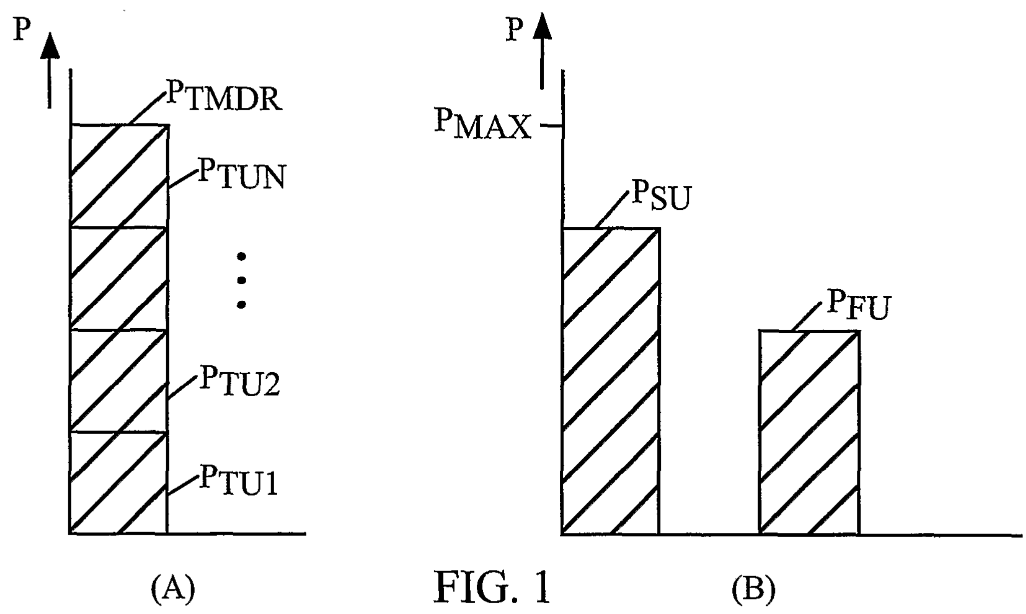

FIG. 1

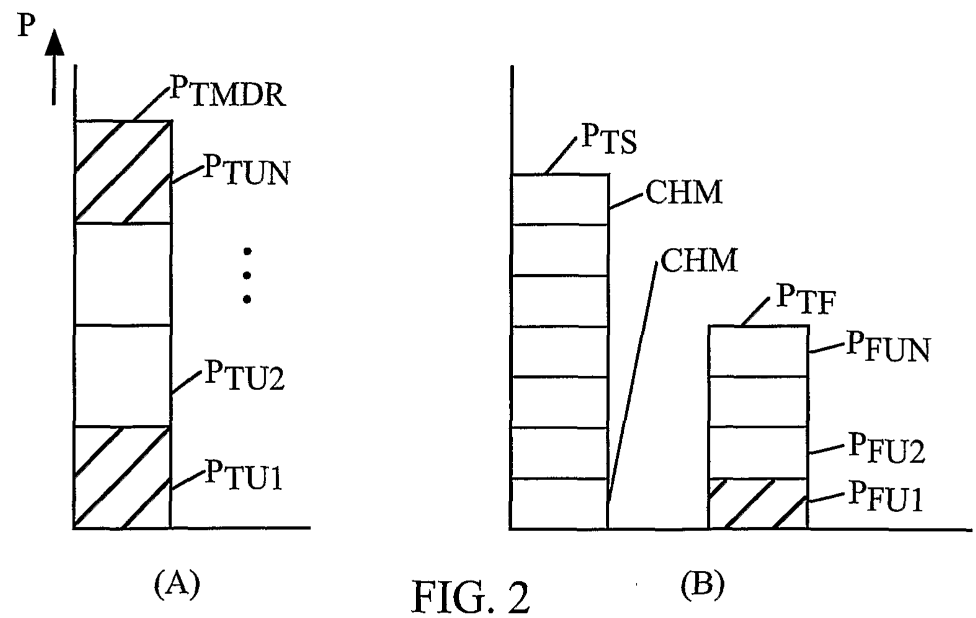

FIG. 2

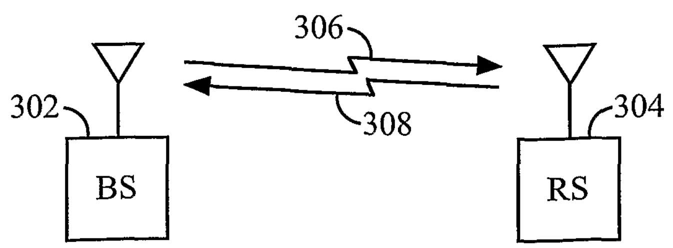

FIG. 3

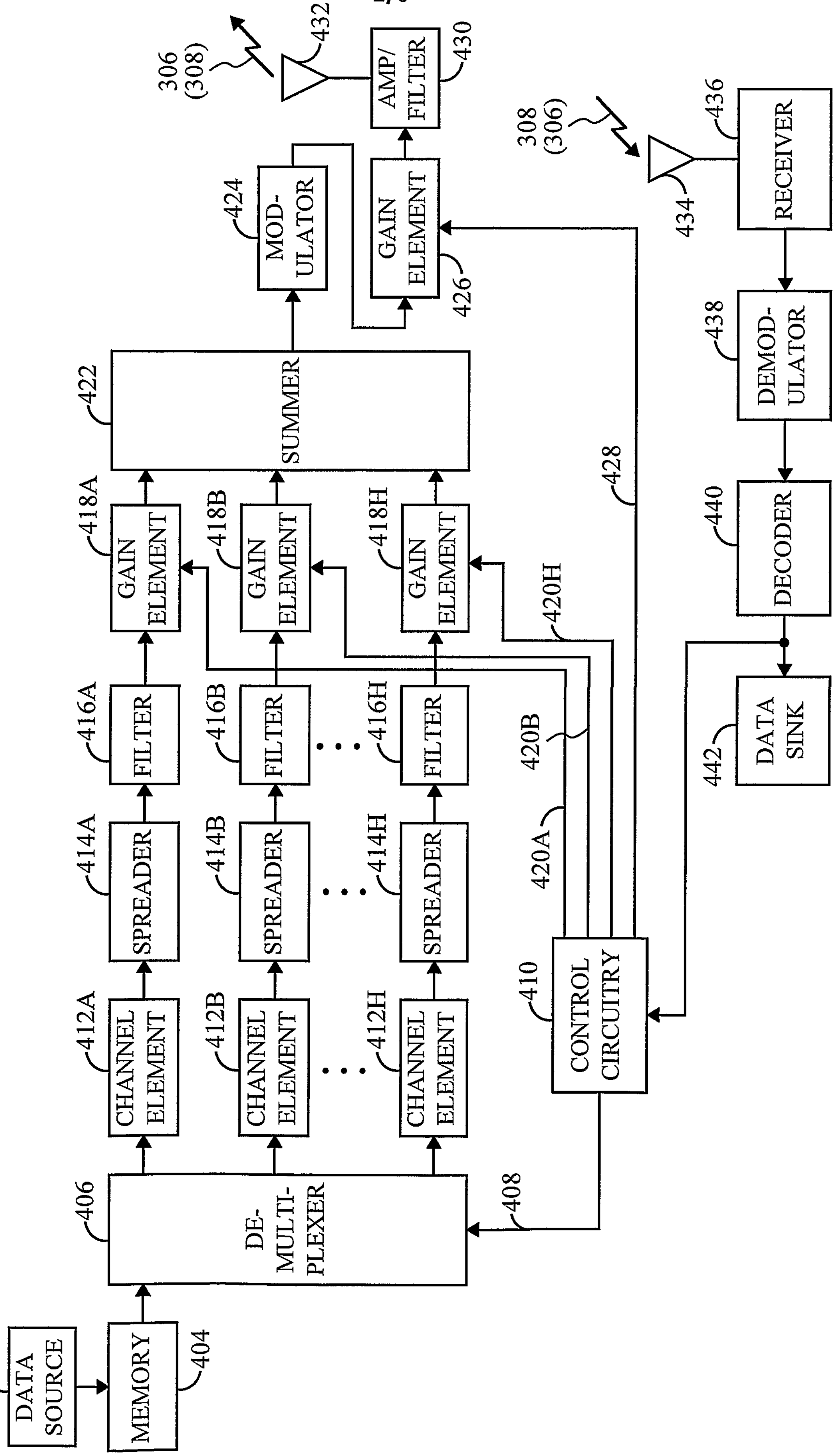
402
DATA SOURCE
404
MEMORY
406
DE-MULTI-PLEXER
408
412A
CHANNEL ELEMENT
412B
CHANNEL ELEMENT
412H
CHANNEL ELEMENT
414A
SPREADER
414B
SPREADER
414H
SPREADER
416A
FILTER
416B
FILTER
416H
FILTER
418A
GAIN ELEMENT
418B
GAIN ELEMENT
418H
GAIN ELEMENT
410
CONTROL CIRCUITRY
420A
420B
420H
428
422
SUMMER
424
MOD-ULATOR
426
GAIN ELEMENT
430
AMP/ FILTER
432
306 (308)
308 (306)
434
436
RECEIVER
438
DEMOD-ULATOR
440
DECODER
442
DATA SINK

FIG. 4

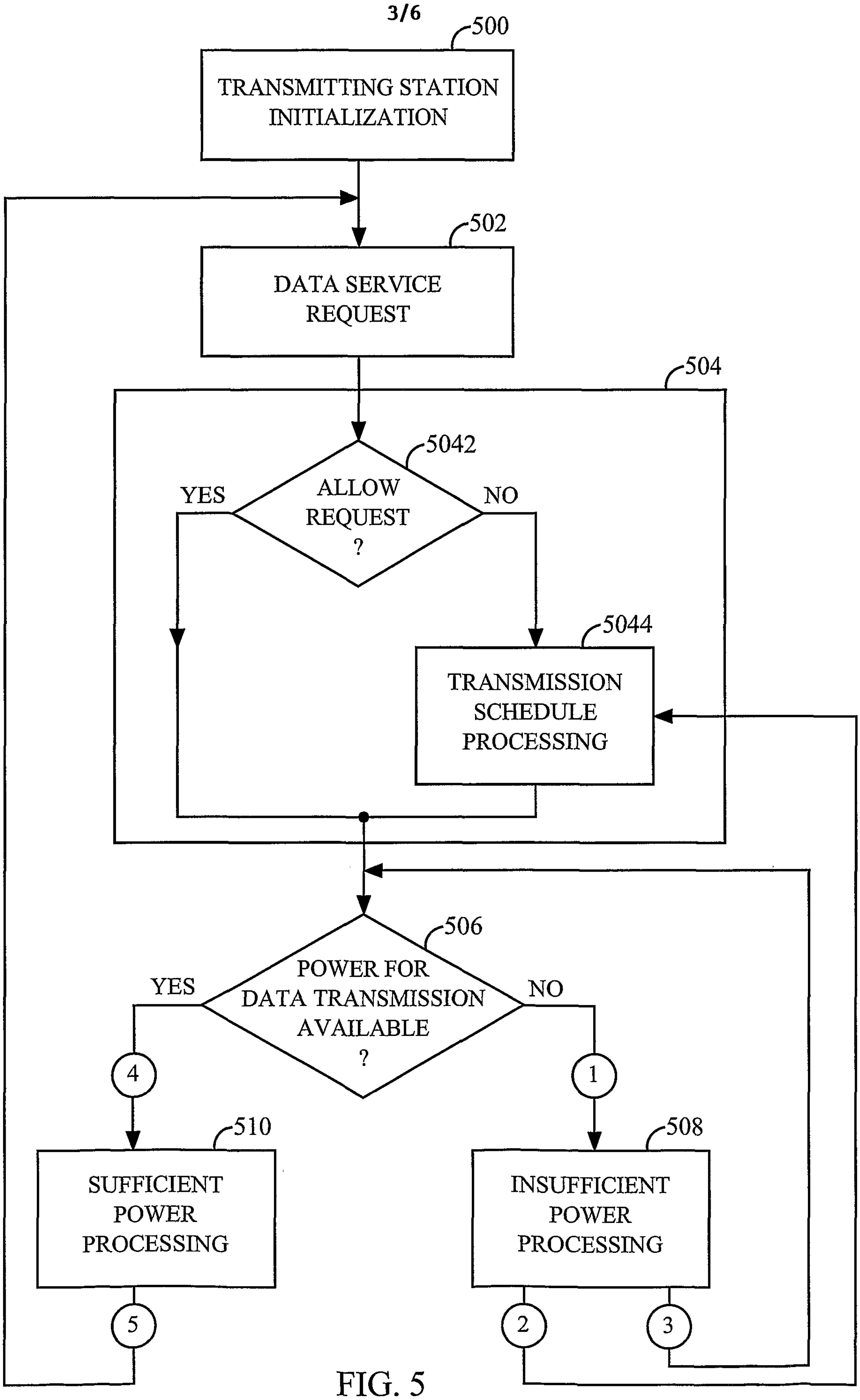
500
TRANSMITTING STATION INITIALIZATION
502
DATA SERVICE REQUEST
504
5042
ALLOW REQUEST ?
YES
NO
5044
TRANSMISSION SCHEDULE PROCESSING
506
POWER FOR DATA TRANSMISSION AVAILABLE ?
YES
NO
4
1
510
SUFFICIENT POWER PROCESSING
508
INSUFFICIENT POWER PROCESSING
5
2
3

FIG. 5

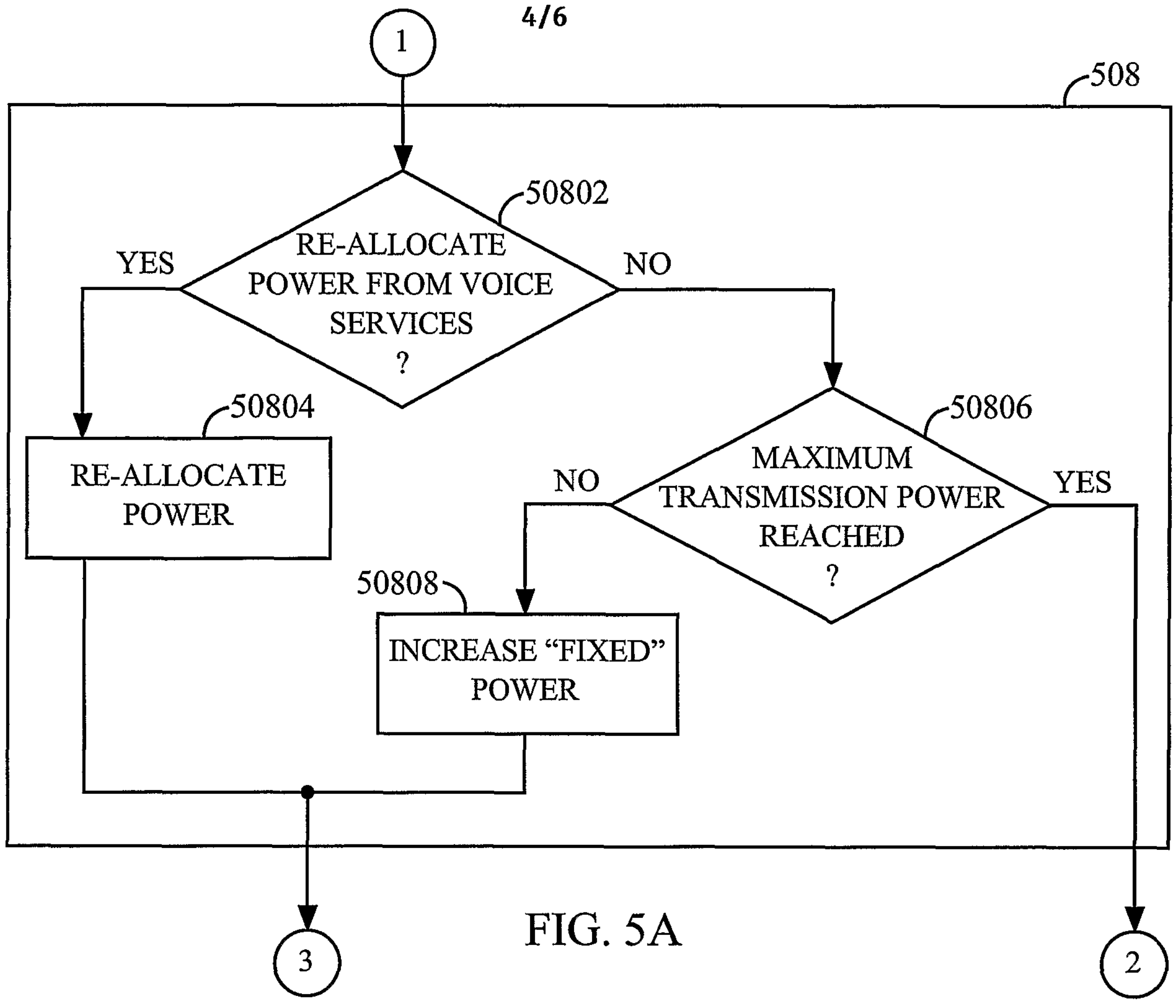
1
508
50802
RE-ALLOCATE POWER FROM VOICE SERVICES ?
YES
NO
50804
RE-ALLOCATE POWER
50806
MAXIMUM TRANSMISSION POWER REACHED ?
NO
YES
50808
INCREASE "FIXED" POWER
3
2

FIG. 5A

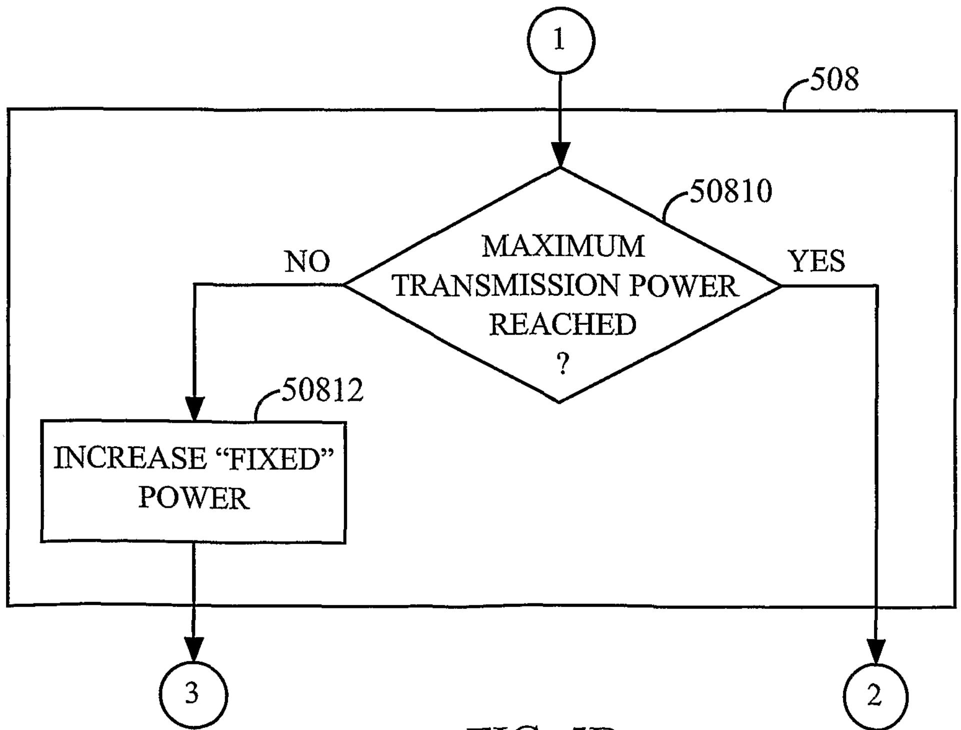
1
508
50810
MAXIMUM TRANSMISSION POWER REACHED ?
NO
YES
50812
INCREASE "FIXED" POWER
3
2

FIG. 5B

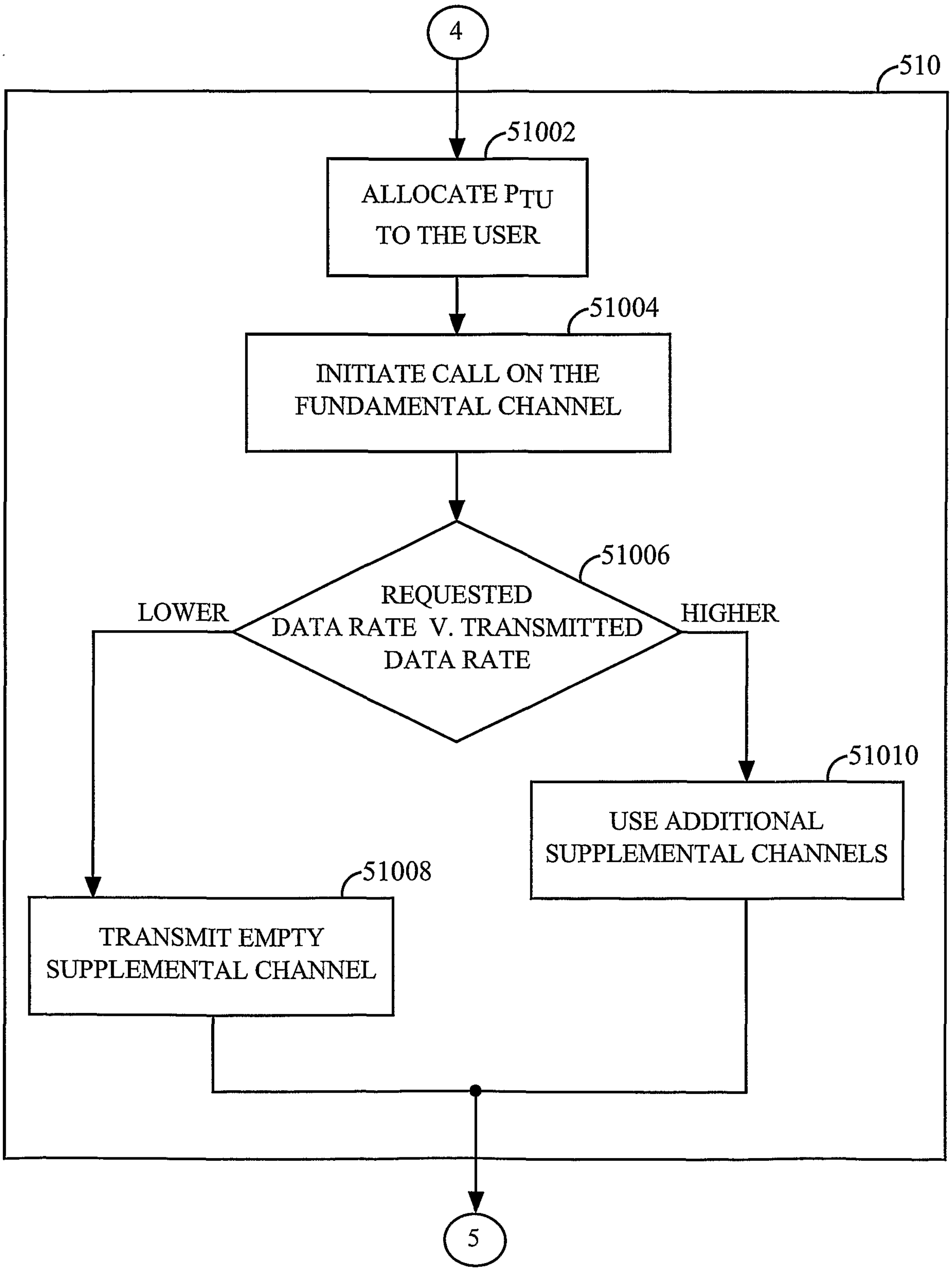
4
510
51002
ALLOCATE P_{TU} TO THE USER
51004
INITIATE CALL ON THE FUNDAMENTAL CHANNEL
51006
REQUESTED DATA RATE V. TRANSMITTED DATA RATE
LOWER
HIGHER
51010
USE ADDITIONAL SUPPLEMENTAL CHANNELS
51008
TRANSMIT EMPTY SUPPLEMENTAL CHANNEL
5

FIG. 5C

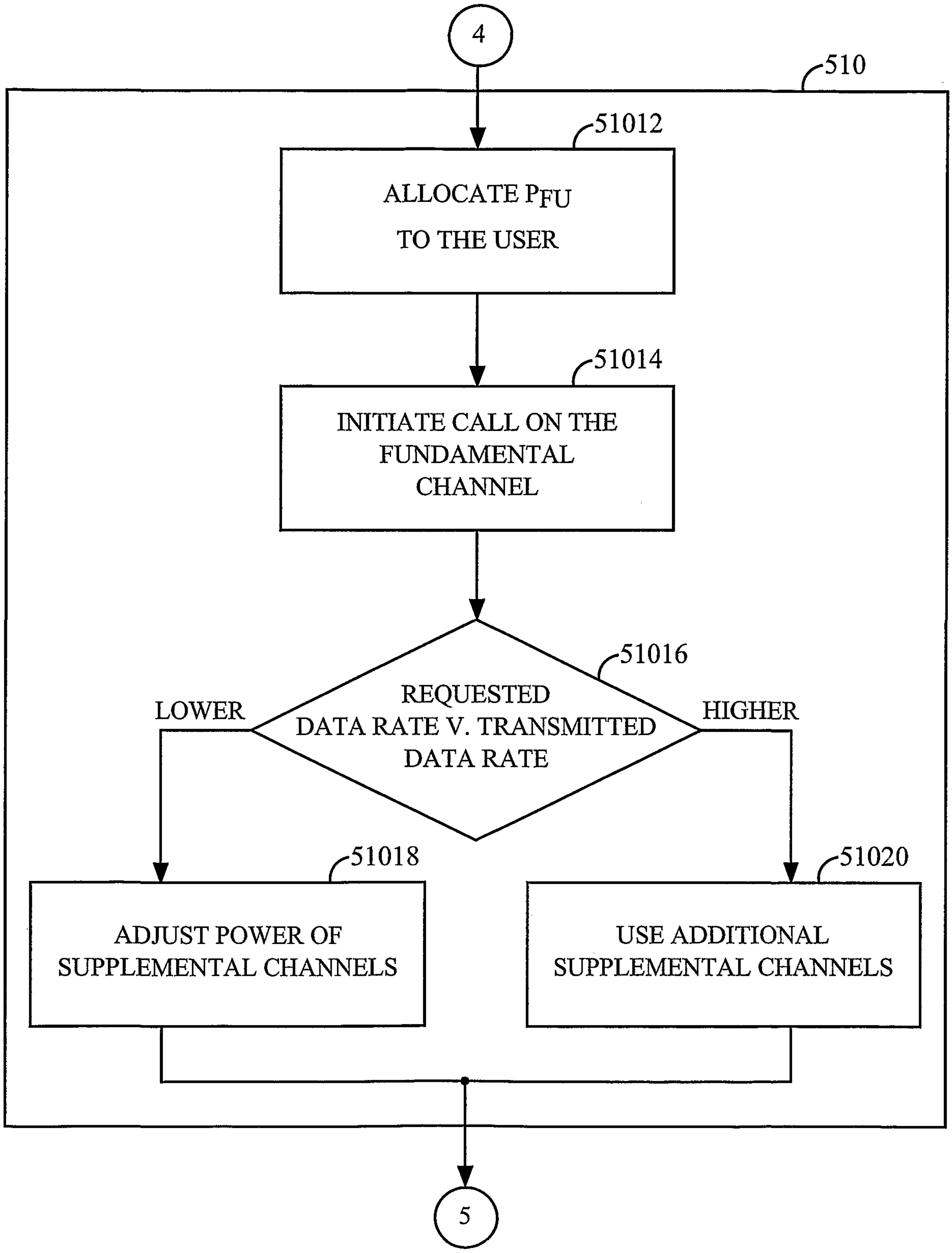
4
510
51012
ALLOCATE P_{FU}
TO THE USER
51014
INITIATE CALL ON THE
FUNDAMENTAL
CHANNEL
51016
REQUESTED
DATA RATE V. TRANSMITTED
DATA RATE
LOWER
HIGHER
51018
ADJUST POWER OF
SUPPLEMENTAL CHANNELS
51020
USE ADDITIONAL
SUPPLEMENTAL CHANNELS
5

FIG. 5D