US 20030190926A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2003/0190926 A1**

(43) **Pub. Date: Oct. 9, 2003**

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(54) **METHOD AND APPARATUS FOR TRANSMITTING DATA IN A PACKET DATA COMMUNICATION SYSTEM**

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(21) Appl. No.: **10/429,458**

(22) Filed: **May 5, 2003**

Related U.S. Application Data

(62) Division of application No. 09/971,430, filed on Oct. 5, 2001.

(60) Provisional application No. 60/311,702, filed on Aug. 10, 2001.

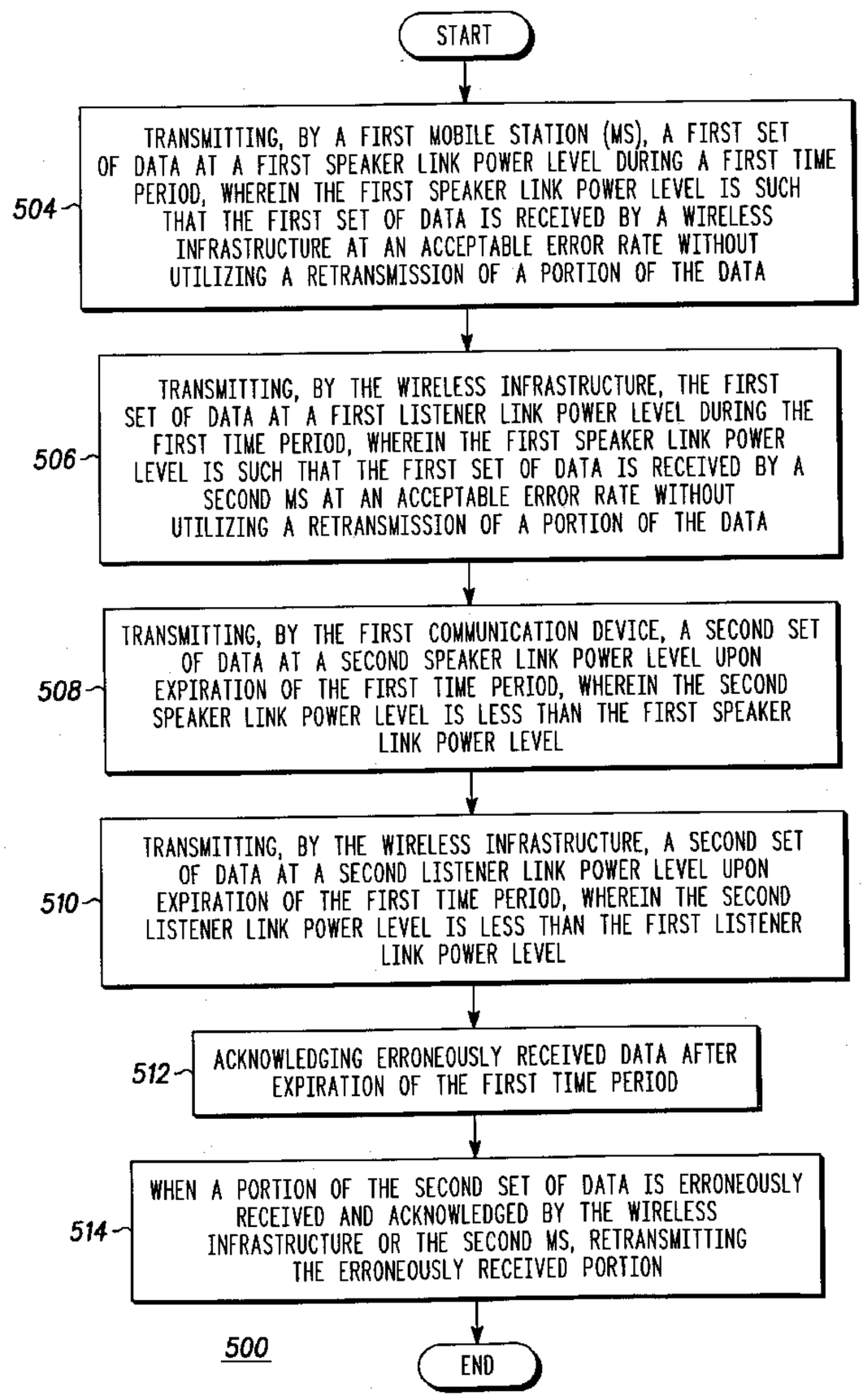
Publication Classification

(51) **Int. Cl.**[7] **H04B 7/00**; H04Q 7/20

(52) **U.S. Cl.** **455/522**; 455/517

(57) **ABSTRACT**

A wireless communication system transmits data over a first link from a first mobile station (MS) to an infrastructure at a first speaker link power level, and over a second link from the infrastructure to a second MS at a first listener link power level, during a first time period. Each of the first power levels is designed to avoid the need for retransmissions of erroneously received data. Upon expiration of the first time period, data is transmitted over the first and second links at reduced power levels, which transmissions include retransmissions of erroneously received data. Error targets used in the transmission of data may also be adjusted after expiration of the first time period. In addition, the power levels and error rate targets may be individually adjusted on a link-by-link basis based on the RF loading of each link and/or based on error metrics determined for each link.



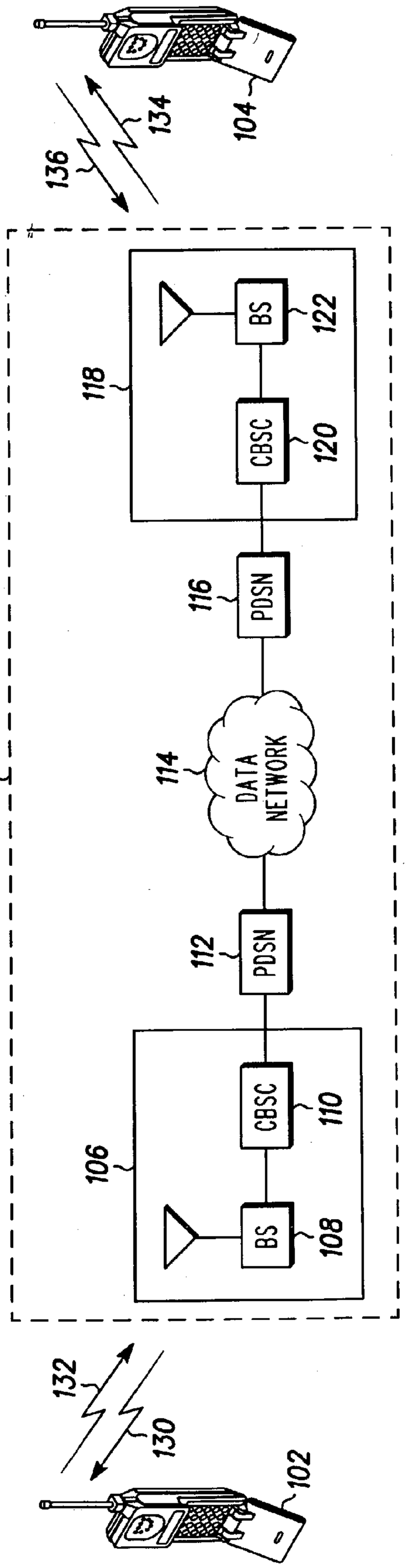

104
134
136
118
BS
122
CBSC
120
116
PDSN
124
114
DATA NETWORK
112
PDSN
106
CBSC
110
BS
108
100
132
130
102

FIG. 1

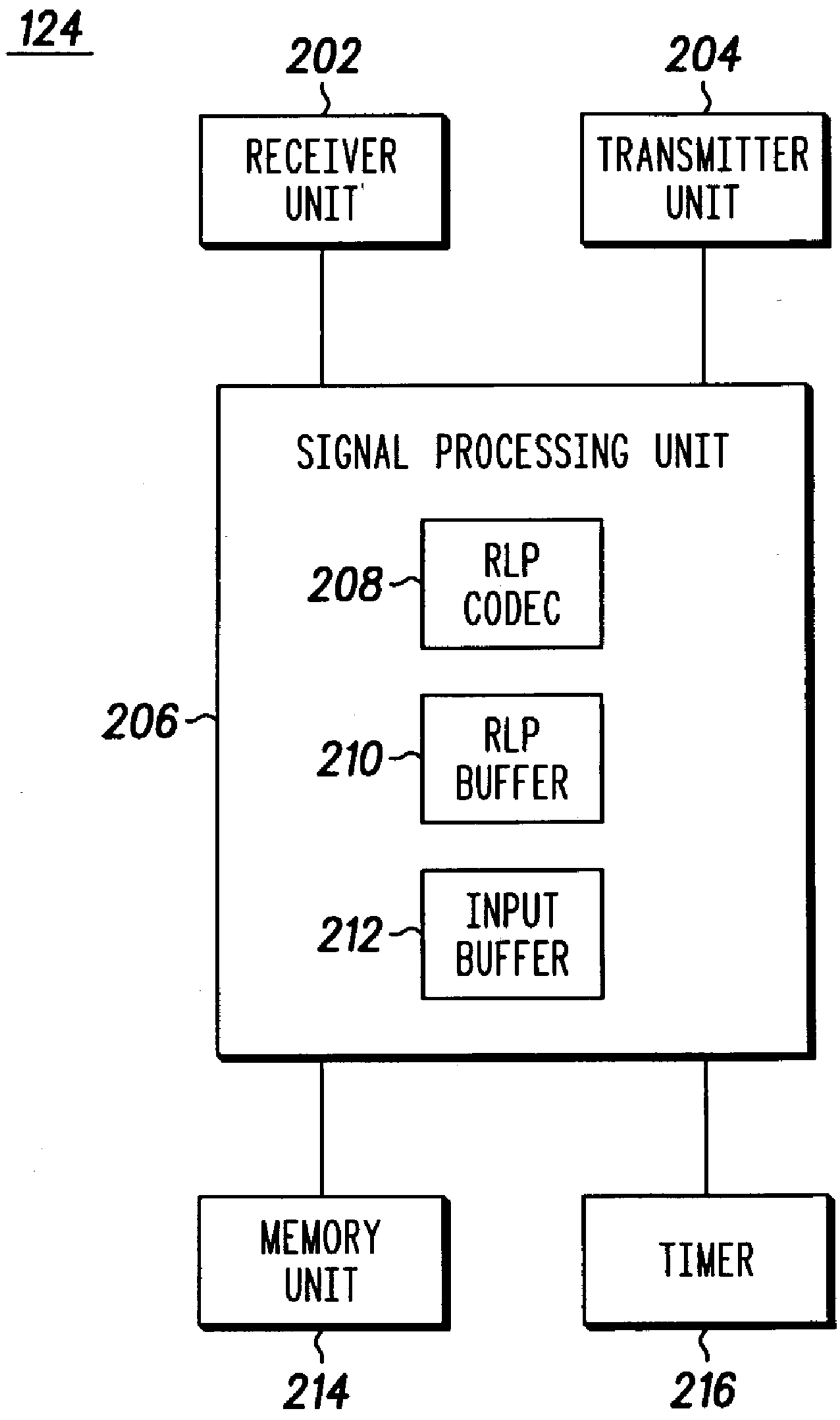

124
202
RECEIVER UNIT
204
TRANSMITTER UNIT
SIGNAL PROCESSING UNIT
208
RLP CODEC
206
210
RLP BUFFER
212
INPUT BUFFER
MEMORY UNIT
TIMER
214
216

FIG.2

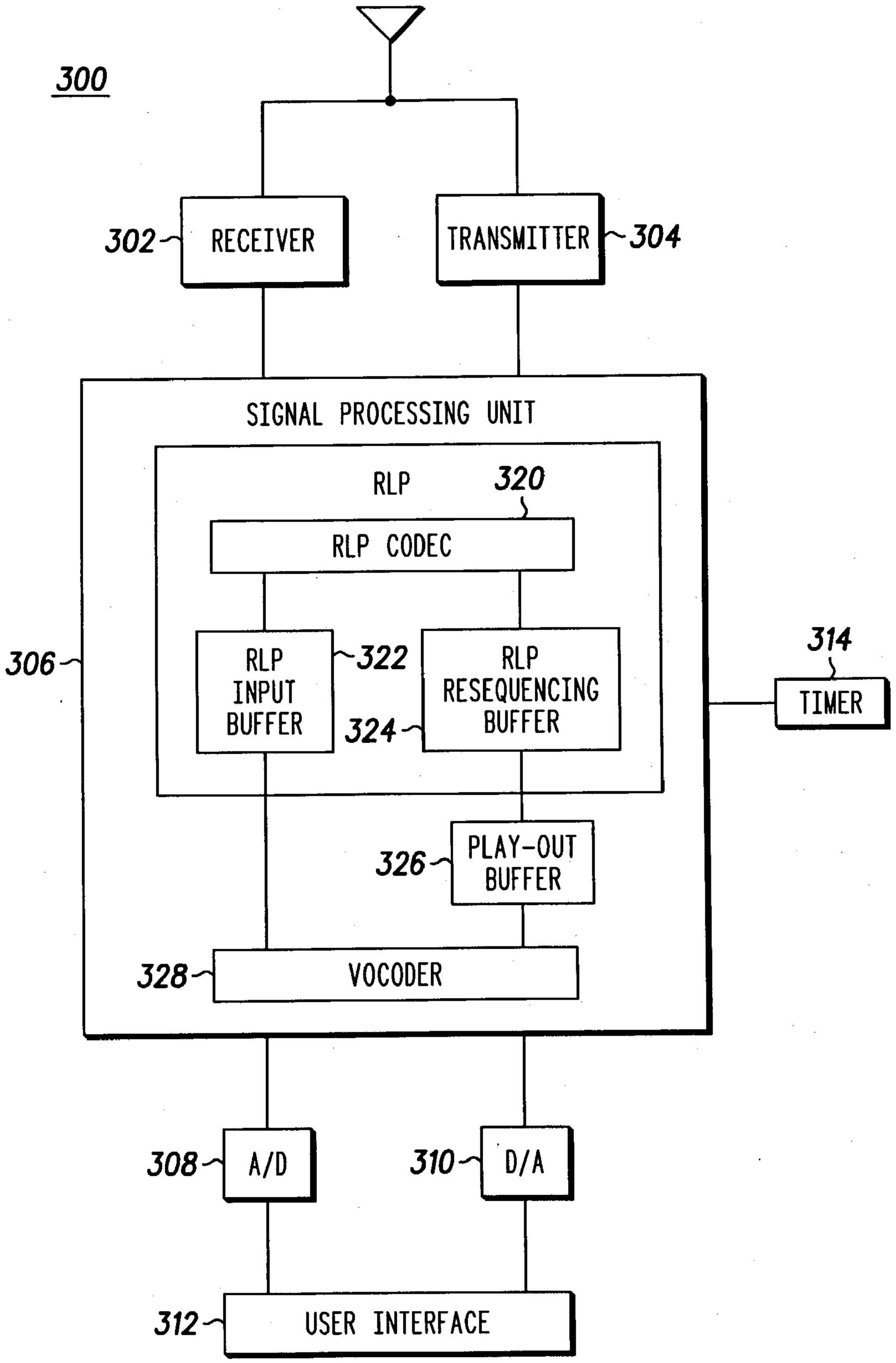

300
302
RECEIVER
TRANSMITTER
304
SIGNAL PROCESSING UNIT
RLP
320
RLP CODEC
306
RLP INPUT BUFFER
322
324
RLP RESEQUENCING BUFFER
314
TIMER
326
PLAY-OUT BUFFER
328
VOCODER
308
A/D
310
D/A
312
USER INTERFACE

FIG.3

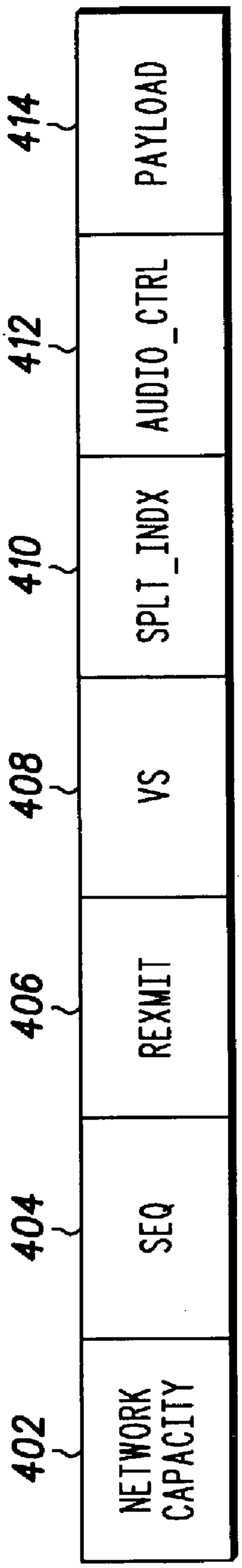
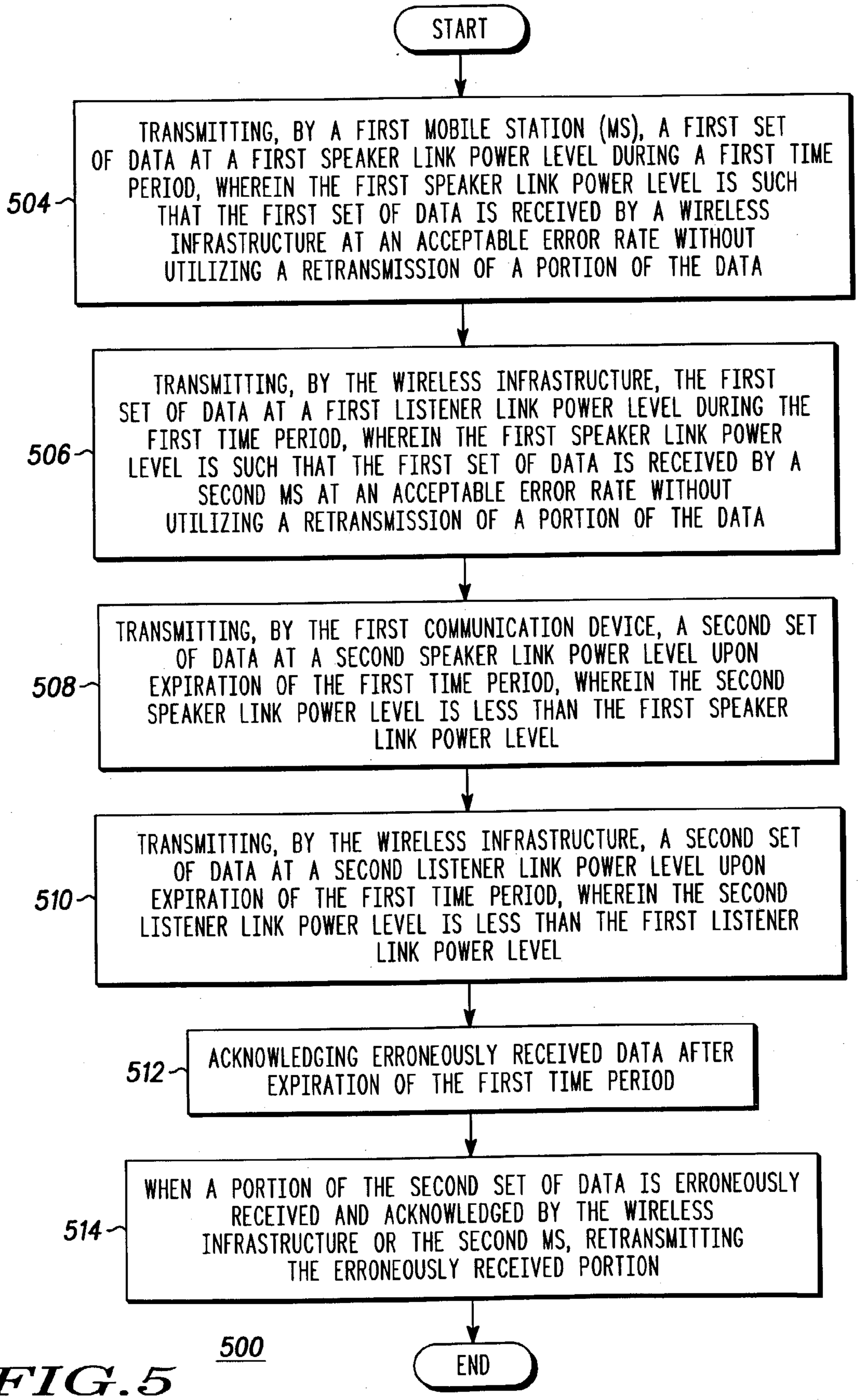

414
PAYLOAD
412
AUDIO_CTRL
410
SPLI_INDX
408
VS
406
REXMIT
404
SEQ
402
NETWORK CAPACITY
400

FIG. 4


START
504
TRANSMITTING, BY A FIRST MOBILE STATION (MS), A FIRST SET OF DATA AT A FIRST SPEAKER LINK POWER LEVEL DURING A FIRST TIME PERIOD, WHEREIN THE FIRST SPEAKER LINK POWER LEVEL IS SUCH THAT THE FIRST SET OF DATA IS RECEIVED BY A WIRELESS INFRASTRUCTURE AT AN ACCEPTABLE ERROR RATE WITHOUT UTILIZING A RETRANSMISSION OF A PORTION OF THE DATA
506
TRANSMITTING, BY THE WIRELESS INFRASTRUCTURE, THE FIRST SET OF DATA AT A FIRST LISTENER LINK POWER LEVEL DURING THE FIRST TIME PERIOD, WHEREIN THE FIRST SPEAKER LINK POWER LEVEL IS SUCH THAT THE FIRST SET OF DATA IS RECEIVED BY A SECOND MS AT AN ACCEPTABLE ERROR RATE WITHOUT UTILIZING A RETRANSMISSION OF A PORTION OF THE DATA
508
TRANSMITTING, BY THE FIRST COMMUNICATION DEVICE, A SECOND SET OF DATA AT A SECOND SPEAKER LINK POWER LEVEL UPON EXPIRATION OF THE FIRST TIME PERIOD, WHEREIN THE SECOND SPEAKER LINK POWER LEVEL IS LESS THAN THE FIRST SPEAKER LINK POWER LEVEL
510
TRANSMITTING, BY THE WIRELESS INFRASTRUCTURE, A SECOND SET OF DATA AT A SECOND LISTENER LINK POWER LEVEL UPON EXPIRATION OF THE FIRST TIME PERIOD, WHEREIN THE SECOND LISTENER LINK POWER LEVEL IS LESS THAN THE FIRST LISTENER LINK POWER LEVEL
512
ACKNOWLEDGING ERRONEOUSLY RECEIVED DATA AFTER EXPIRATION OF THE FIRST TIME PERIOD
514
WHEN A PORTION OF THE SECOND SET OF DATA IS ERRONEOUSLY RECEIVED AND ACKNOWLEDGED BY THE WIRELESS INFRASTRUCTURE OR THE SECOND MS, RETRANSMITTING THE ERRONEOUSLY RECEIVED PORTION
END

500

FIG.5

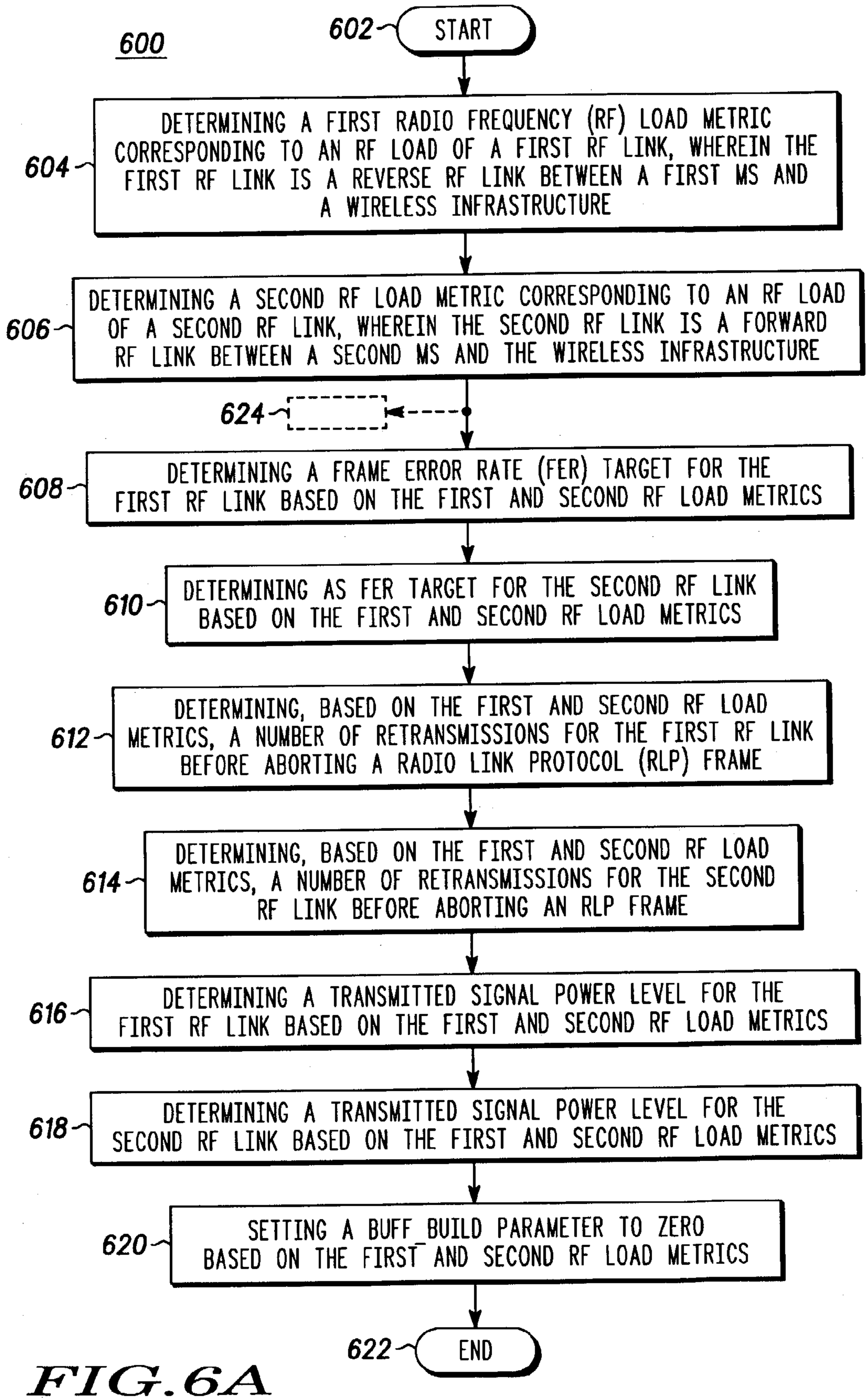

600
602
START
604
DETERMINING A FIRST RADIO FREQUENCY (RF) LOAD METRIC CORRESPONDING TO AN RF LOAD OF A FIRST RF LINK, WHEREIN THE FIRST RF LINK IS A REVERSE RF LINK BETWEEN A FIRST MS AND A WIRELESS INFRASTRUCTURE
606
DETERMINING A SECOND RF LOAD METRIC CORRESPONDING TO AN RF LOAD OF A SECOND RF LINK, WHEREIN THE SECOND RF LINK IS A FORWARD RF LINK BETWEEN A SECOND MS AND THE WIRELESS INFRASTRUCTURE
624
608
DETERMINING A FRAME ERROR RATE (FER) TARGET FOR THE FIRST RF LINK BASED ON THE FIRST AND SECOND RF LOAD METRICS
610
DETERMINING AS FER TARGET FOR THE SECOND RF LINK BASED ON THE FIRST AND SECOND RF LOAD METRICS
612
DETERMINING, BASED ON THE FIRST AND SECOND RF LOAD METRICS, A NUMBER OF RETRANSMISSIONS FOR THE FIRST RF LINK BEFORE ABORTING A RADIO LINK PROTOCOL (RLP) FRAME
614
DETERMINING, BASED ON THE FIRST AND SECOND RF LOAD METRICS, A NUMBER OF RETRANSMISSIONS FOR THE SECOND RF LINK BEFORE ABORTING AN RLP FRAME
616
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE FIRST RF LINK BASED ON THE FIRST AND SECOND RF LOAD METRICS
618
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE SECOND RF LINK BASED ON THE FIRST AND SECOND RF LOAD METRICS
620
SETTING A BUFF_BUILD PARAMETER TO ZERO BASED ON THE FIRST AND SECOND RF LOAD METRICS
622
END

FIG.6A

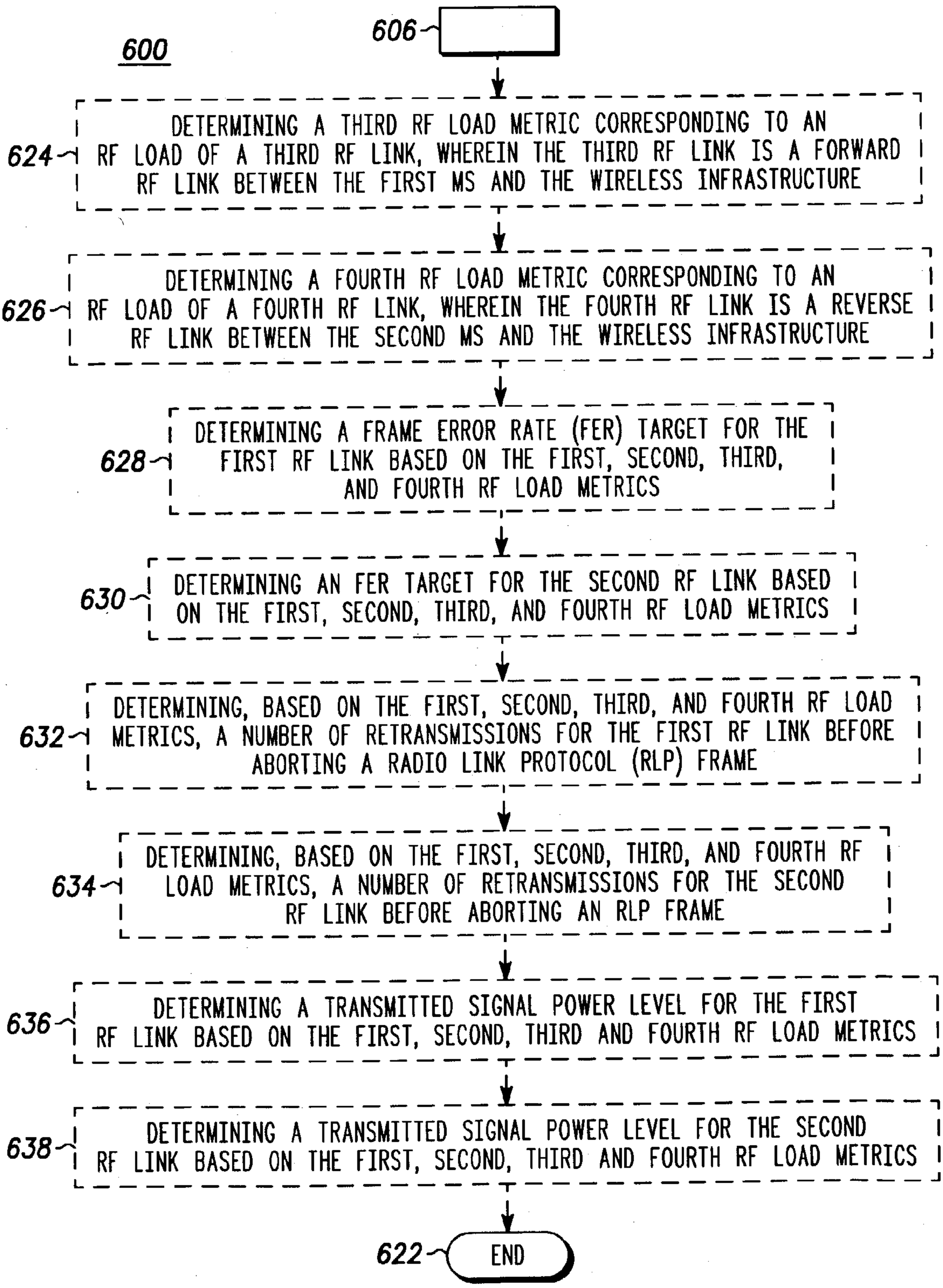

600
606
624
DETERMINING A THIRD RF LOAD METRIC CORRESPONDING TO AN RF LOAD OF A THIRD RF LINK, WHEREIN THE THIRD RF LINK IS A FORWARD RF LINK BETWEEN THE FIRST MS AND THE WIRELESS INFRASTRUCTURE
626
DETERMINING A FOURTH RF LOAD METRIC CORRESPONDING TO AN RF LOAD OF A FOURTH RF LINK, WHEREIN THE FOURTH RF LINK IS A REVERSE RF LINK BETWEEN THE SECOND MS AND THE WIRELESS INFRASTRUCTURE
628
DETERMINING A FRAME ERROR RATE (FER) TARGET FOR THE FIRST RF LINK BASED ON THE FIRST, SECOND, THIRD, AND FOURTH RF LOAD METRICS
630
DETERMINING AN FER TARGET FOR THE SECOND RF LINK BASED ON THE FIRST, SECOND, THIRD, AND FOURTH RF LOAD METRICS
632
DETERMINING, BASED ON THE FIRST, SECOND, THIRD, AND FOURTH RF LOAD METRICS, A NUMBER OF RETRANSMISSIONS FOR THE FIRST RF LINK BEFORE ABORTING A RADIO LINK PROTOCOL (RLP) FRAME
634
DETERMINING, BASED ON THE FIRST, SECOND, THIRD, AND FOURTH RF LOAD METRICS, A NUMBER OF RETRANSMISSIONS FOR THE SECOND RF LINK BEFORE ABORTING AN RLP FRAME
636
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE FIRST RF LINK BASED ON THE FIRST, SECOND, THIRD AND FOURTH RF LOAD METRICS
638
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE SECOND RF LINK BASED ON THE FIRST, SECOND, THIRD AND FOURTH RF LOAD METRICS
622
END

FIG.6B

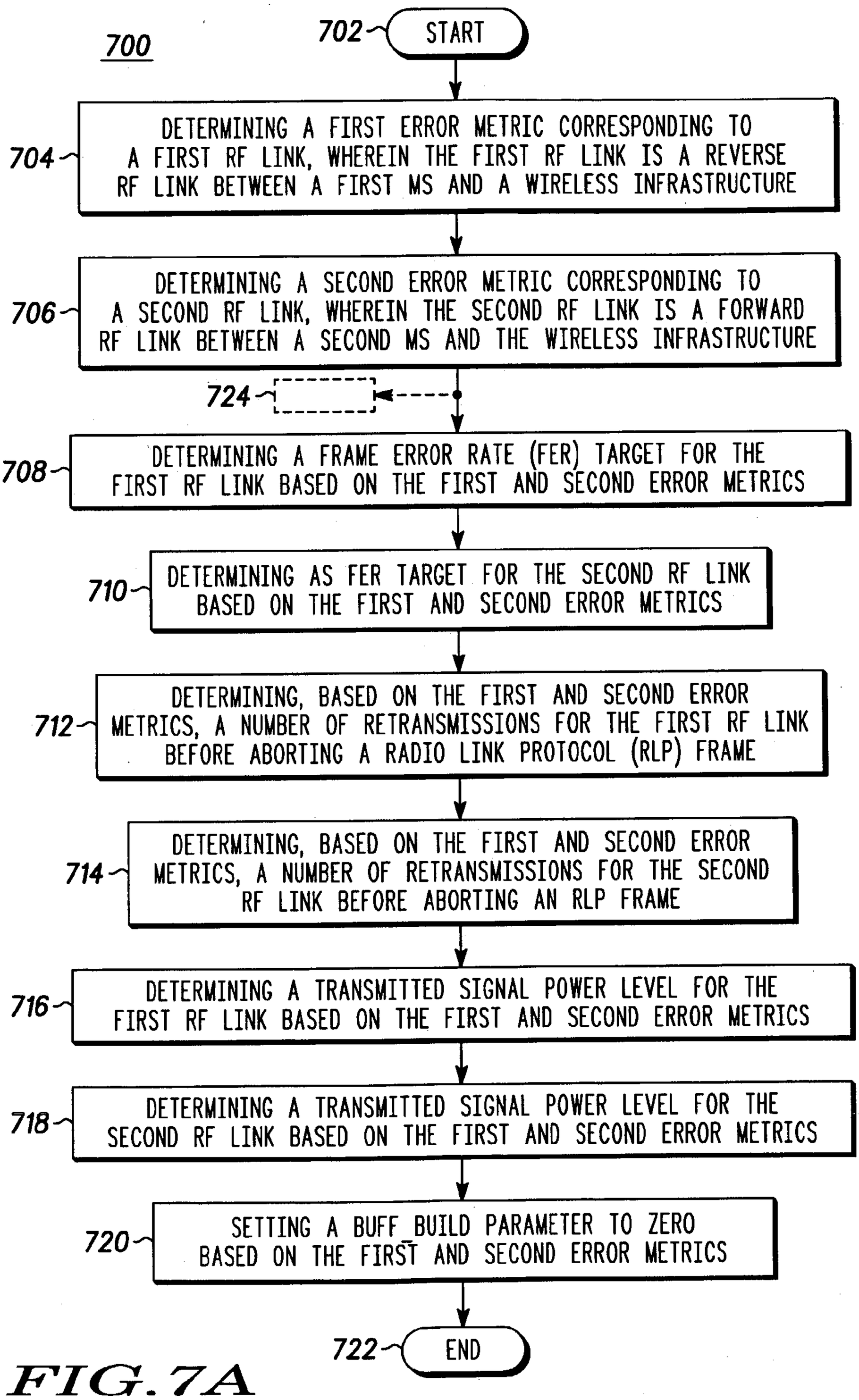
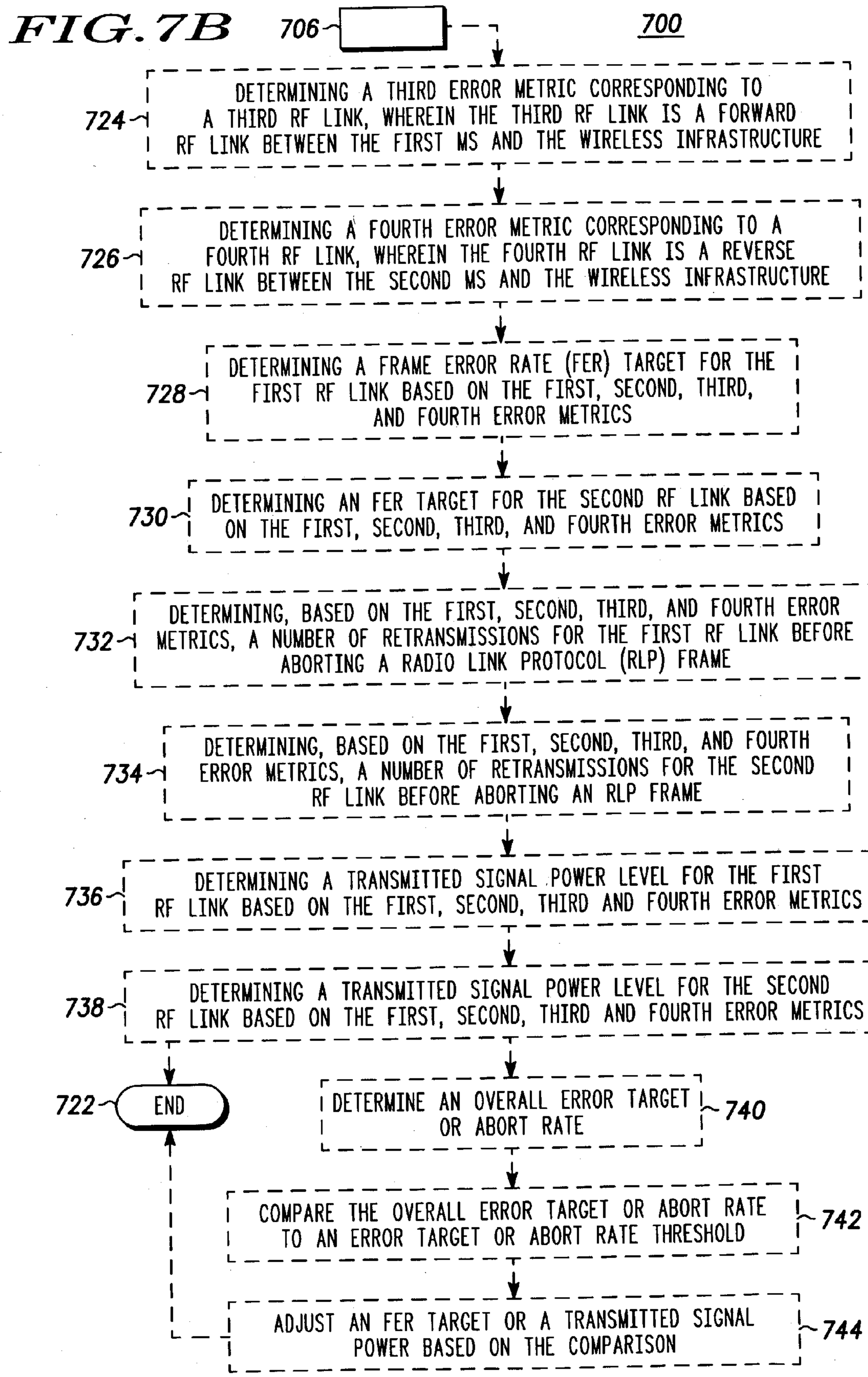

700
702
START
704
DETERMINING A FIRST ERROR METRIC CORRESPONDING TO A FIRST RF LINK, WHEREIN THE FIRST RF LINK IS A REVERSE RF LINK BETWEEN A FIRST MS AND A WIRELESS INFRASTRUCTURE
706
DETERMINING A SECOND ERROR METRIC CORRESPONDING TO A SECOND RF LINK, WHEREIN THE SECOND RF LINK IS A FORWARD RF LINK BETWEEN A SECOND MS AND THE WIRELESS INFRASTRUCTURE
724
708
DETERMINING A FRAME ERROR RATE (FER) TARGET FOR THE FIRST RF LINK BASED ON THE FIRST AND SECOND ERROR METRICS
710
DETERMINING AS FER TARGET FOR THE SECOND RF LINK BASED ON THE FIRST AND SECOND ERROR METRICS
712
DETERMINING, BASED ON THE FIRST AND SECOND ERROR METRICS, A NUMBER OF RETRANSMISSIONS FOR THE FIRST RF LINK BEFORE ABORTING A RADIO LINK PROTOCOL (RLP) FRAME
714
DETERMINING, BASED ON THE FIRST AND SECOND ERROR METRICS, A NUMBER OF RETRANSMISSIONS FOR THE SECOND RF LINK BEFORE ABORTING AN RLP FRAME
716
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE FIRST RF LINK BASED ON THE FIRST AND SECOND ERROR METRICS
718
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE SECOND RF LINK BASED ON THE FIRST AND SECOND ERROR METRICS
720
SETTING A BUFF_BUILD PARAMETER TO ZERO BASED ON THE FIRST AND SECOND ERROR METRICS
722
END

FIG. 7A

FIG. 7B


706
700
724
DETERMINING A THIRD ERROR METRIC CORRESPONDING TO A THIRD RF LINK, WHEREIN THE THIRD RF LINK IS A FORWARD RF LINK BETWEEN THE FIRST MS AND THE WIRELESS INFRASTRUCTURE
726
DETERMINING A FOURTH ERROR METRIC CORRESPONDING TO A FOURTH RF LINK, WHEREIN THE FOURTH RF LINK IS A REVERSE RF LINK BETWEEN THE SECOND MS AND THE WIRELESS INFRASTRUCTURE
728
DETERMINING A FRAME ERROR RATE (FER) TARGET FOR THE FIRST RF LINK BASED ON THE FIRST, SECOND, THIRD, AND FOURTH ERROR METRICS
730
DETERMINING AN FER TARGET FOR THE SECOND RF LINK BASED ON THE FIRST, SECOND, THIRD, AND FOURTH ERROR METRICS
732
DETERMINING, BASED ON THE FIRST, SECOND, THIRD, AND FOURTH ERROR METRICS, A NUMBER OF RETRANSMISSIONS FOR THE FIRST RF LINK BEFORE ABORTING A RADIO LINK PROTOCOL (RLP) FRAME
734
DETERMINING, BASED ON THE FIRST, SECOND, THIRD, AND FOURTH ERROR METRICS, A NUMBER OF RETRANSMISSIONS FOR THE SECOND RF LINK BEFORE ABORTING AN RLP FRAME
736
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE FIRST RF LINK BASED ON THE FIRST, SECOND, THIRD AND FOURTH ERROR METRICS
738
DETERMINING A TRANSMITTED SIGNAL POWER LEVEL FOR THE SECOND RF LINK BASED ON THE FIRST, SECOND, THIRD AND FOURTH ERROR METRICS
722
END
DETERMINE AN OVERALL ERROR TARGET OR ABORT RATE
740
COMPARE THE OVERALL ERROR TARGET OR ABORT RATE TO AN ERROR TARGET OR ABORT RATE THRESHOLD
742
ADJUST AN FER TARGET OR A TRANSMITTED SIGNAL POWER BASED ON THE COMPARISON
744

METHOD AND APPARATUS FOR TRANSMITTING DATA IN A PACKET DATA COMMUNICATION SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates generally to wireless packet data communication systems, and, in particular, to the transmission of data in a wireless packet data communication system.

BACKGROUND OF THE INVENTION

[0002] Wireless packet data communication systems are well known and consist of many types, including land mobile radio, cellular radiotelephone, and personal communication systems. With each communication system, data is transmitted between a transmitting communication device and a receiving communication device via a communication resource that includes a communication channel that operates over a physical resource, typically a frequency bandwidth.

[0003] In a typical packet data communication system, information is transmitted in data packets, or data frames. In a transmitting communication device, a lengthy data stream is typically subdivided into multiple data blocks. Each data block is then wrapped with a header to form a data packet. Included in the header for each data packet is a sequence number corresponding to the position of the data block in the data stream. The sequence numbers allow a receiving communication device to receive the multiple data packets comprising the multiple data blocks in any order and to reassemble the original data stream.

[0004] The receiving communication device stores the received data blocks in a resequencing, or jitter, buffer, where the data blocks are reordered in their proper sequence and stored. The jitter buffer stores a predetermined amount of data and, when full, conveys the stored data to a user of the receiving communication device, that is, a listener, via a user interface.

[0005] In a typical Radio Link Protocol (RLP) wireless communication system, erroneously received data packets are acknowledged by transmission of a NAK message by the receiving communication device. The NAK message includes an identifier of the erroneously received data packet. The transmitted data packets are stored in a memory of the transmitting communication device. When the transmitting communication device receives the NAK message, the transmitting communication device retransmits the identified data packet.

[0006] By storing data in a jitter buffer, gaps in voice may be avoided, which gaps result from the retransmission of erroneously received data. For example, the data stream conveyed from the transmitting communication device to the receiving communication device may be an audio message "Do not place the order." If the data packets corresponding to the word "not" are erroneously received, the data in those packets would not be conveyed to the listener in the absence of a retransmission. The received message might then be conveyed as "Do place the order," with a gap appearing in place of the word "not." Therefore, jitter buffers are used to store all data received after the erroneously received data packet, pending retransmission of the erroneous packet. When the retransmitted packet is received, the packet is inserted into its proper position among the stored data and the data is played out to the listener. The jitter buffer typically is of sufficient size that the jitter buffer can store all data received subsequent to the erroneously received data until the erroneously received data is acknowledged, retransmitted, and properly inserted into the data stored in the buffer.

[0007] Although the use of the jitter buffer improves the reliability of a data communication by providing for the retransmission of erroneously received data, the use of the jitter buffer also produces a delay in the set up of a dispatch communication. In order to prevent a gap from appearing at some point in a voice communication due to the acknowledgment and retransmission of erroneously received packets, the receiving communication device does not initially convey a voice communication to the listener until the jitter buffer is full. By imposing a system delay at the start of the conversation, erroneously received data may be retransmitted and inserted in already received data without creating a subsequent voice gap when a later erroneous packet is received and subsequently received data must be stored.

[0008] For a communication system that employs a single acknowledgment and retransmission, the jitter buffer-related delay may be 200 ms or more. This delay is in addition to other call set up delays between the moment that a user of the transmitting communication device, that is, a speaker, initiates a call, such as by pressing a push-to-talk (PTT) button on a keypad of the device, to the moment that an audio message input by the speaker into the transmitting communication device is conveyed to the listener at the receiving communication device. Similarly, a jitter buffer delay resulting from a filling of a jitter buffer in a receiving communication device occurs each time there is a change in who is speaking in the dispatch communication.

[0009] Any delay in call set up is undesirable, as is any delay in the time that it takes an audio message spoken into a transmitting communication device to be conveyed to a listener at a receiving communication device. One alternative to imposing a jitter buffer delay upon a dispatch call set up is to increase a power level used to transmit data packets. It is well known that there is an inverse relationship between a data packet or frame error rate (FER) and power level at which the data packet is transmitted. Transmitting data packets at higher power levels diminishes the probability that intervening factors in the propagation environment will interfere with the transmission and corrupt the transmitted data packet. If the power level is great enough, the FER may be reduced to a level where retransmission of erroneously received data is no longer necessary in order to achieve an acceptable FER. However, by transmitting data packets at an increased power level, the possibility that the transmission will interfere with other communications using the same or adjacent frequency bandwidths is increased.

[0010] Therefore a need exists for a method and an apparatus for reducing jitter buffer delay while minimizing the interference created for other communications using the same or adjacent frequency bandwidths.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **FIG. 1** is a block diagram of a wireless packet data communication system in accordance with an embodiment of the present invention.

[0012] **FIG. 2** is a functional block diagram of an infrastructure of **FIG. 1** in accordance with an embodiment of the present invention.

[0013] **FIG. 3** is a block diagram of a mobile communication device of **FIG. 1** in accordance with an embodiment of the present invention.

[0014] **FIG. 4** is a block diagram of an RLP frame in accordance with an embodiment of the present invention.

[0015] **FIG. 5** is a logic flow diagram of the steps executed by a communication system in transmitting data packets in accordance with an embodiment of the present invention.

[0016] **FIG. 6A** is a logic flow diagram of the steps executed by a communication system in transmitting data packets in accordance with another embodiment of the present invention.

[0017] **FIG. 6B** is a continuation of the logic flow diagram of **FIG. 6A** of the steps executed by a communication system in transmitting data packets in accordance with another embodiment of the present invention.

[0018] **FIG. 7A** is a logic flow diagram of the steps executed by a communication system in transmitting data packets in accordance with another embodiment of the present invention.

[0019] **FIG. 7B** is a continuation of the logic flow diagram of **FIG. 7A** of the steps executed by a communication system in transmitting data packets in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0020] To address the need for a method and an apparatus for reducing jitter buffer delay while minimizing the interference created for other communications using the same or adjacent frequency bandwidths, a wireless communication system is provided that transmits data over a first link from a first mobile station (MS) to an infrastructure at a first speaker link power level, and over a second link from the infrastructure to a second MS at a first listener link power level, during a first time period. Each of the first power levels is designed to avoid the need for retransmissions of erroneously received data. Upon expiration of the first time period, data is transmitted over the first and second links at reduced power levels, which transmissions include retransmissions of erroneously received data. Error targets used in the transmission of data may also be adjusted after expiration of the first time period. In addition, the power levels and error rate targets may be individually adjusted on a link-by-link basis based on the RF loading of each link and/or based on error metrics determined for each link.

[0021] Generally, an embodiment of the present invention encompasses a method for transmitting data including a step of transmitting, by a first communication device, a first set of data at a first power level during a first time period, wherein the first power level is such that the first set of data is received by a second communication device at an acceptable error rate without utilizing a retransmission of a portion of the first set of data. The method further includes steps of transmitting, by the first communication device, a second set of data at a second power level upon expiration of the first time period, wherein the second power level is less than the first power level, and when a portion of the second set of data is erroneously received by the second communication device, retransmitting the erroneously received portion.

[0022] Another embodiment of the present invention encompasses a method for transmitting data in a wireless communication system, wherein the communication system includes a first wireless communication device, a wireless infrastructure in communication with the first communication device via a reverse link, and a second wireless communication device in communication with the infrastructure via a forward link. The method includes steps of determining a first radio frequency (RF) load metric corresponding to an RF load of the reverse link and determining a second RF load metric corresponding to an RF load of the forward link. The method further includes steps of determining an acceptable error rate for the forward link based on the first and second RF load metrics and determining an acceptable error rate for the reverse link based on the first and second RF load metrics.

[0023] Still another embodiment of the present invention encompasses a method for transmitting data in a wireless communication system that includes a first wireless communication device, a wireless infrastructure in communication with the first communication device via a first reverse link and a first forward link, and a second wireless communication device in communication with the infrastructure via a second reverse link and a second forward link. The method includes steps of determining a first error metric corresponding the first reverse link, determining a second error metric corresponding the first forward link, and determining an acceptable frame error rate of one or more of the first reverse link, and the second forward link based on the first error metric and the second error metric.

[0024] The present invention may be more fully described with reference to FIGS. **1-7B**. **FIG. 1** is a block diagram of a wireless packet data communication system **100** in accordance with an embodiment of the present invention. Communication system **100** includes multiple mobile stations (MS's) **102, 104**, (two shown) such as cellular telephones or radiotelephones. Each MS **102, 104** is serviced by a respective base site **108, 122** in a respective radio access network (RAN) **106, 118**. Each base site includes at least one base transceiver station (BTS) (not shown).

[0025] Each base site **108, 122** provides wireless communications services to the mobile units in the base site's coverage area. That is, base site **108** provides communications services to MS **102** and base site **122** provides communications services to MS **104**. Each RAN **106, 118** further includes a respective centralized base station controller (CBSC) **110, 120** in communication with the respective base site **108, 122**. Each RAN **106, 118** is in communication with a respective packet data service node (PDSN) **112, 116,** which PDSN's are in turn in communication with a data network **114**, such as the Internet. Together, RAN's **106** and **118**, PDSN's **112** and **116**, and data network **114** are collectively referred to herein as a fixed infrastructure **124**.

[0026] Each RAN **106, 118** provides wireless voice and data communication services to the mobile stations in the RAN's coverage area and may do so in accordance with virtually any wireless communication protocol. Preferably, communication system **100** is a Code Division Multiple Access (CDMA) communication system that operates in

accordance with the TIA/EIA (Telecommunications Industry Association/Electronic Industries Association) IS-2000 standard, hereby incorporated herein, which provides a compatability standard for IS-2000 communication systems, and RAN's **106** and **118** are each an IS-2000 access network. However, those who are of ordinary skill in the art realize that communication system **100** may utilize any one of multiple communication protocols, such as Time Division Multiple Access (TDMA), Global System for Mobile communications (GSM), or Orthogonal Frequency Division Multiplexing (OFDM).

[**0027**] Base site **108**, wirelessly communicates with MS **102** via a forward link **130** and a reverse link **132**. Similarly, base site **122** wirelessly communicates with MS **104** via a forward link **134** and a reverse link **136**. Each of forward links **130**, **134** and reverse links **132**, **136** includes multiple communication channels. Typically, the multiple communication channels of each link include a pilot channel, multiple paging channels, and multiple traffic channels. Preferably, communication system **100** preferably is a Code Division Multiple Access (CDMA) communication system in which a communication channel comprises an orthogonal code that is used to cover transmitted data; however, in alternative embodiments system **100** may be a Time Division Multiple Access (TDMA) or Global System for Mobile communication (GSM) communication system in which a communication channel comprises a time slot or a Frequency Division Multiple Access (FDMA) or Orthogonal Frequency Division Multiple Access (OFDM) communication system in which a communication channel comprises a frequency bandwidth.

[**0028**] **FIG. 2** is a functional block diagram of fixed infrastructure **124** in accordance with an embodiment of the present invention. Infrastructure **124** includes a receiver unit **202** and a transmitter unit **204** that are each in communication with a signal processing unit **206**. The functions of signal processing unit **206** may be performed by one or more microprocessors or a digital signal processors (DSP's). Signal processing unit **206** includes a radio link protocol (RLP) coder/decoder (codec) **208** that decodes data received via receiver unit **202** and that encodes data for transmission via transmitter **204**. Signal processing unit **206** further includes an RLP buffer **210**, preferably a resequencing, or jitter, buffer and an input buffer **212**; however, in another embodiment of the present invention each of RLP buffer **210** and input buffer **212** may be included in a memory unit **214** associated with signal processing unit **206**.

[**0029**] **FIG. 3** is a block diagram of a mobile station **300**, such as MS **102** and MS **104**, in accordance with an embodiment of the present invention. Mobile station **300** includes a receiver **302** and a transmitter **304** that are each in communication with a signal processing unit **306**, such as a microprocessor or a digital signal processor (DSP). Signal processing unit **306** executes multiple applications, such as vocoder **328**, and programs that are stored in the signal processing unit or in an associated memory and that permit the functioning of mobile station **300**. Signal processing unit **306**, or alternatively the memory associated with the signal processing unit, further includes an RLP input buffer **322** that stores RLP frames for subsequent transmission via transmitter **304**, an RLP resequencing, or jitter, buffer **324** that stores RLP frames received via receiver **302**, and a play-out buffer **326** that stores vocoder frames derived from the RLP frames stored in RLP jitter buffer **324**. Mobile station **300** further includes an analog-to-digital converter (A/D) **308** and a digital-to-analog converter (D/A) **310** in communication with signal processing unit **306** and a user interface **312** in communication with each of A/D **308** and D/A **310**. User interface **312** provides an interface with a user of mobile station **300** whereby the user may input information into the mobile station or receive information output by the mobile station.

[**0030**] When a user of a mobile station, such as MS **102**, wishes to initiate a dispatch communication with a target mobile station, such as MS **104**, the user depresses a push-to-talk (PTT) key included in user interface **312**. Depression of the PTT key causes MS **102** to transmit a dispatch request over a channel in reverse link **132**, preferably an access channel (ACH). The dispatch request includes an identifier uniquely associated with MS **102**.

[**0031**] Upon receiving the dispatch request, infrastructure **124**, preferably RAN **106**, assigns MS **102** use of a traffic channel in each of reverse link **132** and forward link **130**. Traffic channels, or speaker radio frequency (RF) links, are then set up in each of reverse link **132** (i.e., a speaker reverse RF link) and forward link **130** (i.e., a speaker forward RF link) between MS **102** and infrastructure **124** by well known channel assignment and call set up techniques. After the speaker RF links are built and infrastructure **124** receives a response to a paging message from MS **104** verifying an availability of MS **104**, RAN **106** conveys a message to MS **102** on the speaker reverse RF link indicating that the MS can play a talk permit tone (TPT), such as a beep, informing the user of MS **102** that he or she may begin speaking into MS **102**. Preferably, this message is sent via CDMA signaling. MS **102** then plays the TPT.

[**0032**] In addition, upon receiving the dispatch request from MS **102**, infrastructure **124**, via RAN **118**, sends a paging message to MS **104** over a paging channel in forward link **134**. In response to receiving the paging message, MS **104** and RAN **118** engage in an exchange of CDMA signaling messages in order to set up traffic channels, or listener RF links, in each of forward link **134** (a listener forward RF link) and reverse link **136** (a listener reverse RF link). The listener RF links provide an over-the-air link by which RAN **118** may transmit RLP frames to MS **104**. By building the speaker reverse RF link in reverse link **132** and the listener forward RF link in forward link **134**, an overall forward link is established between MS **102** and MS **104** that comprises two RF legs or links, that is, the speaker reverse RF link and the listener forward RF link.

[**0033**] The process of setting up the speaker RF links typically begins prior to the transmission of the paging messages to MS **104**. As a result, set up of the speaker RF links is typically completed prior to the completion of the set up of the listener RF links. In the prior art, the user of MS **102**, that is, the speaker, is not permitted to begin speaking until the listener RF links are completed. The amount of time elapsing between completion of the speaker RF links and completion of the listener RF links can be 400 ms or more. In the prior art, it can take 500 ms or longer to fill RLP jitter buffer **326** in MS **104** before the MS begins playing out voice.

[**0034**] When the TPT is played, the user of MS **102** may begin speaking. In one embodiment of the present invention,

MS **102** does not produce any vocoded frames or transmit any RLP frames until the MS detects significant voice activity, saving RF bandwidth. In another embodiment of the present invention, MS **102** begins producing vocoded frames upon expiration of the TPT. In the latter embodiment, MS **102**, and in particular vocoder **328**, generates and transmits silent vocoded frames until the speaker begins speaking.

[**0035**] When the user of MS **102** begins speaking into the MS, the audio information is digitized by A/D **308** to produce digital data. MS **102** routes the digital data to signal processing unit **306** of MS **102**, which routes the digital data to vocoder **328**. Vocoder **328** compresses the digital data pursuant to any one of numerous well known voice compression algorithms to produce multiple vocoded frames. Preferably each vocoded frame is either 99 bits in length, with a vocoded frame generated every 45 ms, or is 128 bits in length, with a vocoded frame generated every 30 ms. Each vocoded frame is then sent to RLP input buffer **322**, where the frame may be combined with other vocoded frames output by vocoder **328** and is wrapped with an RLP header to produce an RLP frame. MS **102** then transmits the RLP frame to RAN **106** via codec **320**, transmitter **304** and the speaker reverse RF link.

[**0036**] **FIG. 4** is a block diagram of an RLP frame **400** in accordance with an embodiment of the present invention. RLP frame **400** includes a payload **414** comprising one or more vocoder frames and further includes a header comprising data fields **402-412**. A network capacity data field **402** provides an indication of the capacity that the network is operating at. Preferably this data field indicates whether the network is operating at above or below a predefined threshold. A sequence (SEQ) data field **404** contains the least significant bits of the data frames sequence number. The sequence number corresponds to a position, in time, of the RLP frame relative to other RLP frames generated by the MS as part of an audio communication. The sequence number allows a receiving communication device to receive the RLP frames in any order and then to reorder the frames in the order in which the frames were generated. When an RLP frame is retransmitted, the SEQ value of the original RLP frame is maintained. A retransmitted frame data field (REXMIT) **406** is set to '1' when the frame is retransmitted data frame and otherwise is set to '0'. A vocoded frame data field (VS) **408** indicates the number of vocoded frames included in the RLP frame, and a split index data field (SPLT_INDX) **410** indicates whether any vocoded frames had to be split among multiple RLP frames An audio play-out control data field (AUDIO_CTRL) **412** indicates whether the audio receiver should begin play-out of any received codec samples. This field is set to '1' to indicate play-out should begin and '0' to indicate play-out should not begin and buffering should take place.

[**0037**] In order to minimize jitter buffer delay and to maximize utilization of the RF links connecting MS **102** to MS **104**, communication system **100** controls and adjusts the power levels at which RLP frames are transmitted over the RF links, that is, the speaker reverse RF link and the listener forward RF link, included in the overall forward link between MS **102** and MS **104** and adjusts the target error rates for each RF link. **FIG. 5** is a logic flow diagram **500** of steps executed by system **100** in exchanging data between MS **102** and MS **104** in accordance with an embodiment of the present invention. Logic flow diagram **500** begins when MS **102** begins transmitting RLP frames to infrastructure **124** via the speaker reverse RF link in reverse link **132**. MS **102** transmits **(504)** the frames at a first speaker link power level. The first speaker link power level is based on an initial, low frame error rate (LOW_FER) target for the overall forward link between MS **102** and MS **104**. The first speaker link power level is designed to be a high enough power level that the RLP frames received by the target mobile station, that is, MS **104**, will achieve the LOW_FER target without the need to employ any retransmissions of RLP frames by either infrastructure **124** or MS **104**. MS **102** transmits the frames at the first power level and based on the LOW_FER target for a first period of time, that is, a first buffer build (BUFF_BUILD) period of time, after the speaker begins speaking.

[**0038**] The LOW_FER target is a desired frame error rate (FER) for received RLP frames in the absence of retransmissions of erroneously received frames. This target may vary with the type of data being transmitted. For example, voice communications are more tolerant of errors than data communications and therefore a higher FER may be acceptable for voice communications. By way of another example, and merely for the purpose of illustrating the principles of the present invention, suppose that the minimum tolerable FER for voice communications is 1 percent (%) and that there is a zero (0) percent NAK erasure rate. Without any retransmissions, the LOW_FER target should be set at, at most, 1%. However, if one retransmission is permitted and an FER of 1% is desired, then the FER target may be set at 10%. By setting the FER target at 10%, approximately 10% of the originally transmitted RLP frames are erroneously received and then approximately 10% of the retransmitted RLP frames are erroneously received, for an overall error rate of 10%×10%=1% (i.e., 0.10×0.10=0.01). By using retransmissions and targeting a higher FER (i.e., 10%), the RLP frames may be transmitted at a lower power level, thereby minimizing interference with other communications using the same or adjacent bandwidths. However, by using retransmissions, additional system **100** bandwidth is consumed and system capacity and efficiency is reduced.

[**0039**] The BUFF_BUILD time period is approximately the length of time that it takes to fill RLP buffer **324** in an MS receiving RLP frames. Preferably, the size of jitter buffer **324** is approximately the maximum length of time that may expire from a transmission, by a receiving communication device, of an acknowledgment of an erroneously received RLP frame until the receiving communication device receives a correctly retransmitted frame, after a predetermined maximum number of retransmissions, or aborts the frame, which ever shall last occur, plus a little slack to compensate for variations in system **100** performance. An abort simply indicates that system **100** has given up on attempting to transmit that particular frame. An abort is well defined in the IS-707 standard, which standard is promulgated by the TIA/EIA and is hereby incorporated herein. The greater the number of retransmissions permitted of an erroneously received RLP frame, the greater size of the jitter buffer. Assuming that only one retransmission is permitted of an erroneously received RLP frame, a preferred default value for the BUFF_BUILD period of time is 300 ms.

[**0040**] RLP frames received by infrastructure **124** after the speaker RF links are built and prior to the completion of the

listener RF links are stored in RLP buffer **210** in the infrastructure. Infrastructure **124**, in particular signal processing unit **206**, may also perform an error check on each frame to determine whether the frame was correctly received and determine an error metric that measrues an error rate for the received signal. For example, the error metric may be an FER or a bit error rate (BER) for each received RLP frame, or may be a signal-to-noise ratio (SNR), a carrier-to-interference ratio (CIR), or an E_b/I_o ratio (energy per bit/interference power density (per Hertz)) determined for the received signal and compared to a respective SNR, CIR, or E_b/I_o threshold.

[**0041**] In one embodiment of the present invention, the frames stored in RLP buffer **210** are not reseqeunced, leaving the task of resequencing solely up to listener MS **104**. In another embodiment of the present invention, signal processing unit **206** determines a buffer depth of RLP buffer **210**, that is, the amount of data stored in the buffer. The determined buffer depth is then compared to a buffer depth threshold that is stored in memory unit **214** or a memory associated with signal processing unit **206**. When the determined buffer depth is greater than the buffer depth threshold, signal processing unit **206** resequences the frames stored in buffer **210**. Otherwise signal processing unit **206** does not resequence the stored frames. By resequencing RLP frames, infrastructure **124** adds a measure of reliability to system **100** and improves the efficiency with which listener MS **104** may determine whether the MS is missing a frame. By resequencing RLP frames only when the determined buffer depth is greater than the buffer threshold, delay is minimized in the conveyance of RLP frames from MS **102** to MS **104** during the BUFF_BUILD time period, particularly when RLP frames are conveyed by infrastructure **124** to MS **104** prior to RLP buffer **210** being completely filled.

[**0042**] During the BUFF_BUILD time period, the first speaker link power level has been set at a sufficiently high rate that data retransmissions are not required for the speaker RF links. As a result, in one embodiment of the present invention, infrastructure **124** transmits the RLP frames stored in buffer **210** to their intended destination, that is, MS **104**, as soon as the listener RF links are built. In another embodiment of the present invention, infrastructure **124** determines a buffer depth of RLP buffer **210** before transmitting the stored frames. Infrastructure **124** then transmits the stored frames to MS **104** only after determining that the buffer depth of buffer **210** is at least equal to a buffer depth target for play-out buffer **326** in MS **104**. The buffer depth target is approximately the amount of time that expires between a time that MS **104** first transmits an acknowledgment of an erroneously received frame and a time that the MS either correctly receives a retransmitted frame, after a predetermined maximum number of retransmissions, or aborts the frame, which ever shall last occur, plus a little slack to compensate for variations in system **100** performance.

[**0043**] During the BUFF_BUILD time period, infrastructure **124** transmits (**506**) RLP frames to MS **104** at a first listener link power level on the listener forward RF link. Similar to the first speaker link power level, the first listener link power level is also based on the low frame error rate (LOW_FER) target and is a high enough power level that the LOW_FER target may be achieved at MS **104** without the need for employing retransmissions of data. Preferably, the LOW_FER target is preprogrammed into system **100**, in particular into infrastructure **124**. When the speaker RF links are built, RAN **106** informs MS **102** of the power level required for the initial transmission of RLP frames, that is, the first speaker link power level. This power level is preferably communicated through an exchange of preambles between MS **102** and RAN **106** as is well known in the art. Alternatively, during the CDMA signaling in the setting up of the speaker RF links, RAN **106** signals MS **102** to increase or decrease the transmitted power level until the LOW_FER target is achieved, as determined by the infrastructure. When MS **104** and RAN **118** build the listener RF links, RAN **118** sends MS **104** a CDMA signaling message that informs the MS of the LOW_FER target sought to be achieved. Alternatively, the LOW_FER target and/or the first listener link power level may be preprogrammed into MS **102** and/or MS **104**. Then, as part of the CDMA signaling during the building of the listener RF links, MS **104** signals RAN **118** to increase or decrease the transmitted power level until the LOW_FER target is achieved, as determined by the MS.

[**0044**] When MS **104** begins receiving RLP frames from infrastructure **124**, the MS routes each frame to signal processing unit **306** included in the MS. In turn, signal processing unit **306** routes the frame to codec **320**, which decodes the frame and routes the decoded frame to RLP jitter buffer **324**. Signal processing unit **306** also performs an error check on each RLP frame,determining whether the frame was correctly received and determining an error metric, such as an FER, a BER, an SNR, a CIR, or an E_b/I_o ratio, for forward link **134**. MS **104** may then convey the error information to infrastructure **124**. During the BUFF_BUILD time period, incorrectly received RLP frames are erased, or dropped, by each of MS **104** and infrastructure **124** and there are no retransmissions of the erased or dropped frames.

[**0045**] MS **104** stores correctly received RLP frames in RLP jitter buffer **324**, where the frames are reordered based on the sequencing (SEQ) number included in the RLP header of each frame. Signal processing unit **306** of MS **104** extracts the transmitted vocoded frames, in the order that they were transmitted, from the reordered RLP frames stored in RLP jitter buffer **324** and stores the vocoded frames in play-out buffer **326**. When MS **104** is authorized to begin playing out the vocoded frames, signal processing unit **306** routes the vocoded frames to vocoder **328**, where the vocoded frames are decompressed and played out to the user of MS **104** via D/A **310** and user interface **312**.

[**0046**] In one embodiment of present invention, MS **104** is authorized, either by system design or by infrastructure **124**, to play out the audio information included in the received RLP frames as soon as the frames are received by the MS. In another embodiment of the present invention, wherein infrastructure **124** sends RLP frames to MS **104** before the depth of RLP buffer **210** attains a depth equal to the target depth of play-out buffer **326**, the infrastructure may instruct MS **104** to wait an amount of time equal to the difference between the depth of buffer **210** and the target depth of buffer **326** before playing out the audio information included in the received RLP frames. In the latter embodiment, infrastructure **124** causes MS **104** to delay playing out voice until the infrastructure has received, and transmitted to MS **104**, sufficient data to fill play-out buffer **326** in the MS.

[0047] Preferably, infrastructure **124** instructs, or authorizes, MS **102** to begin playing out audio information via the AUDIO_CNTRL data field of the RLP frames. In one embodiment of the present invention, during the BUFF_BUILD time period MS **102** sets the AUDIO_CTRL data field of each data frame to a value of '0.' When infrastructure **124** receives RLP frames from MS **102**, and MS **104** in turn receives RLP frames from infrastructure **124**, each of infrastructure **124** and MS **104** checks each received RLP frame for the value stored in the AUDIO_CTRL data field. So long as the value stored in the AUDIO_CTRL data field of their respectively received RLP frames is '0,' infrastructure **124** and MS **104** each processes their respectively received RLP frames without acknowledging the erroneously received frames.

[0048] When MS **104** detects a '1' in the AUDIO_CTRL data field of a received RLP frame, the MS interprets this as authorization to play out received audio information. Therefore, when infrastructure **124** wishes to instruct, or authorize, MS **104** to begin playing out audio information, the infrastructure inserts a value of '1' into the AUDIO_CTRL data field of an RLP frame. When infrastructure **124** wishes to instruct, or authorize, MS **104** to begin playing out audio information as soon as the listener RF links are built, the infrastructure inserts a '1' into the AUDIO_CTRL data field of all RLP frames sent to the MS. Alternatively, when the depth of RLP buffer **210** is less than the target depth of play-out buffer **326** at the time that infrastructure **124** begins transmitting RLP frames to MS **104**, and the infrastructure wishes to instruct MS **104** to wait an amount of time equal to the buffer depth difference before playing out audio information, then the infrastructure inserts a '0' into an AUDIO_CTRL data field of each transmitted RLP frame until an amount of time equal to the buffer depth difference expires after the transmission of the initial RLP frame to MS **104**. Upon expiration of the amount of time equal to the buffer depth difference, infrastructure **124** then begins inserting '1's into the AUDIO_CTRL data field of RLP frames transmitted to MS **104**.

[0049] When MS **104** first detects a received RLP frame with the AUDIO_CTRL data field set to '1,' a dispatch application executed by signal processing unit **306** of MS **104** is signaled to begin playing out the vocoded frames stored in play-out buffer **326**. After the expiration of the BUFF_BUILD time period, MS **102** inserts a value of '1' in the AUDIO_CTRL data field of all subsequently transmitted RLP frames until the speaker button release (end of talk spurt) is detected. In one embodiment of the present invention, expiration of the BUFF_BUILD time period is determined by MS **102** by reference to a timer **314** coupled to signal processing unit **306** of the MS. Infrastructure **124** then determines the expiration of the BUFF_BUILD time period by detecting a '1' in the AUDIO_CTRL data field of received RLP frames. Upon determining the expiration of the BUFF_BUILD time, infrastructure **124** also inserts a value of '1' in the AUDIO_CTRL data field of all subsequently transmitted RLP frames. MS **104** then determines the expiration of the BUFF_BUILD time period by detecting a '1' in the AUDIO_CTRL data field of received RLP frames.

[0050] In another embodiment of the present invention, expiration of the BUFF_BUILD time period is determined by each of MS **102**, infrastructure **124**, and MS **104** by reference to timers **216**, **314** respectively coupled to their signal processing units **206**, **306**. In yet another embodiment of the present invention, the expiration of the BUFF_BUILD time period is dynamically determined by infrastructure **124** based on the time at which the infrastructure determines that one or more of RLP buffer **210**, jitter buffer **324**, and play-out buffer **326** is full. Infrastructure **124** is able to approximately determine when buffers **324** or **326** are full based on known buffer sizes, a known FER, the number of frames transmitted by the infrastructure to the buffers, and a known play-out rate of the MS. Infrastructure **124** may then convey information concerning the expiration of the BUFF_BUILD period to each of MS **102** and MS **104**.

[0051] Upon determining that the BUFF_BUILD time period has expired, each of infrastructure **124** and MS **104** begins acknowledging (**512**) erroneously received RLP frames by transmitting an acknowledgment (i.e., a NAK). Infrastructure **124** sends a NAK for each erroneously received frame to MS **102** via forward link **130**, and MS **104** sends a NAK for each erroneously received frame to infrastructure **124** via reverse link **136**. Based on the received NAK's, infrastructure **124** is able to determine a frame error rate (FER) for reverse link **136**, and MS **102** is able to determine a frame error rate (FER) for forward link **130**. Alternatively, infrastructure **124** and MS **102** may also determine error metrics such as a BER, SNR, CIR, or E_b/I_o ratio based on the received NAK's. MS **102** may then convey the FER, BER, SNR, CIR, and/or E_b/I_o ratio results to infrastructure **124**.

[0052] After the expiration of the BUFF_BUILD time period, when infrastructure **124** correctly receives RLP frames from MS **102**, the infrastructure forwards the frames to their intended destination, that is, MS **104**. However, when infrastructure **124** receives an erroneous RLP frame from MS **102**, the infrastructure transmits a NAK to MS **102** that identifies the erroneous frame and stores RLP frames subsequently received from MS **102** in RLP buffer **210**. Included in the NAK is an identifier of the erroneously received frame. Similarly, when MS **104** receives an erroneous RLP frame from infrastructure **124** after the expiration of the BUFF_BUILD time period, MS **104** transmits a NAK to the infrastructure that identifies the erroneous frame and stores RLP frames subsequently received from the infrastructure in jitter buffer **324**. NAK's are well known in the art and will not be described in greater detail herein.

[0053] When MS **102** or infrastructure **124** receives a NAK, MS **102** or infrastructure **124** retransmits (**514**) the RLP frame identified in the NAK, setting the retransmitted frame data field (REXMIT) of the retransmitted frame to '1.' When infrastructure **124** or MS **104** correctly receives the retransmitted RLP frame, the correctly received frame is inserted into the frame's sequential position among the RLP frames that have been buffered in the respective RLP buffer **210**, **324**. After adding the correctly retransmitted frame to the frames stored in buffers **210** or **324**, infrastructure **124** or MS **104** respectively convey their buffered frames to MS **104** or the listener using MS **104**. When either infrastructure **124** or MS **104** erroneously receives a retransmitted frame a predetermined number of times, preferably once, then the infrastructure or the MS aborts the frame and transmits the frames stored in respective buffers **210** and **324** without the inclusion of the erroneous frame. Those who are of ordinary skill in the art realize that the number of times that a frame

is retransmitted before being aborted is up to the designer of the system and that other numbers of retransmissions may be used herein without departing form the spirit and scope of the present invention.

[**0054**] In addition, upon expiration of the BUFF_BUILD time period, each of infrastructure **124** and MS **104** switches to a higher frame error rate (HIGH_FER) target for the processing of RLP frames, and each of and MS **102** and infrastructure **124** switches to a correspondingly lower transmitted power level. That is, after the acknowledgments begin, each of infrastructure **124** and MS **104** can tolerate a greater percentage of errors per data transmission since erroneously received RLP frames are being acknowledged and retransmitted. As a result, when infrastructure **124** begins acknowledging erroneously received frames, MS **102** begins transmitting **(508)** RLP frames at a second speaker link power level that is less than the first speaker link power level. Similarly, when MS **104** begins acknowledging erroneously received frames, infrastructure **124** begins transmitting **(510)** RLP frames at a second listener link power level that is less than the first speaker link power level.

[**0055**] By transmitting RLP frames at higher power levels that minimize the need to acknowledge erroneously received frames, and seeing a LOW_FER target appropriate for communications that do not include acknowledgments, communication system **100** minimizes the use of the jitter buffer **324** during the BUFF_BUILD period. By minimizing the use of jitter buffer **324**, communication system **100** is able to play out audio information to a listener using MS **104** sooner than is possible in the prior art. Furthermore, communication system **100** allows the speaker using MS **102** to begin speaking even before the listener RF links are built, storing the transmitted RLP frames in buffer **210** in infrastructure **124** until the listener RF links are built. Upon completion of the listener RF links, the RLP frames stored in buffer **210** may be immediately downloaded to MS **104** and immediately played out by the MS. Alternatively, infrastructure **124** may instruct MS **104** to delay playing out voice until the infrastructure has received, and transmitted to MS **104**, sufficient data to fill play-out buffer **326** in the MS.

[**0056**] Due to voice compression by vocoder **328** in MS **102** and voice decompression by vocoder **328** in MS **104**, audio information is received by MS **104** more quickly than the MS can play it out. As a result, during the BUFF_BUILD period, communication system **100** fills jitter buffer **324** in MS **104** while the MS is playing out audio information. After jitter buffer **326** is filled, the BUFF_BUILD period ends. At this time, jitter buffer **324** in MS **104** is filled and acknowledgments and retransmissions are instituted in communication system **100**. Since the jitter buffer is filled, an acknowledgment and a retransmission of an RLP frame erroneously received by infrastructure **124** or MS **104** will not create a gap in the play out of audio information. Furthermore, since acknowledgments and a retransmissions are being used, a higher FER target is established for the overall link between MS **102** and MS **104** and RLP frames are transmitted at lower power levels. By transmitting RLP frames at lower power levels, RF interference with other communications sharing the same bandwidth or adjacent bandwidths is minimized.

[**0057**] The process described above for expediting the play out of audio information to a listener in a dispatch communication is also applicable to a change in who is speaking in a dispatch communication. Similar to the initiation of a dispatch communication, a listener using a mobile station involved in a dispatch communication, such as a user of MS **104**, who wishes to speak may reserve traffic channels in a reverse link and a forward link, such as reverse link **136** and forward link **134**, by depressing the PTT key on the user's MS. Speaker RF links are then established for use by the user in each of reverse link **136** and forward link **134**, and listener RF links are established for the listener, that is MS **102**, in forward link **130** and reverse link **132**. Alternatively, MS **102** and MS **104** may each be able to maintain their already established RF links. The above described process may then be used to expedite the play out of audio information from the user of MS **104** to the user of MS **102** and to any other participants in the dispatch call, whose jitter buffers are preferably all reset.

[**0058**] In another embodiment of the present invention, MS **102** and infrastructure **124** may adjust one or more of frame error rate (FER) targets and transmitted signal power levels for their respective legs of the forward link between MS **102** and MS **104** at any time during a dispatch communication. **FIGS. 6A and 6B** are a logic flow diagram **600** of steps executed by system **100** in adjusting FER targets and transmitted power levels of a packet data communication in accordance with another embodiment of the present invention. Logic flow **600** begins **(602)** when infrastructure **124** determines **(604)** a first radio frequency (RF) load metric corresponding to an RF load of reverse link **132**, which reverse link includes the speaker reverse RF link. For example, the determined RF load metric may be a measure of the reverse link RF capacity presently in use, such as a percentage of all existing traffic channels in reverse link **132** that are currently assigned to active communications, or a percentage of all existing traffic channels in reverse link **132** that are unassigned and available for assignment. Infrastructure **124** also determines **(606)** a second RF load metric corresponding to an RF load of forward link **134**, which forward link includes the listener forward RF link.

[**0059**] Based on the first and second RF load metrics, infrastructure **124** then determines **(608)** an FER target for the speaker reverse RF link and further determines **(610)** an FER target for the listener forward RF link. The FER targets are the FER's that communications on each link are desired to attain. As described in detail above, the setting of an FER target is dependent upon the number of retransmissions permitted of an erroneously received frame. The infrastructure may also determine **(612)** a number of retransmissions for the speaker RF links before aborting a frame transmitted over the speaker reverse RF link and may determine **(614)** a number of retransmissions for the listener RF links that may be attempted before aborting a frame in the listener forward RF link.

[**0060**] Also, as is apparent to one of ordinary skill in the art, the attained FER is related the to the power level used to transmit the RLP frames, as greater numbers of retransmissions and higher transmitted power levels each corresponds to lower FER's. As a result, based on the determined FER targets, infrastructure **124** may also do one or more of determine **(616)** a transmitted signal power level for the speaker reverse RF link, determine **(618)** a transmitted

signal power level for the listener forward RF link, and set (**620**) the BUFF_BUILD parameter to zero, and the logic flow ends (**622**).

[**0061**] For example, and merely for the purpose of illustrating the principles of the present invention, infrastructure **124** may determine that the RF load of reverse link **132** is greater than the RF load of forward link **134**. Since forward link **134** is less crowded, infrastructure **124** may determine that forward link **134** can support more retransmissions of erased frames, a higher transmitted signal power level, or both, than reverse link **132**. As a result, infrastructure **124** may decide to use more layers of acknowledgments (e.g., NAK's) on the speaker RF links, such as twice acknowledging erroneously received RLP frames instead of once. Alternatively, infrastructure **124** may determine that the speaker RF links should use fewer layers of acknowledgments or a lower transmitted signal power so as to free up RF capacity in reverse link **134** and/or reduce the levels of interference on the reverse link.

[**0062**] Furthermore, since the overall forward link FER for a signal transmitted from MS **102** to MS **104** is a combination of the FER's for signals transmitted over the leg from MS **102** to infrastructure **124** and over the leg from infrastructure **124** to MS **104**, the infrastructure may decide to make concurrent adjustments to transmissions over the speaker reverse RF link and the listener forward RF link in order to maintain an overall forward link (i.e., from MS **102** to MS **104**) FER target. For example, infrastructure **124** may adopt a lower FER target for the listener forward RF link and a higher FER target for the speaker reverse RF link while maintaining an overall forward link FER target. Alternatively, or in addition to adjusting FER targets, infrastructure **124** may decide to increase the transmitted power level for the listener forward RF link and reduce the transmitted power level for the speaker reverse RF link in order to maintain an overall forward link FER target.

[**0063**] In still another embodiment of the present invention, infrastructure **124** may further determine (**624**) a third RF load metric corresponding to an RF load of forward link **130** and determine (**626**) a fourth RF load metric corresponding to an RF load of the reverse link **136**. Infrastructure **124** may then determine (**628**, **630**) an FER target for each of the speaker reverse RF link and the listener forward RF link based on each of the first, second, third, and fourth RF load metrics. Furthermore, based on the first, second, third, and fourth RF load metrics, infrastructure **124** may also determine (**632**, **634**) a maximum number of retransmissions for each of the speaker RF links and the listener RF links and/or may further determine (**636**, **638**) transmitted signal power levels for each of the speaker RF link **132** and the listener forward RF link.

[**0064**] In yet another embodiment of the present invention, instead of adjusting the FER targets and/or transmitted signal power levels for one or more legs of the link between MS **102** and MS **104** based on determined RF loads, the adjustments may be based on error metrics determined for each leg. **FIGS. 7A and 7B** are a logic flow diagram **700** of the transmission of data by system **100** in accordance with another embodiment of the present invention. Logic flow diagram **700** begins (**702**) when infrastructure **124** determines (**704**) a first error metric corresponding to the speaker reverse RF link. Preferably the error metric is an FER or an abort rate; however, those who are of ordinary skill in the art realize that there are many ways to determine an error metric for an RF link. The error metric may be based on bit error rates or may be based on a comparison of a signal power-to-interference ratio to a predetermined threshold. An abort rate corresponds to a percentage of frames that are aborted.

[**0065**] Infrastructure **124** also determines (**706**) a second error metric corresponding to the listener forward RF link. Based on the first and second error metrics, infrastructure **124** then determines (**708**) an FER target for the speaker reverse RF link and further determines (**710**) an FER target for the listener forward RF link. The infrastructure may also determine (**712**) a number of retransmissions for the speaker RF links before aborting a frame transmitted over the speaker RF links, and may determine (**714**) a number of retransmissions for the listener RF links that may be attempted before aborting a frame transmitted over the listener RF links. Based on the first and second error metrics, infrastructure **124** may also do one or more of determine (**716**) a transmitted signal power level for the speaker reverse RF link, determine (**718**) a transmitted signal power level for the listener forward RF link, and set (**720**) the BUFF_BUILD parameter to zero, and the logic flow ends (**722**).

[**0066**] In another embodiment of the present invention, infrastructure **124** may further determine (**724**) a third error metric corresponding to the speaker forward RF link and determine (**726**) a fourth error metric corresponding to the listener reverse RF link. The third error metric may be based on NAK's received by MS **102** from infrastructure **124** and the fourth error metric may be based on NAK's received by infrastructure **124** from MS **104**. Based on each of the first, second, third, and fourth error metrics, infrastructure **124** then determines (**728**, **730**) an FER target for any one or more of the speaker reverse RF link and the listener forward RF link. Furthermore, based on the first, second, third, and fourth error metrics, infrastructure **124** may also determine (**732**, **734**) a number of retransmissions for each of the speaker reverse RF link and the listener forward RF link before a frame is aborted and/or determine (**736**, **738**) a transmitted signal power level for each of the speaker reverse RF link and the listener forward RF link.

[**0067**] In still another embodiment of the present invention, infrastructure **124** may determine (**740**) an overall error target, such as an overall FER target, or an overall abort rate, for transmissions from MS **102** and MS **104** based on the first and second, or additionally the third and fourth, error metrics. Infrastructure **124** then compares (**742**) the overall error target or abort rate to an error target or abort rate threshold and adjusts (**744**) an FER target or transmitted signal power level for one or more of the speaker RF links and the listener RF links based on the comparison. In this way infrastructure **124** can maintain an overall error rate or abort rate for the link between MS **102** and MS **104** while individually adjusting the performance of each leg of the link. By individually adjusting each leg of the link, retransmissions may be utilized on the legs that can best afford retransmissions and transmissions may be made at higher power levels on the legs where the transmissions will least interfere with other communications.

[**0068**] For example, and again merely for the purpose of illustrating the principles of the present invention, infra-

structure **124** may utilize the following formula in making adjustments to the error rates of one or more links **130-136**. First, infrastructure **124** estimates 'Pr(AB)' wherein Pr(AB)=Abort Probability across reverse link **132** and forward link **134**. The Abort Probability may be estimated by directly measuring it or by estimating it as follows:

$$Pr(AB)=S_ABORT+(1-S_ABORT)*R_ABORT;$$

[**0069**] wherein

$$S_ABORT=SF*(SN+(1-SN)*SF)^{SRNDS},$$

$$R_ABORT=RF*(RN+(1-RN)*RF)^{RRNDS},$$

[**0070**] and SF=Sender's (i.e., MS **102**) Frame Erasure Rate (for reverse link **132**), SN=Sender's NAK Erasure Rate (for forward link **130**), SRNDS=Sender's number of NAKs Prior to Aborting (summing over all rounds), RF=Receiver's (i.e., MS **104**) Frame Erasure Rate (for reverse link **136**), RN=Receiver's NAK Erasure Rate (for forward link **134**), and RRNDS=Receiver's number of NAKs Prior to Aborting (summing over all rounds). Infrastructure **124** also determines the RF load for each of links **130-136**.

[**0071**] Infrastructure **124** then compares 'Pr(AB)' to a target level for the abort probability, that is, AB_Target. When Pr(AB) is greater than ('>') AB_Target, then infrastructure **124** increases the FER on the link **130-136** with the least remaining RF capacity. When Pr(AB) is less than ('<') AB_Target, then infrastructure **124** decreases the FER on the link **130-136** with the most remaining RF capacity. By adjusting the FER's based on the above formulas, infrastructure **124** is able to reduces the total forward link RF impact of a call while maintaining the same effective RLP frame abort rate across the entire call.

[**0072**] In sum, wireless packet data communication system **100** transmits data from a first mobile station (i.e., MS **102**) to infrastructure **124** at a first speaker link power level, and from the infrastructure **124** to a second mobile station (i.e., MS **104**) at a first listener link power level, during a first time period, that is, the BUFF_BUILD time period. Preferably, the first time period is approximately the length of a jitter buffer. Each of the first speaker link power level and the first listener link power level is designed to avoid the need for retransmissions of erroneously received data. By eliminating the need for retransmissions, the play-out buffer **326** in MS **104** may filled sooner and voice communications may be relayed from the speaker to the listener more quickly. Upon expiration of the first time period, data is transmitted from MS **102** to infrastructure **124** and from the infrastructure to MS **104** at reduced power levels, which transmissions include retransmissions of erroneously received data. By subsequently operating at reduced power levels, RF interference with other on-going communications may be minimized.

[**0073**] Frame error rate (FER) targets used in the transmission of data may also be adjusted after expiration of the first time period. In addition, the power levels and FER's may be individually adjusted on a link-by-link basis based on the RF loading of each link and/or based on error metrics determined for each link. In this way, interference for on-going communications in each link is minimized while overall, with respect to the conveyance of data from MS **102** to MS **104**, error targets are maintained.

[**0074**] While the present invention has been particularly shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that various changes may be made and equivalents substituted for elements thereof without departing from the spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed herein, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for transmitting data comprising steps of:

transmitting, by a first communication device, a first set of data at a first power level during a first time period, wherein the first power level is such that the first set of data is received by a second communication device at an acceptable error rate without utilizing a retransmission of a portion of the first set of data;

transmitting, by the first communication device, a second set of data at a second power level upon expiration of the first time period, wherein the second power level is less than the first power level; and

when a portion of the second set of data is erroneously received by the second communication device, retransmitting the erroneously received portion.

2. The method of claim 1, wherein the second communication device includes a jitter buffer and wherein the first time period is approximately the same size as the jitter buffer.

3. The method of claim 1, wherein the first power level comprises a first speaker link power level, wherein the second power level comprises a second speaker link power level, wherein the second communication device comprises a wireless infrastructure, and wherein the method further comprises steps of:

transmitting, by the wireless infrastructure, the first set of data at a first listener link power level upon expiration of the first time period, wherein the first listener link power level is such that the first set of data is received by a third communication device at an acceptable error rate without utilizing a retransmission of a portion of the first set of data;

transmitting, by the by the wireless infrastructure, the second set of data at a second listener link power level upon expiration of the first time period, wherein the second listener link power level is less than the first listener link power level; and

when a portion of the second set of data is erroneously received by the third communication device, retransmitting, by the wireless infrastructure, the erroneously received portion.

4. The method of claim 3, wherein the first time period comprises the time that expires between completing a set up of a traffic link between the first communication device and the infrastructure and the completing a set up of a traffic link between the infrastructure and the third communication device, and further comprising a step of playing out, by the third communication device, at least a portion of the first set of data upon receiving the at least a portion of the first set of data.

5. The method of claim 3, wherein the third communication device includes a play-out buffer, wherein the first time period comprises a time period that is approximately equal to a buffer depth target for the play-out buffer, and further comprising a step of playing out, by the third communication device, at least a portion of the first set of data upon receiving the at least a portion of the first set of data.

6. The method of claim 5, wherein a length of the first time period is preprogrammed into each of the first communication device, the infrastructure, and the third communication device.

7. The method of claim 5, further comprising steps of:

determining, by the infrastructure, a length of the first time period; and

conveying, by the infrastructure, the determined length of the first time period to each of the first communication device and the third communication device.

8. The method of claim 3, further comprising steps of:

determining, by the infrastructure, a length of the first time period; and

conveying, by the infrastructure, an expiration of the first time period to the third communication device through a data field in a radio link protocol (RLP) header.

9. The method of claim 1, wherein the first power level comprises a first speaker link power level, wherein the second power level comprises a second speaker link power level, wherein the second communication device comprises a wireless infrastructure, and wherein the method further comprises steps of:

transmitting, by the wireless infrastructure, the first set of data at a first listener link power level upon expiration of the first time period, wherein the first listener link power level is such that the first set of data is received by a third communication device at an acceptable error rate without utilizing a retransmission of a portion of the first set of data;

transmitting, by the by the wireless infrastructure, the second set of data at a second listener link power level during the first time period, wherein the second listener link power level is less than the first listener link power level; and

when a portion of the second set of data is erroneously received by the third communication device, retransmitting, by the wireless infrastructure, the erroneously received portion.

10. The method of claim 9, wherein the third communication device includes a play-out buffer, wherein the first time period comprises a time period that is approximately equal to a buffer depth target for the play-out buffer, and further comprising a step of playing out, by the third communication device, at least a portion of the first set of data upon expiration of the first time period.

11. A method for transmitting data in a wireless communication system, wherein the communication system comprises a first wireless communication device, a wireless infrastructure in communication with the first communication device via a reverse link, and a second wireless communication device in communication with the infrastructure via a forward link, the method comprising steps of:

determining a first radio frequency (RF) load metric corresponding to an RF load of the reverse link;

determining a second RF load metric corresponding to an RF load of the forward link;

determining an acceptable error rate for the forward link based on the first and second RF load metrics; and

determining an acceptable error rate for the reverse link based on the first and second RF load metrics.

12. The method of claim 11, wherein the wireless infrastructure is in communication with the first communication device via a first reverse link and a first forward link, wherein the wireless infrastructure is in communication with the second communication device via a second reverse link and a second forward link, wherein the step of determining a first radio frequency (RF load) metric comprises a step of determining a first RF load metric corresponding to the first reverse link, wherein the step of determining a second RF load metric comprises a step of determining a second RF load metric corresponding to the second forward link, and further comprising steps of:

determining a third RF load metric corresponding to a RF load of the first forward link;

determining a fourth RF load metric corresponding to a RF load of the second reverse link; and

wherein acceptable error rates are determined for each of the first forward link, the first reverse link, the second forward link, and the second reverse link based on the first, second, third, and fourth RF load metrics.

13. A method for transmitting data in a wireless communication system, wherein the communication system comprises a first wireless communication device, a wireless infrastructure in communication with the first communication device via a first reverse link and a first forward link, and a second wireless communication device in communication with the infrastructure via a second reverse link and a second forward link, the method comprising steps of:

determining a first error metric corresponding the first reverse link;

determining a second error metric corresponding the first forward link; and

determining an acceptable frame error rate of one or more of the first reverse link, and the second forward link based on the first error metric and the second error metric.

14. The method of claim 13, further comprising steps of:

determining a third error metric corresponding the second reverse link;

determining a fourth error metric corresponding the second forward link; and

determining an acceptable frame error rate of one or more of the first reverse link and the second forward link based on the first second, third, and fourth error metrics.

15. The method of claim 13, further comprising steps of:

determining a third error metric corresponding the second reverse link;

determining a fourth error metric corresponding the second forward link; and

determining a probability of aborting a transmission of data from the first communication unit to the second communication unit based on the first, second, third, and fourth error metrics to produce an abort probability;

comparing the abort probability to an abort probability threshold to produce a comparison; and

adjusting an acceptable error rate of one or more of the first reverse link, the first forward link, the second reverse link, and the second forward link based on the comparison.

16. The method of claim 13, further comprising steps of:

determining a first radio frequency (RF) load metric corresponding to a RF load of the first reverse link;

determining a second RF load metric corresponding to a RF load of the first forward link;

determining a third RF load metric corresponding to a RF load of the second reverse link;

determining a fourth RF load metric corresponding to a RF load of the second forward link; and

determining which link, from among the first reverse link, the first forward link, the second reverse link, and the second forward link, has a greatest RF load based on the first, second, third, and fourth RF load metrics; and

wherein the step of adjusting an acceptable error rate comprises a step of decreasing an acceptable error rate of the link that has the greatest RF load when the abort probability is greater than the abort probability threshold.

17. The method of claim 16, wherein the error rate is adjusted by reducing a number of attempted retransmissions of erroneously received data on the link that has the greatest radio frequency (RF) load when the abort probability is greater than the abort probability threshold.

18. The method of claim 16, wherein the number of attempted retransmissions is reduced by reducing the use of acknowledgments on the link that has the greatest radio frequency (RF) load.

19. The method of claim 13, further comprising steps of:

determining a first radio frequency (RF) load metric corresponding to a RF load of the first reverse link;

determining a second RF load metric corresponding to a RF load of the first forward link;

determining a third RF load metric corresponding to a RF load of the second reverse link;

determining a fourth RF load metric corresponding to a RF load of the second forward link; and

determining which link, from among the first reverse link, the first forward link, the second reverse link, and the second forward link, has a lowest utilization rate based on the first, second, third, and fourth RF load metrics; and

wherein the step of adjusting an acceptable error rate comprises a step of increasing an acceptable error rate of the link that has the lowest RF load when the abort probability is less than the abort probability threshold.

20. The method of claim 19, wherein the error rate is adjusted by increasing a number of attempted retransmissions of erroneously received data on the link that has the lowest RF load when the abort probability is less than the abort probability threshold.

21. The method of claim 19, wherein the number of attempted retransmissions of erroneously received data is reduced by reducing the use of acknowledgments on the link that has the lowest RF load.

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