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(71) Applicant *(for all designated States except US)*: **HUAWEI TECHNOLOGIES CO., LTD.** [CN/CN]; Huawei Administration Building, Bantian, Longgang District, Guangdong, Shenzhen, Guangdong 518129 (CN).

(71) Applicant *(for US only)*: **FUTUREWEI TECHNOLOGIES, INC.** [US/US]; 5340 Legacy Drive, Suite 175, Plano, Texas 75024 (US).

(72) Inventors: **CALLARD, Aaron**; 2663 Conn ST., Ottawa, Ontario K2B 7C4 (CA). **STEPHENNE, Alex**; 141 West Ridge Drive, Stittsville, Ontario K2S 2H3 (CA). **AU, Kelvin Kar Kin**; 233 Tandalee Cres., Kanata, Ontario K2M 0A2 (CA).

(74) Agent: **CARLSON, Brian A.**; Slater & Matsil, L.L.P., 17950 Preston Rd., Suite 1000, Dallas, Texas 75252 (US).

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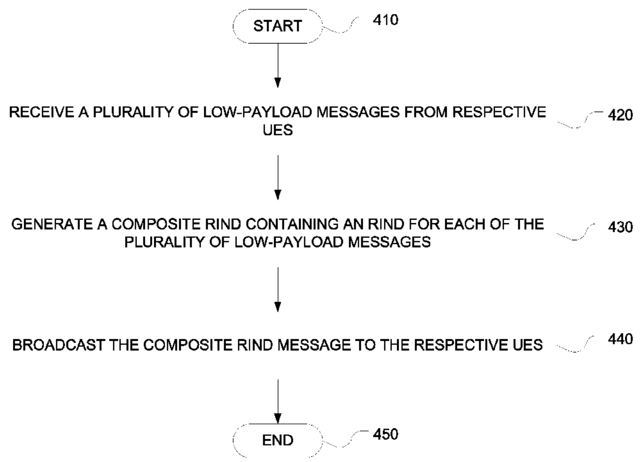

FIG. 4

(57) **Abstract**: An embodiment method of indicating reception of a plurality of low-payload messages includes receiving the plurality of low-payload messages from respective user equipments (UEs). The method also includes generating a composite reception indication (RIND) containing a RIND for each of the plurality of low-payload messages. The method also includes broadcasting the composite RIND to the respective UEs.

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System and Method for Low-Payload Acknowledgment

This patent application claims priority to U.S. Patent Application No. 14/537,615, filed on November 10, 2014, entitled “System and Method for Low-Payload Acknowledgment,” which is hereby incorporated herein by reference.

TECHNICAL FIELD

The present invention relates generally to acknowledging low-payload messages in wireless systems, and, in particular embodiments, to a base station, a user equipment (UE), and methods for transmitting and acknowledging low-payload methods.

BACKGROUND

Driven largely by smart phones, tablets, and video streaming, the amount of wireless data handled by wireless networks has risen markedly and is expected to continue to rise by orders of magnitude over the next ten years. In addition to the sheer volume of data, the number of devices is expected to continue to grow exponentially, possibly reaching into the billions of devices, along with radically higher data rates. Different applications will place different requirements on the performance of future wireless networks. Future wireless networks are expected to be highly flexible, highly efficient, open, and customizable for customers and consumers.

In addition, with the increased deployment of small cells, heterogeneous networks (het-nets), machine to machine (M2M) communications, and networks of devices, where thousands or millions of devices are attached, there is a need for optimization in the application layers and in the physical layers of a wireless access link.

SUMMARY

An embodiment method of indicating reception of a plurality of low-payload messages includes receiving the plurality of low-payload messages from respective user equipments (UEs). The method also includes generating a composite reception indication (RIND) containing a RIND for each of the plurality of low-payload messages. The method also includes transmitting the composite RIND to the respective UEs.

An embodiment method of transmitting a low-payload message includes transmitting an original message having payload data to a base station. The method also includes receiving a composite RIND broadcast. The method also includes extracting a RIND corresponding to the original message from the composite RIND broadcast. The method also includes evaluating the extracted RIND relative to the payload data in the original message. The method also includes initiating a correction procedure when the evaluating indicates an error in receiving the original message at the base station.

An embodiment base station includes a radio resource controller (RRC), a receiver, a processor, and a transmitter. The RRC is configured to provision at least one physical uplink channel (PUCH) over which a plurality of low-payload messages are received from respective UEs. The receiver is configured to receive the low-payload messages and detect respective payload data. The processor is configured to generate a composite RIND containing respective RINDs for each of the plurality of low-payload messages according to the respective payload data. The transmitter is configured to transmit the composite RIND to the respective UEs.

An embodiment UE includes a transmitter, a receiver, and a processor. The transmitter is configured to transmit an original message having payload data to a base station. The receiver is configured to receive a composite RIND. The processor is configured to extract a RIND corresponding to the original message from the composite RIND. The processor is further configured to evaluate the extracted RIND relative to the payload data. The processor is further configured to initiate a correction procedure when the extracted RIND indicates an error in receiving the original message at the base station.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Figure 1 is a diagram of a wireless communication system;

Figure 2 is a block diagram of one embodiment of a base station;

Figure 3 is a block diagram of one embodiment of a UE;

Figure 4 is a flow diagram of one embodiment of a method of indicating reception of low-payload messages;

Figure 5 is a flow diagram of one embodiment of a method of transmitting a low-payload message; and

Figure 6 is a block diagram of one embodiment of a computing system.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The making and using of embodiments are discussed in detail below. It should be appreciated, however, that the present invention provides many applicable inventive concepts that may be embodied in a wide variety of specific contexts. The specific embodiments discussed are merely illustrative of specific ways to make and use the invention, and do not limit the scope of the invention.

In wireless communication systems, various indications and other low-payload message transmissions are made by devices to applications or to the network via uplink (UL) transmissions. The various indications include one-bit indications such as presence indications, keep-alive signaling, and service requests, among others. In current systems, these transmissions can create an inordinate amount of signaling and overhead on the radio link and in the application layers. For example, both a UE sending a 1-bit payload protected by a cyclic redundancy check (CRC) and a base station sending back an ACK or NACK transmission incur a relatively large amount of overhead. These inefficiencies apply to many low-payload messages. A low-payload message can be transmitted without a CRC. A more efficient approach to determining if the low-payload message was correctly received by the base station can be had. In particular, a reception indication (RIND) can be transmitted by the base station to the UE to indicate the information has been received by the base station. The UE then compares the RIND to its original low-payload message to determine if the message was correctly received.

Transmission of ACK/NACK may also be wasteful with respect to use of radio resources and that low-payload transmissions can be acknowledged in a more efficient manner. When a base station receives multiple low-payload messages over various UL channels, the base station can indicate it received the multiple low-payload messages in a single composite RIND. A base station is sometimes referred to as an access point (AP), a station, a node B, or an enhanced node B (eNB), among other references. The composite RIND can be broadcast to the respective devices that originated the multiple low-payload messages. A device is sometimes referred to as a UE, a mobile device, a mobile, a terminal, a user, or a station, among other references. Each device determines which portion of the composite RIND corresponds to its UL message and determines whether the transmission was successful or whether some correction is needed. The overhead for including an error detection code, such as a CRC, for each RIND, can be excessive both in the uplink and in the downlink response.

When the base station receives the low-payload UL transmissions, it detects the payload data. The amount of payload data in a low-payload message can vary per system. In certain systems, low-payload is from 1 to 20 bits of data. In other embodiments, a larger payload may be considered low-payload, for example 100 bits. The precise distinction between low-payload and a normal payload depends on the overhead structure for the communication system. For example, in certain embodiments, a low-payload message is one without an error detection code and a normal payload is one with an error detection code. In some systems, the overhead involved in transmitting a 20 bit payload is excessive. In other systems, the overhead for the 20 bit payload is manageable. In certain systems, the overhead for transmitting a 30 bit payload is excessive.

Rather than transmitting individual RINDs to the various UEs, the base station can generate a composite RIND that can be broadcast to the various UEs. The composite RIND can include multiple elements corresponding to respective UEs. More specifically, each element corresponds to a RIND for a received low-payload message, which is useful in systems where a given UE transmits more than one low-payload message. In some embodiments, the base station can compute an error detection code, such as a CRC, for the composite RIND, which is included in the composite RIND transmission. In certain embodiments, the composite RIND simply echoes back the detected payload from each of the received low-payload messages. For example, in an embodiment where the low-payload messages each have a 1 bit payload, the base station packs each 1 bit detected payload into a bitmap for the composite RIND. In other embodiments, the base station can also include a disposition instruction in the RIND for the originating UEs, for example, indicating resources allocated for a channel over which additional data can be transmitted.

In yet another embodiment, where the low-payload messages each have a multiple bit payload, the base station can compute a signature for the received low-payload transmission and use that as the RIND for the message. The signature can be, in certain embodiments, based on a CRC or a secure hash (SHA) function. The signature is sometimes referred to as a hash. In some embodiments, the elements of the composite RIND may be compressed before transmission using standard compression techniques, including, for example, arithmetic coding. With the composite RIND, resources are conserved by encoding the composite RIND in a single transmission using a single CRC.

The number of elements in a composite RIND can be the same as the number of UEs that are allocated resources in the low-payload uplink channel. In certain embodiments, the number of elements can be reduced to a subset of UEs addressed in the broadcast channel. For example, if UEs are separated into groups of different geometry, each broadcast of the composite RIND can be addressed to one particular group of UEs at different times. The broadcast pattern for each group is known at the transmitter and receiver via configuration signaling. In other embodiments, the predictability of the low-payload traffic from UEs can be utilized to reduce the number of elements in the composite RIND, such that each broadcast of the composite RIND corresponds to the UEs' low-payload traffic generated over a certain time interval.

When a particular UE receives the broadcasted composite RIND, it determines which element of the composite RIND corresponds to its transmission and extracts its individual RIND. The UE compares its RIND to the original low-payload message. In embodiments that echo the payload back in the composite RIND, the value of the individual RIND is simply compared to the original payload data. If the RIND and data match, the transmission is considered successful. Otherwise, the UE can undertake some corrective action. In embodiments where the base station computes a signature for the respective payloads and places the signature into the composite RIND, the UE checks the returned signature against a signature computed for the low-payload message by the UE. If the signatures match, the transmission is considered successful. Otherwise, the UE can undertake some corrective action. If the composite RIND does not include an individual RIND associated with the UE's original low-payload message, the UE can undertake some corrective action. In other embodiments, where the RIND includes a disposition instruction, the UE checks the RIND against the low-payload message and takes the appropriate action according to the disposition instruction.

Higher-layer entities can request creation of a radio bearer for transmission of small amounts of information from devices. The low-payload message can involve multi-byte packet transmissions over an uplink channel. For example, in a 3GPP LTE system, the transmission may be over a physical uplink shared channel (PUSCH). In certain embodiments, a UE has initial access to a network base station over a random access channel (RACH) or physical RACH (PRACH). In alternative embodiments, the UE can use other methods to notify the base station. The UE notifies the base station that it needs to send data, what kind of data will be transmitted, and how much. The base station then allocates resources for the uplink channel accordingly.

Figure 1 is a diagram of one embodiment of a wireless communication system 100 within which the base station and method of acknowledging low-payload messages may be embodied or carried out. Wireless communication system 100 includes a base station 110 that serves one or more UEs, such as UE 120, UE 130, UE 140, UE 150, UE 160 and UE 170, by receiving communications originating from the UEs and forwarding the communications to their respective intended destinations, or by receiving communications destined for the UEs and forwarding the communications to their respective intended UEs. Some UEs can communicate directly with one another as opposed to communicating through base station 110.

Figure 2 is a block diagram of one embodiment of a communication system 200. Within communication system 200, a base station 210 communicates with UEs 240. Base station 210 includes a processor 214, a transmitter 216, a receiver 218, an isolator 220, an antenna 222, and a data bus 224. Processor 214 includes a radio resource controller (RRC) 212 and communicates to receiver 218 and transmitter 216 through data bus 224. Transmissions are made by transmitter 216 through isolator 220 and antenna 222. Transmissions are received through antenna 222, isolator 220, and receiver 218. Data is relayed among processor 214, receiver 218, and transmitter 216 over data bus 224.

Processor 214 can be implemented in one or more processors, one or more application specific integrated circuits (ASICs), one or more field-programmable gate arrays (FPGAs), dedicated logic circuitry, or any combination thereof, all collectively referred to as a processor. The various functions for processor 214 can be stored as instructions in non-transitory memory for execution by the processor.

RRC 212 allocates time and frequency resources to establish radio bearers for UL and downlink (DL) channels. Processor 214 is configured to execute a protocol stack that can contain various layers, such as a packet data convergence protocol (PDCP) layer, a radio link control (RLC) layer, a media access control (MAC) layer, and a physical (PHY) layer, among others. Data signals and control signals flowing between base station 210 and UEs 240 are processed by processor 214.

At the PHY layer of base station 210, data is transmitted to UEs 240 via transmitter 216 over a DL channel, e.g., a physical downlink channel (PDCH) 232. Data is received at base station 210 via receiver 218 from UEs 240 over at least one UL channel, e.g., physical uplink channel (PUCH) 230. Base station 210 receives multiple low-payload messages from UEs 240 over PUCHs 230. The received signals are initially received at antenna 222 and passed through isolator 220 before arriving at receiver 218. Once converted to baseband digital signals, processor 214 processes the received signals and detects and decodes the payload data in each of the low-payload messages. Processor 214 then determines a RIND for each of the decoded low-payload messages. The RIND can include the original low-payload message, detected payload data, a signature, or a disposition instruction for the originating UE. Processor 214 combines the RINDs for each of the low-payload messages into a composite RIND. The combining can take a variety of forms. In certain embodiments, the combining can be accomplished with a RIND bitmap, where each low-payload message is allocated one or more bits in the RIND bitmap. The composite RIND can then be encoded and broadcast back to UEs 240 through transmitter 216 over PDCH 232.

Figure 3 is a block diagram of another embodiment of a communication system 300. Within communication system 300, a UE 310 communicates with a base station 340. UE 310 includes a processor 312, a transmitter 314, a receiver 316, a data bus 318, an isolator 320, and an antenna 322. Processor 312 communicates to receiver 316 and transmitter 314 through data bus 318. Transmissions are made by transmitter 314 through isolator 320 and antenna 322. Transmissions are received through antenna 322, isolator 320, and receiver 316. Data is relayed among processor 312, transmitter 314, and receiver 316 over data bus 318.

Processor 312, receiver 316, and transmitter 314 can be implemented in one or more processors, one or more application specific integrated circuits (ASICs), one or more field-programmable gate arrays (FPGAs), dedicated logic circuitry, or any combination thereof, all collectively referred to as a processor. The respective functions for processor 312, receiver 316, and transmitter 314 can be stored as instructions in non-transitory memory for execution by the processor.

Processor 312 is configured to execute a protocol stack that can contain various layers, including a PDCP layer, a RLC layer, a MAC layer, and a PHY layer, among others. Data signals and control signals flowing between UE 310 and base station 340 are processed by processor 312.

At the PHY layer of UE 310, data is transmitted to base station 340 via transmitter 314 over an UL channel, e.g., a PUCH 330. Data is received at UE 310 via receiver 316 from base station 340 over a DL channel, e.g., a PDCH 332. Processor 312 generates a low-payload message that is to be transmitted to base station 340. The low-payload message is then passed to transmitter 314 over data bus 318. UE 310 transmits the low-payload message over PUCH 330 through antenna 322. UE 310 waits for a RIND from base station 340. UE 310 monitors downlink channels over which the RIND may be transmitted. The amount of time waited can vary and is typically specified as an acknowledgment period. If no RIND is received in that period, UE 310 assumes base station 340 did not receive the low-payload message and a correction procedure is initiated.

When base station 340 receives the low-payload message, base station 340 broadcasts a composite RIND over PDCH 332. UE 310 receives the composite RIND at receiver 316. Receiver 316 passes the received message to processor 312. The composite RIND contains RINDs for multiple low-payload messages received by base station 340 that were transmitted by various UEs, one of which is UE 310. Processor 312 extracts a RIND corresponding to its low-payload message from the composite RIND. In certain embodiments, the ACK is an echo of the payload data transmitted in the original low-payload message and detected by base station 340. Processor 312 compares the echoed payload data to the originally transmitted payload data. If the echoed payload matches the transmitted payload, base station 340 has successfully received the low-payload message. In other embodiments, the RIND is a signature computed by base station 340 according to the detected original low-payload message. Processor 312 compares the signature to the transmitted payload data to determine the success of the transmission. In certain embodiments, the RIND can include disposition instructions for UE 310 to carry out. For example, in some embodiments, a RIND can be accompanied by an indicator that resources are allocated for a channel over which additional data can be transmitted.

When the RIND is not received or when the received RIND indicates an unsuccessful receipt of the low-payload message by base station 340, processor 312 initiates a correction procedure. Many different correction procedures are possible. In certain embodiments, the correction procedure includes retransmitting the original payload in a new low-payload message. In another embodiment, the correction procedure includes transmitting a new low-payload message with updated data in the payload. The use of one correction procedure over another depends on the communication system. For example, in certain embodiments where a given low-payload message is transmitted periodically, by the time a RIND is received by UE 310, new data is available for the next periodic transmission. When the original payload data is no longer useful, there is no value in retransmitting.

Figure 4 is a flow diagram of one embodiment of a method of indicating reception of low-payload messages. The method begins at a start step 410. At a receiving step 420, a plurality of low-payload messages are received at a base station. The plurality of low-payload messages originate from respective UEs. The respective UEs can include hundreds or more distinct UEs. A given UE can also transmit multiple low-payload messages. The base station receives each low-payload message and attempts to decode the payload data in each received low payload message (cumulatively referred to as the plurality of decoded payloads). The base station then uses the plurality of decoded payloads generate a composite RIND at a generation step 430. In certain embodiments, the composite RIND can be a bitmap where each low-payload message is allocated at least one bit in the bitmap. In certain embodiments, the individual RINDs for the plurality of low-payload messages include an echo of the detected low-payload message. For example, a RIND for a 1-bit payload would be the one bit of payload detected by the base station. In alternative embodiments, where the payload is sufficiently large, the individual RINDs can be signatures computed for each payload. Once the composite RIND is generated, the composite RIND is broadcast to the respective UEs at a broadcasting step 440. In certain embodiments, the composite RIND is encoded using forward error correction (FEC). In alternative embodiments, a CRC is computed for the composite RIND and appended to the transmission.

In alternative embodiments, the base station starts a correction period timer T1 and waits for reception of low-payload message retransmissions from one or more of the UEs. If the timer T1 expires, the received low-payload message is assumed to be correct and is processed by the base station. If a low-payload message retransmission is received before the expiration of the timer, then the base station discards the low-payload message originally received and generates a RIND for the retransmitted low-payload message. The method ends at an end step 450. Those skilled in the art will appreciate that there are a plurality of different mechanisms that can be employed in place of a timer, including setting an alert for an absolute time

Figure 5 is a flow diagram of one embodiment of a method of transmitting a low-payload message. The method begins at a start step 510. At a transmitting step 520, an original low-payload message is transmitted to a base station by a UE. The original low-payload message has a payload. The size of the payload can vary for different communication systems. At a receiving step 530, a composite RIND broadcast transmitted by the base station is received by the UE. At an extraction step 540, the UE extracts a RIND from the composite RIND message associated with the original low-payload message. Which portions of the composite RIND correspond to the UE can be predetermined, such as through a negotiation or system setup. In alternative embodiments, the UE can determine which portion of the composite RIND corresponds to the original low-payload message by analyzing other data in the composite RIND, such as headers.

At an evaluation step 550, the UE evaluates the extracted RIND relative to the payload data in the original low-payload message. In certain embodiments, where the RIND includes an echo of the payload data detected by the base station, the evaluation includes a comparison of the original payload data to the payload data in the RIND. In alternative embodiments, the evaluation includes a comparison of a signature computed by the base station and included in the RIND. If a RIND corresponding to the original low-payload message is not included in the composite RIND, the UE assumes that an error occurred in receipt of the original low-payload message at the base station.

At a correcting step 560, a correction procedure is initiated according to the result of evaluation step 550. When the evaluation indicates an error in receipt of the original low-payload message at the base station, the correction procedure is initiated. When the evaluation indicates the receipt of the original low-payload message was successful, the correction procedure is not initiated. The correction procedure can include a variety of steps, including retransmitting the original payload, transmitting a new low-payload message carrying new payload data, or transmitting additional data over a designated UL channel.

Figure 6 is a block diagram of a computing system 600 that may be used for implementing the devices and methods disclosed herein. Specific devices may utilize all of the components shown or only a subset of the components. Levels of integration may vary from device to device. Furthermore, a device may contain multiple instances of a component, such as multiple processing units, processors, memories, transmitters, receivers, etc. The computing system 600 may comprise a processing unit 602 that may be equipped with one or more input/output devices, such as a speaker, microphone, mouse, touchscreen, keypad, keyboard, printer, display, and the like. The processing unit may include a central processing unit (CPU) 614, memory 608, a mass storage device 604, a video adapter 610, and an I/O interface 612 connected to a bus 620.

The bus 620 may be one or more of any type of several bus architectures including a memory bus or memory controller, a peripheral bus, video bus, or the like. The CPU 614 may comprise any type of electronic data processor. The memory 608 may comprise any type of non-transitory system memory such as static random access memory (SRAM), dynamic random access memory (DRAM), synchronous DRAM (SDRAM), read-only memory (ROM), a combination thereof, or the like. In an embodiment, the memory 608 may include ROM for use at boot-up, and DRAM for program and data storage for use while executing programs.

The mass storage 604 may comprise any type of non-transitory storage device configured to store data, programs, and other information and to make the data, programs, and other information accessible via the bus 620. The mass storage 604 may comprise, for example, one or more of a solid state drive, hard disk drive, a magnetic disk drive, an optical disk drive, or the like.

The video adapter 610 and the I/O interface 612 provide interfaces to couple external input and output devices to the processing unit 602. As illustrated, examples of input and output devices include a display 618 coupled to the video adapter 610 and a mouse/keyboard/printer 616 coupled to the I/O interface 612. Other devices may be coupled to the processing unit 602 and additional or fewer interface cards may be utilized. For example, a serial interface such as Universal Serial Bus (USB) (not shown) may be used to provide an interface for a printer.

The processing unit 602 also includes one or more network interfaces 606, which may comprise wired links, such as an Ethernet cable or the like, and/or wireless links to access nodes or different networks. The network interfaces 606 allow the processing unit 602 to communicate with remote units via the networks. For example, the network interfaces 606 may provide wireless communication via one or more transmitters/transmit antennas and one or more receivers/receive antennas. In an embodiment, the processing unit 602 is coupled to a local-area network 622 or a wide-area network for data processing and communications with remote devices, such as other processing units, the Internet, remote storage facilities, or the like.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

WHAT IS CLAIMED IS:

1. A method of indicating reception of a plurality of low-payload messages, comprising:

receiving the plurality of low-payload messages from respective user equipments (UEs);

generating respective reception indications (RINDs) for the plurality of low-payload messages;

generating a composite RIND containing the respective RINDs; and

transmitting the composite RIND to the respective UEs.

2. The method of Claim 1 wherein each of the plurality of low-payload messages comprises between one and thirty two bits of payload data, inclusively.

3. The method of Claim 1 wherein each of the received low-payload messages is received without a corresponding error checking code.

4. The method of Claim 1 wherein the generating one of the respective RINDs comprises repeating the corresponding low-payload message.

5. The method of Claim 1 wherein the generating one of the respective RINDs comprises computing a signature associated with the corresponding low-payload message.

6. The method of Claim 1 wherein the generating the composite RIND comprises encoding the composite RIND using a forward error correction code.

7. The method of Claim 1 wherein the generating the composite RIND comprises encoding the composite RIND using a cyclic redundancy check.

8. The method of Claim 1 wherein the step of transmitting includes broadcasting a message including the composite RIND.

9. The method of Claim 1 further comprising:

waiting for a correction period of time after the transmitting; and

receiving, during the correction period, at least one correction message from at least one of the respective UEs in response to the composite RIND.

10. The method of Claim 1 further comprising allocating resources in a physical downlink channel (PDCH) over which the transmitting is carried out.

11. The method of Claim 1 further comprising detecting respective payload data in the plurality of low-payload messages.

12. The method of Claim 1 wherein the generating the respective RINDs comprises determining a disposition for each of the plurality of low-payload messages to be carried out by the respective UEs.

13. A method of transmitting a low-payload message, comprising:
transmitting an original message having payload data to a base station;
receiving a composite reception indication (RIND) broadcast over a broadcast channel;
extracting a RIND corresponding to the original message from the composite RIND;
evaluating the extracted RIND relative to the payload data in the original message; and
initiating a correction procedure when the evaluating indicates an error in receiving the original message at the base station.

14. The method of Claim 13 wherein the original transmitted message does not contain an error checking code corresponding to the payload data.

15. The method of Claim 13 wherein extracting the RIND corresponding to the original message comprises extracting the RIND at a predetermined position in the composite RIND.

16. The method of Claim 13 wherein extracting the RIND corresponding to the original message comprises evaluating a header associated with each RIND in the composite RIND.

17. The method of Claim 13 wherein the evaluating comprises comparing a value of the extracted RIND to a value of the payload data.

18. The method of Claim 13 wherein the evaluating comprises comparing a value of the extracted RIND to a signature for the payload data.

19. The method of Claim 13 wherein the correction procedure comprises retransmitting the payload data in a new message to the base station.

20. The method of Claim 13 wherein the correction procedure comprises transmitting a new message having updated payload data.

21. The method of Claim 13 wherein the payload data is between one and thirty two bits of data, inclusively.

22. A base station, comprising:

a receiver configured to receive a plurality of low-payload messages from respective user equipments (UEs) and detect respective payload data;

a transmitter configured to transmit a composite reception indication (RIND) to the respective UEs;

a processor coupled to the receiver and the transmitter, and having a radio resource controller (RRC) configured to provision physical uplink channels (PUCHs) over which the plurality of low-payload messages are received, wherein the processor is configured to generate the composite RIND containing respective RINDs for each of the plurality of low-payload messages according to the respective payload data.

23. A user equipment (UE), comprising:

a transmitter configured to transmit an original message having payload data to a base station;

a receiver configured to receive a composite reception indication (RIND); and

a processor coupled to the transmitter and the receiver, and configured to:

extract a RIND corresponding to the original message from the composite RIND,

evaluate the extracted RIND relative to the payload data, and

initiate a correction procedure when the extracted RIND indicates an error in receiving the original message at the base station.

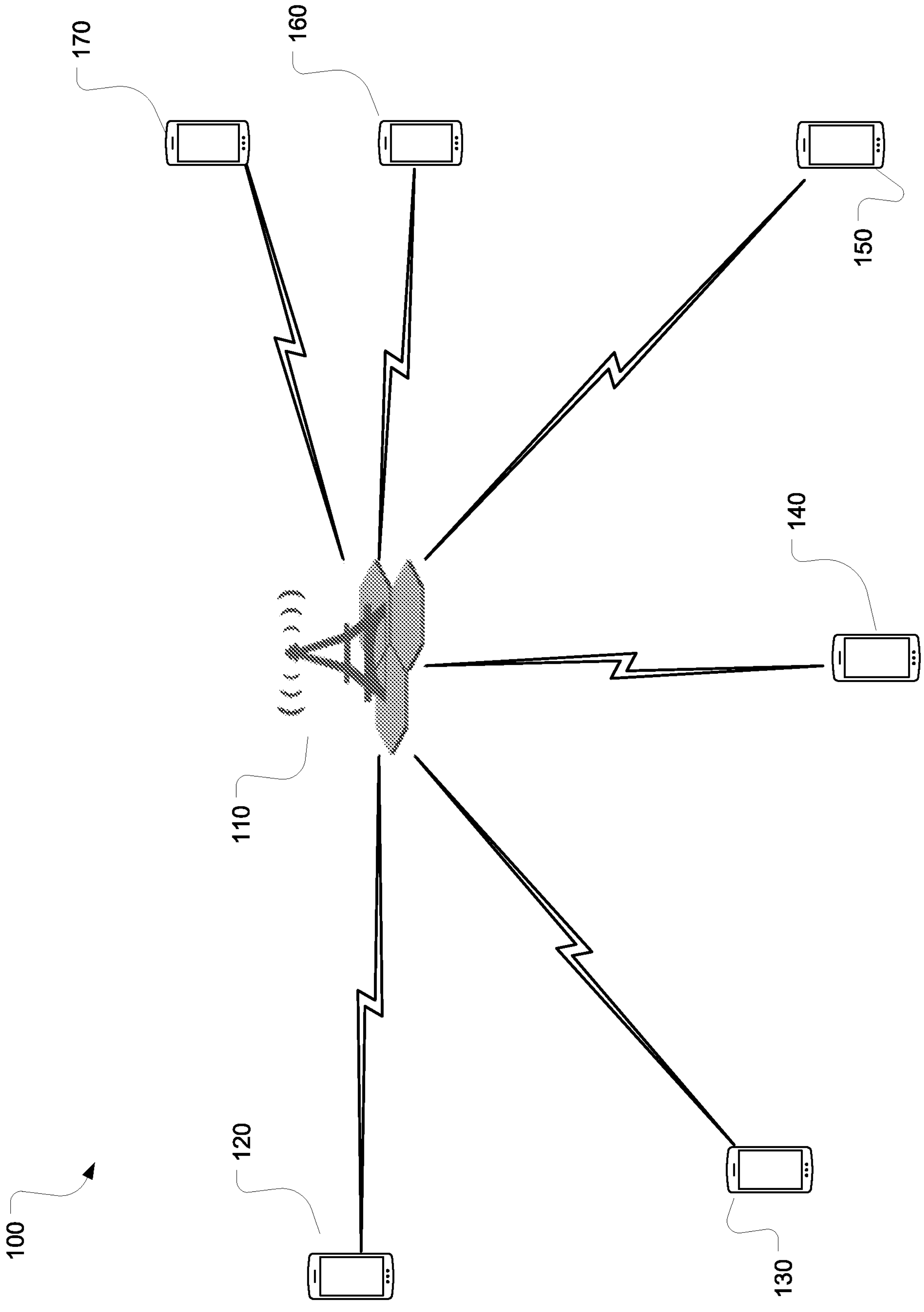

FIG. 1

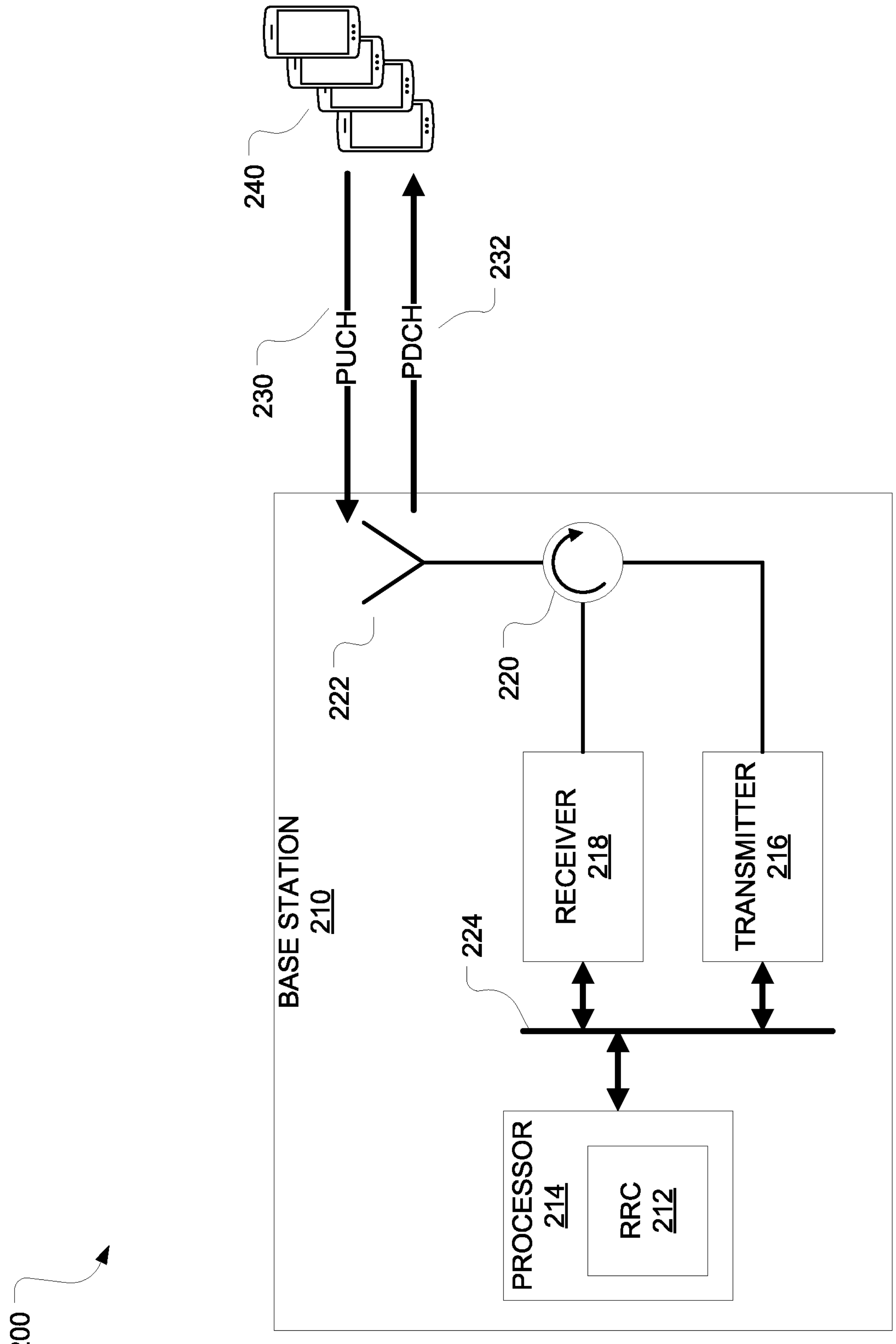
200
BASE STATION 210
PROCESSOR 214
RRC 212
RECEIVER 218
TRANSMITTER 216
224
222
220
PUCH
PDCH
230
232
240

FIG. 2

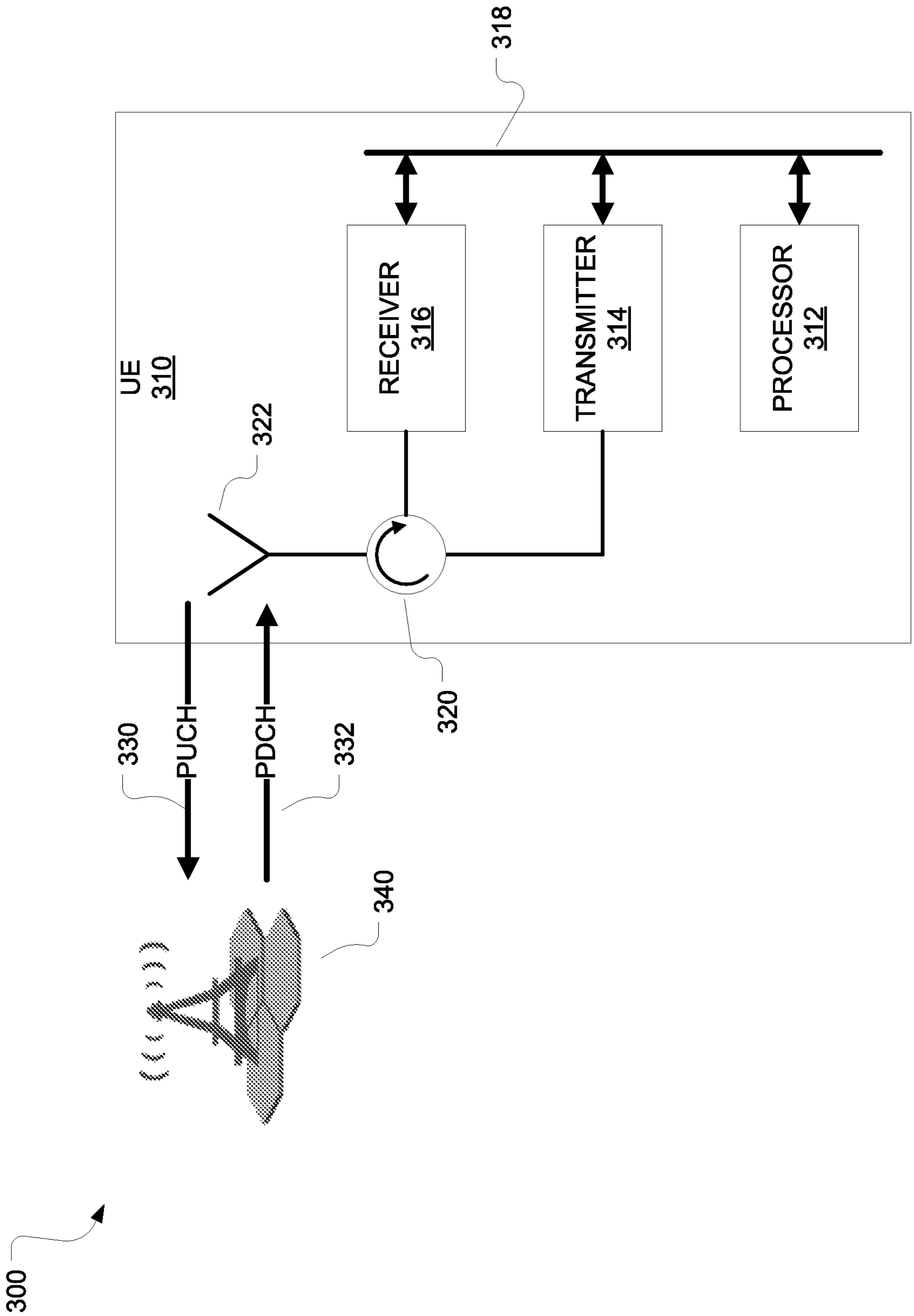
300
UE
310
RECEIVER
316
TRANSMITTER
314
PROCESSOR
312
318
322
320
PUCH
330
PDCH
332
340

FIG. 3

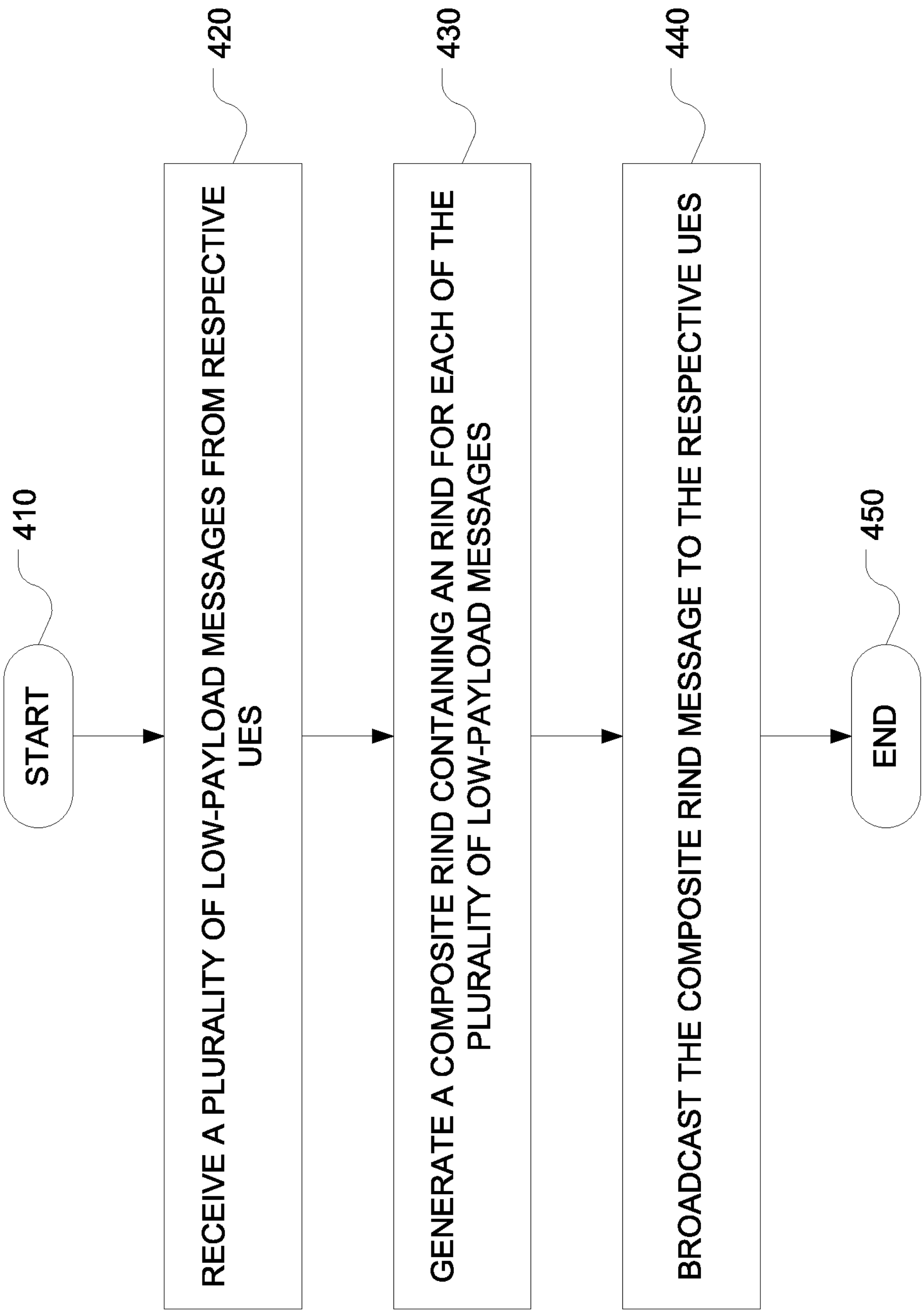
410
START
420
RECEIVE A PLURALITY OF LOW-PAYLOAD MESSAGES FROM RESPECTIVE UES
430
GENERATE A COMPOSITE RIND CONTAINING AN RIND FOR EACH OF THE PLURALITY OF LOW-PAYLOAD MESSAGES
440
BROADCAST THE COMPOSITE RIND MESSAGE TO THE RESPECTIVE UES
450
END

FIG. 4

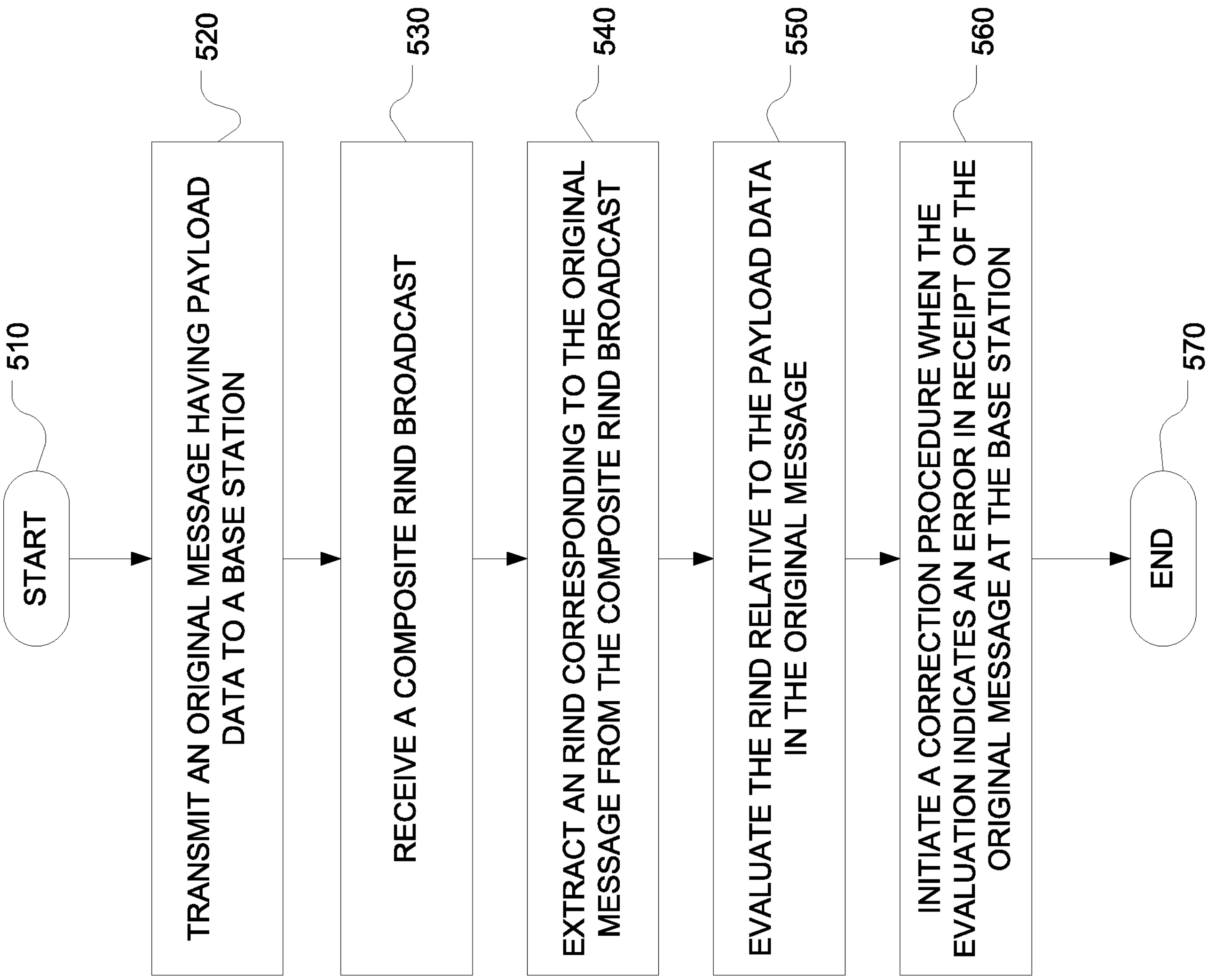
START
510
TRANSMIT AN ORIGINAL MESSAGE HAVING PAYLOAD DATA TO A BASE STATION
520
RECEIVE A COMPOSITE RIND BROADCAST
530
EXTRACT AN RIND CORRESPONDING TO THE ORIGINAL MESSAGE FROM THE COMPOSITE RIND BROADCAST
540
EVALUATE THE RIND RELATIVE TO THE PAYLOAD DATA IN THE ORIGINAL MESSAGE
550
INITIATE A CORRECTION PROCEDURE WHEN THE EVALUATION INDICATES AN ERROR IN RECEIPT OF THE ORIGINAL MESSAGE AT THE BASE STATION
560
END
570

FIG. 5

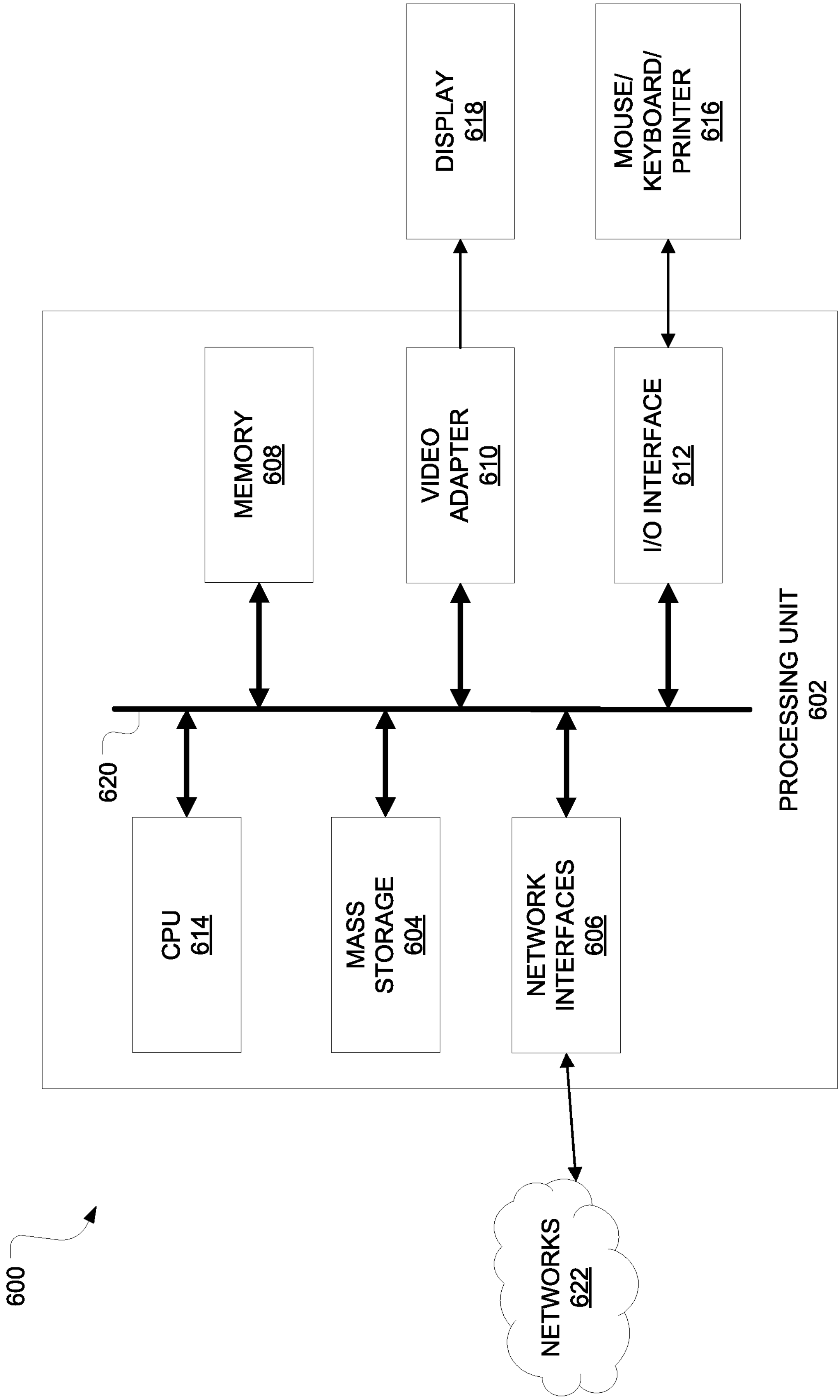
DISPLAY
618
MOUSE/
KEYBOARD/
PRINTER
616
MEMORY
608
VIDEO
ADAPTER
610
I/O INTERFACE
612
PROCESSING UNIT
602
620
CPU
614
MASS
STORAGE
604
NETWORK
INTERFACES
606
600
NETWORKS
622

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/58122

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04L1/18, H04L29/14 (2016.01)
CPC - H04L1/1621, H04L1/0061, H04L1/1887
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) Classification(s): H04L1/18, H04L29/14, H04W (2016.01)
CPC Classification(s): H04L1/1621, H04L1/0061, H04L1/1887, H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data), Google Scholar, IEEE, Ebscohost, Search Terms: low, bit, payload, RIND, ACK, cyclic redundancy check, forward error correction

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y ---------- A	WO 2013/033693 A2, (QUALCOMM INCORPORATED), 07 March 2013, paragraphs [0039], [0043], [0045], [0051], [0054], [0063] [0076], [00105] and [00106].	1-3, 5, 8-12, 22 -------------------- 4, 6, 7
Y ---------- A	US 2011/0216714 A1, (LEE, JH et al.), 08 September 2011, paragraphs [0010], [0017] and [0022].	1-3, 5, 8-12, 22 -------------------- 4, 6, 7
A	US 2010/0037112 A1, (GRAUMANN, P), 11 February 2010, paragraph [0039].	1-12, 22
A	US 2011/0243012 A1, (LUO, X et al.), 06 October 2011, paragraphs [0038], [0070] and [0074].	1-12, 22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 February 2016 (12.02.2016)	26 FEB 2016

Name and mailing address of the ISA/	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/58122

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Group I: Claims 1-12 and 22; Group II: Claims 13-21 and 23

-***-Continued within extra sheet-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
   1-12 and 22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

-***-Continued from Box No. III - Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-12 and 22 are directed toward a method of indicating reception of a plurality of low payload messages and a base station.

Group II: Claims 13-21 and 23 are directed toward a emthod of transmitting a low-payload message and a user equipment.

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I include a plurality of low-payload messages; and generating respective reception indications (RINDs) for the plurality of low-payload messages, which are not present in Group II.

The special technical features of Group II include extracting a RIND corresponding to the original message from the composite RIND; evaluating the extracted RIND relative to the payload data in the original message; and initiating a correction procedure when the evaluating indicates an error in receiving the original message at the base station, which are not present in Group I.

The common technical features shared by Groups I and II are a method of communication relating to a low-payload message comprising: transmitting an original message having payload data from a user equipment; receiving the original message at a base station; receiving a composite reception indication (RIND) broadcast over a broadcast channel at the user equipment; and wherein the composite RIND comprises a respective RIND corresponding to a message.

However, these common features are previously disclosed by US 2011/0032925 A1 to Lee, E et al. (hereinafter 'Lee'). Lee discloses a method of communication relating to a low-payload message comprising: transmitting an original message having payload data from a user equipment (data blocks are transmitted by a plurality of terminals, paragraph [0081]); receiving the original message at a base station (a base station receives and attempts to decode the data blocks, paragraph [0081]); receiving a composite reception indication (RIND) broadcast over a broadcast channel at the user equipment (if any of the data blocks fail to decode, a group NACK is sent to the terminals, paragraph [0081]); and wherein the composite RIND comprises a respective RIND corresponding to a message (the group NACK is followed by feedback information relating to any data blocks that failed, paragraphs [0081] and [0091]).

Since the common technical features are previously disclosed by the Lee reference, these common features are not special and so Groups I and II lack unity.