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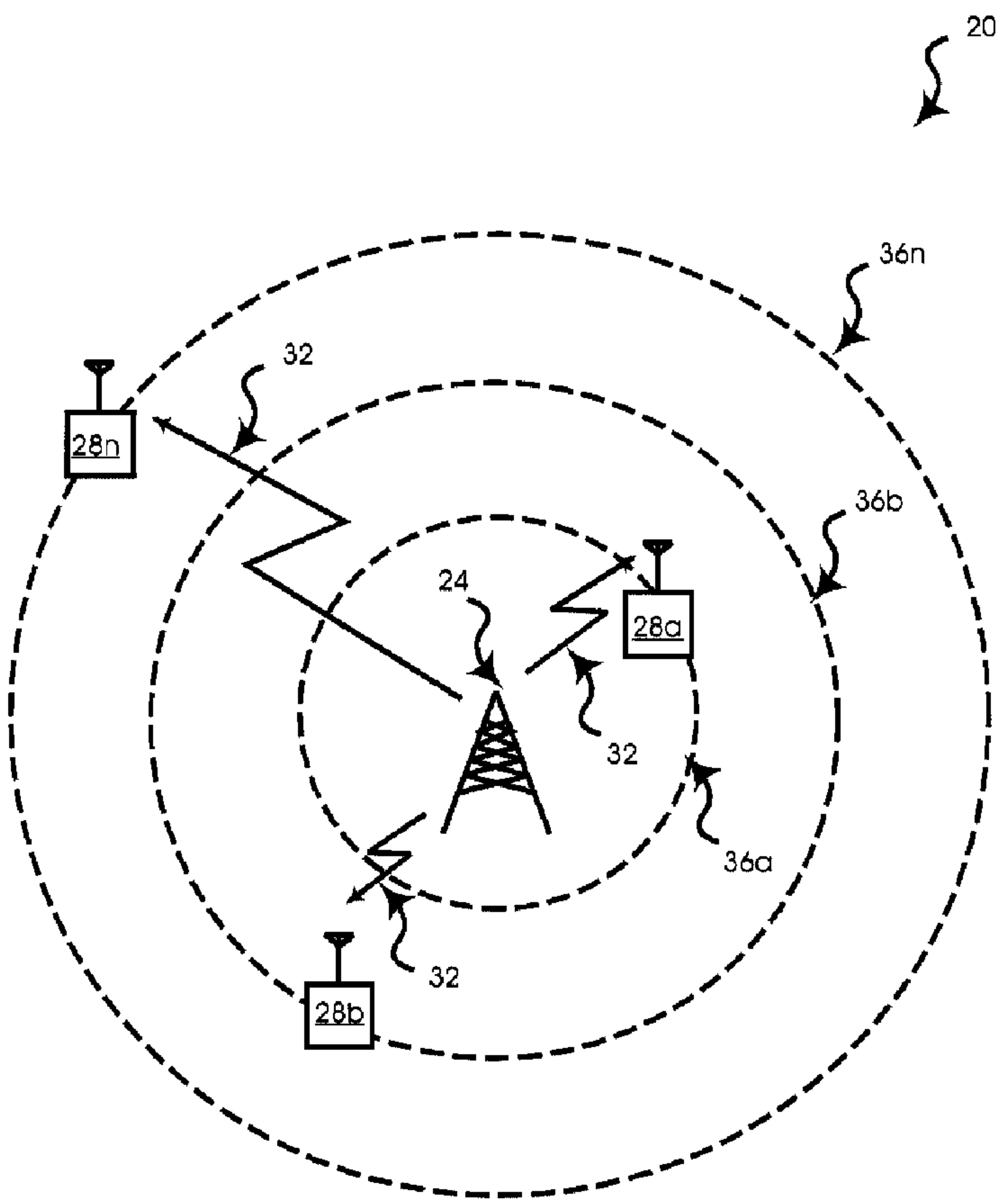

(57) Abrégé/Abstract:
A data channel for transmitting data from a base station to subscriber stations is provided. Each subscriber station has a different service-class which reflects the reception-quality of the data transmitted from the base station. The data channel is

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(57) **Abrégé(suite)/Abstract(continued):**
organized into a plurality of frames. Each frame contains service-class information that is packaged in the frame in such a manner that all subscriber stations can recover the service-class information. The frame also includes payload data destined for at least one of the subscriber stations. The payload data is packaged in the frame in such a manner that the subscriber station having payload data destined therefore can recover its payload data, regardless of its service class. Subscriber stations that have no payload data destined therefore, and/or which are in a poorer service-class than the destined subscriber-stations, can use the service-class information to determine that the remainder of the frame can be ignored. An apparatus, system and method relating to the data channel are also provided.

ABSTRACT

A data channel for transmitting data from a base station to subscriber stations is provided. Each subscriber station has a different service-class which reflects the reception-quality of the data transmitted from the base station. The data channel is organized into a plurality of frames. Each frame contains service-class information that is packaged in the frame in such a manner that all subscriber stations can recover the service-class information. The frame also includes payload data destined for at least one of the subscriber stations. The payload data is packaged in the frame in such a manner that the subscriber station having payload data destined therefore can recover its payload data, regardless of its service class. Subscriber stations that have no payload data destined therefore, and/or which are in a poorer service-class than the destined subscriber-stations, can use the service-class information to determine that the remainder of the frame can be ignored. An apparatus, system and method relating to the data channel are also provided.

DATA COMMUNICATION CHANNEL

FIELD OF THE INVENTION

The present invention relates generally to a method and system for transmitting data from a base station to subscriber stations. More specifically, the present invention relates to a method and system for transmitting data from a base station to subscriber stations, where the subscriber stations have different abilities to receive the transmission and the transmission is packaged correspondingly.

BACKGROUND OF THE INVENTION

Wireless communications has undergone tremendous development and growth. Current digital wireless telephone networks based on multiple access techniques such as CDMA, FDMA or TDMA can offer high quality voice communications. However, these networks are not efficient at offering data communications when a number of users must be serviced, and a sharp increase in demand for data communications over wireless networks is expected.

For example, the IS-95 standard for CDMA networks can offer a maximum data rate of 9.6 kbaud or 14.4 kbaud depending on the selected service. As known to those of skill in the art, however, these rates are generally too slow to meaningfully accommodate modern data applications, such as web-browsing and/or file transfer. Attempts have been made to increase the maximum data rate within IS-95. For example, U.S. Patent Number 5,930,230 to Odenwalder teaches a high data rate CDMA wireless communication system that offers certain improvements over IS-95. However, Odenwalder is directed to the CDMA environment, and primarily contemplates the transfer of data from subscriber stations to base stations, (typically referred to as the "uplink" or "reverse" channel) and thus does not address the need for increased transmission of data from base stations to subscriber stations (typically referred to as the "downlink" or "forward" channel).

Another difficulty exists with IS-95 type networks in that they assign a dedicated communication channel between the base station and a subscriber unit and therefore the bandwidth of the dedicated channel is unavailable to other users in the network, even when no data is being transmitted between the base station and the subscriber unit. Thus, for connectionless services such as packet networks, such a system does not typically provide effective use of limited and/or bandwidth, which is a necessity for servicing large numbers of users.

U.S. Patent 5,949,814, also to Odenwalder ("Odenwalder #2") teaches system which does provide a high data rate supplemental channel for CDMA telecommunications systems. In this scheme, the transmission system includes an in-phase channel set and a quadrature-phase channel set. The in-phase channel set provides a set of orthogonal medium rate control and traffic channels and the quadrature-phase channel set provides the high-rate supplemental channel and an extended set of medium-rate channels that are orthogonal with respect to each other.

While Odenwalder #2 can increase the downlink data transmission rate, it is not generally suitable for transmitting data to multiple subscriber stations, which have different abilities to receive the transmission. Further, Odenwalder #2 requires certain overhead control communication between the base station and the mobile user in order to commence a high data rate communication therebetween. Such a system is not well suited to systems such as packet communication systems where small amounts of data may need to be transferred to users as the necessary overhead may make the communication inefficient relative to the amount of data transferred. Similarly, such a system is not well suited to situations wherein a variety of users need data transmitted to them.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel method, system and apparatus for transmitting data from a base station to one or more subscriber stations, which obviates or mitigates at least one of the above-identified disadvantages of the prior art.

According to one aspect of the invention, there is provided a system for transmitting data comprising a base station having a microprocessor, a modem, a radio and an antenna, the base station operable to transmit a radio signal; a plurality of subscriber stations having a microprocessor, a modem, a radio and an antenna each operable to a receive the signal at a different reception-quality than at least one other the subscriber stations; the signal including a frame having an identifier recoverable by all of the subscriber stations regardless of the reception-qualities, and a remaining portion recoverable by at least one of the subscriber stations, the identifier indicating whether the subscriber station need recover the remaining portion.

According to another aspect of the invention, there is provided a frame for transmission a plurality of subscriber stations each having a reception-quality corresponding to an ability to recover the transmission, the frame comprising an identifier packaged for recovery regardless of the reception-qualities and including information representing whether a receiving subscriber station is within a range of reception-qualities; a header packaged for recovery by subscriber stations within the range and including address information; and at least one payload packet packaged for recovery by subscriber stations in accordance with the address information.

A data channel for transmitting data from a base station to subscriber stations is provided. Each subscriber station has a different service-class which reflects the reception-quality of the data transmitted from the base station. The data channel is organized into a plurality of frames. Each frame contains service-class information that is packaged in the frame in such a manner that all subscriber stations can recover the service-class information. The frame also includes payload data destined for at least one of the subscriber stations. The payload data is packaged in the frame in such a manner that the subscriber station having payload data destined therefor can recover its payload data, regardless of its service class. Subscriber stations that have no payload data destined therefor, and/or which are in a poorer service-class than the destined subscriber-stations, can use the service-class information to determine that the remainder of the frame can be ignored. An apparatus, system and method relating to the data channel are also provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, in which:

Figure 1 is a schematic representation of a network incorporating a data channel in accordance with an embodiment of the invention;

Figure 2 is a schematic representation of the base station shown in Figure 1;

Figure 3 is a schematic representation of one of the subscriber stations shown in Figure 1;

Figure 4 is a schematic representation of a frame for transmission over the network shown in Figure 1;

Figure 5 is a flowchart of a method for assembling and transmitting the frame of Figure 4 in accordance with another embodiment of the invention; and

Figure 6 is a flowchart of a method for receiving and recovering the transmitted frame of Figure 4 in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 1, a wireless network incorporating a system for transmitting data is indicated generally at 20. Network 20 includes a radio base station 24 and a plurality of subscriber stations 28a, 28b ... 28n. In a presently preferred embodiment, radio base station 24 is connected to a data telecommunications network (not shown), such as a land line-based switched data network, by an appropriate gateway and one or more backhauls (not shown in Figure 1), such as a T1, T3, E1, E3, OC3 or other suitable land line link, or can be a satellite or other radio or microwave channel link or any other link suitable for operation as a backhaul as will occur to those of skill in the art.

Base station 24 communicates with subscriber stations 28 which, in a present embodiment, are fixed and installed at subscriber premises, as is common in a wireless local loop (WLL) system. The number 'n' subscriber stations can vary depending upon the amount of radio bandwidth available and/or the configuration and requirements of the subscriber stations 28.

A data channel 32 is established between base station 24 and each subscriber station 28. Data channel 32 carries information to be transferred from base station 24 to respective subscriber stations 28a, 28b ... 28n as needed. Data channel 32 can be implemented with networks using a variety of multiple access techniques, including TDMA, FDMA, CDMA or hybrid systems such as GSM, etc. In a present embodiment, data transmitted over data channel 32 is transmitted as packets encapsulated within frames, the details of which will be discussed in greater detail below.

The ability of a base station 24 to properly receive a signal transmitted to it, hereinafter referred to as the "reception-quality" of the signal, is determined in different manners according to the multiple access technique employed to transmit the signal. For example, in TDMA or FDMA systems, the received signal strength is the determination most often used. In CDMA systems, the ratio of received bit power to received interference power (often expressed as E_s/N_o, where E_s is energy per symbol, and N_o is the received interference energy) is the relevant determination. In any event, the reception-quality of channel 32 at each subscriber station 28 can vary depending on a variety of factors, including multipath interference (from the presence of nearby buildings, etc.), radio noise sources (including transmissions by other users or radio noise sources), geographical features, the distance of the subscriber station 28 from base station 24, the quality of the receiver in the subscriber station 28, etc. as is well understood by those of skill in the art. With distance, typically a signal attenuates as $1/r^N$, where r is the distance between the subscriber station 28 and base station 24, and $N>1$. In IS-95 CDMA systems, for example, N typically is $3<N<5$.

In Figure 1, groups of reception-qualities experienced at subscriber stations are organized and represented as rings 36, where each ring 36a, 36b ... 36n corresponds to a reception-quality at a subscriber station 28a, 28b ... 28n. In the Figure, rings 36a, 36b ... 36n are shown concentrically expanding about base station 24 to indicate increasing distance therefrom, but rings 36 are actually defined with respect to the reception-quality at subscriber stations 28 and thus subscriber station 28b might be physically located closer to base station 24 than subscriber station 28a but is in ring 36b (which has a lower reception-quality than ring 36a) due to the above-mentioned other factors affecting reception-quality, such as nearby noise sources, etc. Thus, as will be apparent to those of skill in the art, Figure 1 is a logical representation of reception-quality rings 36.

Furthermore, Figure 1 illustrates that there is one subscriber station 28a, 28b ... 28n in each ring 36, however it will be understood that in most actual implementations of the present invention, each ring 36 will include multiple subscriber stations 28, each having a reception-quality within a range of reception-qualities defined for the respective ring 36. For example, ring 36a may contain subscriber stations 28 with a reception-quality greater than 20 db, while ring 36b may contain subscriber stations 28 with a reception-quality between 10db and 20db and ring 36n may contain subscriber stations 28 with a reception-quality between -20db and 0db. Accordingly, rings 36 intermediate ring 36b and ring 36n would have reception-qualities between 0db and 10 db. In any event, as illustrated in Figure 1, subscriber station 28n will receive channel 32 at a lower reception-quality than subscriber station 28b, which in turn will receive will receive channel 32 at a lower reception-quality than subscriber station 28a, but at a better reception-quality than subscriber station 28n. As will be described below in more detail, data to be transmitted to a base station 28 is packaged for transmission according to the ring 36 the station is presently in.

It is contemplated that, in most actual implementations each subscriber station 28 may transition between different rings 36 at different times, depending on such factors as weather and/or local noise created by other electrical devices located proximal to the subscriber station 28. Accordingly, at appropriate intervals or predetermined events, each subscriber station 28 will report its present reception-quality to base station 24. Base station 24 operates to maintain a database of the latest reported reception-qualities and groups subscriber stations 28 into rings 36 according to a range of reception-qualities defined for each ring 36.

As used herein, the terms “package”, “packaged” and “packaging” refer to the overall arrangement of the transmission of the packaged data for its reception at an intended destination. Packaging of data can include, without limitation, applying different levels of forward error correcting

(FEC) codes (from no coding to high levels of coding and/or different coding methods), employing different transmissions rates, employing different modulation schemes (QPSK, QAM 4, QAM 16, QAM64, etc.) and any other techniques or methods for arranging data transmission with a selection of the amount of radio (or other physical layer) resources required, the data rate and probability of transmission errors which are appropriate for the transmission. For example, a packet of data can be packaged with 1/4 coding and QAM64 modulation for transmission to a first intended receiver and another packet can be packaged with 1/2 coding and QAM256 modulation for transmission to a second intended receiver which has a better reception-quality than the first.

Figure 2 shows base station 24 in greater detail. Base station 24 comprises an antenna 40, or antennas, for receiving and transmitting radio-communications over communication channel 32. In turn, antenna 40 is connected to a radio 44 and a modem 48. Modem 48 is connected to a microprocessor-router assembly 52. A suitable microprocessor would be a SPARC processor system manufactured by SUN Microsystems. It will be understood that assembly 52 can include multiple microprocessors, as desired. The router within microprocessor-router assembly 52 is connected to a backhaul 56 in any suitable manner, which in turn connects base station 24 to a packet switched data network (not shown).

Referring now to Figure 3, subscriber station 28 is shown in greater detail. Subscriber station 28 comprises an antenna 60, or antennas, for receiving and transmitting radio-communications over communication channel 32. In turn, antenna 60 is connected to a radio 64 and a modem 68, which in turn is connected to a microprocessor-assembly 72.

Microprocessor-assembly 72 can include, for example, a StrongARM processor manufactured by Intel, that performs a variety of functions, including implementing A/D-D/A conversion, filters, encoders, decoders, data compressors, de-compressors and/or packet disassembly. As seen in Figure 3, microprocessor-assembly 72 interconnects modem 68 and a data port 76, for connecting subscriber station 28 to an intelligent device, such as a personal computer, personal digital assistant or the like which is operable to process data received over communication channel 32. Accordingly, microprocessor-assembly 72 is operable to process data between data port 76 and modem 68.

Referring now to Figure 4, a frame for transmission over channel 32 is indicated generally at 100. In a presently preferred embodiment, frame 100 is selected to require 10 milliseconds of transmission time, although longer or shorter transmission times for frame 100 can be selected if desired. As understood by those of skill in the art, frame 100 can be measured in terms of a duration of time. In turn, that duration can carry a given number of symbols for transmission. In turn, those symbols can represent data, the actual amount of data being represented by a symbol depending on how the data is packaged into a symbol, typically packaged using a combination of modulation and encoding. Thus, it will be appreciated that, while the duration of frame and the symbol rate of the frame may remain constant, the effective data rate transmitted within a frame will depend on the packaging of the data. The application of these concepts to the present invention will be discussed in greater detail below.

Frame 100 includes a ring (or reception-quality) packet 104, a header packet 108 and a plurality of payload packets 112_1, 112_2 ... 112_x. As mentioned above, depending upon the packaging of payload packets 112, the quantity 'x' of payload packets 112 in frame 100 can vary, and the factors affecting this variation will be discussed in greater detail further below.

Ring packet 104 is composed of a destination-ring identifier field 116 and a frame-length field 120. It is presently preferred that destination-ring field 116 is two bits in length and frame-length field 120 is ten bits in length. Destination-ring field 116 identifies the outermost ring 36 with the lowest reception-quality from base station 24 for which a frame 100 contains at least one payload packet 112 destined for a subscriber station 28 resident in that outermost ring. For example, a frame 100 with a destination-ring identifier field 116 corresponding to ring 36b can include payload packets for subscriber stations 28a or 28b, but not for 28n. Frame length field 120 contains the value 'x', to indicate the number of payload packets 112_1, 112_2 ... 112_x in frame 100.

Unlike payload packets 112, destination ring field 116 and frame-length field 120 are always packaged into ring packet 104 in a robust manner to ensure recovery by all subscriber stations 28a, 28b ... 28n when frame 100 is transmitted over channel 32. Such robust packaging allows every subscriber station 28 served by base station 24 to recover fields 116 and 120. In the present embodiment, the robustness of ring packet 104 is achieved in the following manner: Fields 116 and 120 undergo a forward error correction (FEC) operation 124 and then undergo a modulation operation 128 prior to their insertion into ring packet 104. The type of forward error correction operation 124 and modulation operation 128 are selected based on the needs of subscriber station 28n (i.e. – the subscriber station 28 with the poorest reception-quality) located on ring 36n.

For example, if channel 32 employs CDMA multiple access technology, it is presently preferred that where subscriber station 28n has an E_s/I_o level of 3db, then a suitable forward error correction operation 124 will be rate ½ coding and modulation operation 128 will be 4-QAM (QPSK). An appropriate combination of forward error correction operation 124 and modulation operation 128 will not only assist and/or assure the recovery of ring packet 104 by subscriber station 28n, but that that the remaining subscriber stations can also recover ring packet 104. Suitable forward error correction operations 124 and modulation operations 128 for a given subscriber station 28n having a given reception-quality will occur to those of skill in the art.

Table I in Appendix I shows exemplary packaging for frame 100 in a CDMA system according to various SNRs. Column 1, labeled Ec/No, is an SNR measurement that indicates the Energy per chip per a given noise level as experienced by a given subscriber station 28. Column 2, labeled spreading factor, indicates the number of chips per symbol. Column 3, labeled Modulation Symbols, indicates the modulation operation used in the packaging of the data. Column 4, labeled coded bits/symbol, indicates the number of bits per symbol after undergoing the modulation operation of column 3. Column 5, labeled code rate, indicates the coding operation used in the packaging of the data. Column 6, labeled symbol repetition factor, indicates the factor by which symbols are repeated, to further package the data for robust recovery. Column 7, labeled bits/symbol, indicates the effective bits per symbol. Column 8, labeled bits/frame, indicates the effective bits per frame assuming all bits in the frame are packaged according to the modulation rate, coding rate and using the symbol repetition factor shown in the same row. Column 9, labeled Es/No, is an SNR measurement that indicates the Energy per symbol per a given noise level as experienced by a given subscriber station 28. Column 10, labeled Eb/No, is an SNR measurement that indicates the Energy per bit per a given noise level. It will be understood by those of skill in the art that columns 1, 9 and 10 bear a fixed relationship to each other.

Accordingly, presently preferred encoding operations 124 (see columns 5 and 6) and modulation operations 128 (see column 3) are shown in Table I. However, other suitable means of packaging destination ring field 116 and frame-length field 120 into ring packet 104 in a robust manner, and/or combinations thereof, will now be apparent to those of skill in the art.

Header packet 108 contains a plurality of identifier-fields 132 which contain identifying information about each payload packet 112. In a present embodiment, identifier fields 132 include an address field 136, a format field 140 and a length field 144. Address field 136 indicates which of the destination subscriber station 28a, 28b ... 28n is intended to receive the respective payload packet 112.

Format field 140 indicates the modulation and encoding used to prepare the respective payload packet 112_x, the details of which will be discussed in greater detail below. Length field 144 indicates the length of the respective payload packet 112. Header packet 108 also contains a CRC packet 148, which can be used by each subscriber station 28a, 28b ... 28n to determine whether it has correctly received header packet 108. Flush-bits 152 are added to ensure recognition of the end of header packet 108 when it is decoded, as understood by those of skill in the art.

It is presently preferred that each address-data field 136 is twelve bits in length, that each format-data field 140 is four bits in length, that each length-data field144 is twelve bits in length, that CRC field 148 is eight bits in length, and that flush-bits 152 are eight bits in length. However, other lengths can be employed to suit particular requirements, as will occur to those of skill in the art.

Identifier-packets 132, CRC packet 148 and flush-bits 152 are packaged into header packet 108 in a suitably robust manner to ensure recovery by all subscriber stations 28 that are located between base station 24 and the ring indicated in destination-ring field 116 (inclusive). In other words, if destination-ring field 116 indicates ring 36b, then the contents of header packet 108 are packaged for robust recovery by all subscriber stations 28 in rings 36a and 36b, but station 28n in ring 36n may not be able to receive header packet 108.

In the present embodiment, the robust packaging of header packet 108 is achieved in the following manner: Packets 132, CRC packet 148 and flush-bits 152 undergo an encoding operation 158 and then undergo a modulation operation 162 to form header packet 108. The forward encoding operation 158 and modulation operation 162 are chosen based on the reception-quality needed to recover header packet 108 by the subscriber stations located on the ring identified by destination-ring field 116. It is presently preferred that encoding operation 158 is rate 1/3 convolutional encoding, and that modulation operation 162 is M-ary QAM, where M can be 4, 16, 64 or 256.

An appropriately chosen combination of encoding operation 158 and modulation operation 162 will not only assist and/or assure the recovery of header packet 108 by a subscriber station 28 located at the ring indicated by destination-ring packet 116, but that that subscriber stations 28 located therebetween and base station 24 can also recover header packet 108. Accordingly, presently preferred encoding operations 124 (see columns 5 and 6) and modulation operations 128 (see column 3) are shown in Table I. However, other suitable encoding operations 158, modulation operations 162, and/or other means of packaging packets 132, CRC packet 148 and flush-bits 152 into header packet

108 in a robust manner, and/or combinations thereof, will occur to those of skill in the art.

Each payload packet 112 is composed of one or more data packets 166 and flush bits 170. Each payload packet 112 is destined for one or more subscriber stations 28 that lie between base station 24 and the ring specified in destination-ring packet 116 (inclusive). Data packets 166 can be any type of data received at base station 24. For example, data packets 166 can be TCP/IP packets, where it is desired to transmit IP packets to a subscriber station 28. Data packets 166 can be specifically addressed to a particular subscriber stations 28a, 28b ... 28n each of which has its own unique address and/or one or more broadcast addresses can be defined.

Data packets 166 can be of any length (as indicated by length field 144) and data to be placed into data packets 166 can be combined or segmented, as needed, to an appropriate size. Generally, a data packet 166 can include a portion of one, or one or more packets intended for a single subscriber station 28. Flush bits 170, which in a present embodiment are eight bits in length, are added to the end of data packets 160 for substantially the same reasons as flush bits 152.

Each data packet 166, and its corresponding set of flush bits 170, is packaged into a respective payload packet 112_1, 112_2 ... 112_x. This packaging is performed in a robust manner, according to the formatting specified in the format field format field 140 respective to its payload packet 112. This packaging assists and/or ensures recovery by the destination subscriber station 28. (Incidentally, other subscriber stations 28 that are located between base station 24 and the ring where the destination subscriber station 28 resides can also recover the payload packet 112, but in general, such recovery will not be performed, and appropriate security measures can be employed to prevent eavesdropping.) For example, if a frame 100 includes a destination ring field 166 defining a transmission to ring 36n and includes a payload packet 112 destined for subscriber station 28b, then the payload packet 112 will be packaged such that it is recoverable by subscriber stations 28a and 28b. The specific forward encoding operation 174 and modulation operation 178 are selected based on the reception-quality at subscriber station 28b located on the ring 36b identified by the address-data field 136 respective to the payload packet 112. It is presently preferred that encoding operation 174 is rate-N convolutional encoding (where N is a real number that is larger than 0) and that modulation operation 178 is "M-ary QAM", (where M can be 4, 16, 64 or 256), and where N and M are selected appropriately for the reception-quality in the ring 36 indicated by format field 140.

It is contemplated that, overall, the encoding operation 174 and/or the modulation operation 178 and/or other robust packaging can be common or individually selected for each payload packet 112 in a single frame 100. For example, where there are a wide range of reception-qualities for subscriber stations 28 within a particular ring 36, then a common modulation operation 178 can be used for each subscriber station 28 within that particular ring 36, but a different encoding operation 174 can be used to accommodate the range of reception-qualities within the ring 36.

The selection of encoding operations 174 and/or modulation operations 178 and/or other robust packaging for each payload packet 112 within frame 100 can depend on the actual application and/or type of data being carried over channel 32. (As the application and/or type of data may have different requirements to achieve the required probability of packet error.) For example, a file transfer transmission (ftp) has a low tolerance to errors compared to a voice over IP (VOIP) connection. Thus payload packets 112 transmitted to a first subscriber station 28 in ring 36b can be encoded with ¼ convolutional coding while payload packets sent to another subscriber station 28 in ring 36b, but for a VOIP connection, can be coded with ½ convolutional coding.

As will be apparent to those of skill in the art, when an encoding operation 174 and modulation operation 178 are common for a destination ring 116, for example ring 36b, payload packets 112 intended for subscriber stations 32 in higher rings, i.e. ring 36a, can also be included in frame 100 if desired, although such payload packets 112 intended for higher rings 36 will be packaged with a superfluous level of robustness for their intended destination.

Presently preferred encoding operations 124 (see columns 5 and 6) and modulation operations 128 (see column 3) are shown in Table I. However, other suitable encoding operations 174, modulation operations 178, and/or means of robustly packaging data packets 166 and flush bits 170 into each payload packet 112, and/or combinations thereof, will occur to those of skill in the art.

Referring now to Figure 5, a method for transmitting data that is in accordance with an embodiment of the present invention is shown. For purposes of assisting in the explanation of the method, reference will be made to network 20 and frame 100. At step 200, data packets 166 are received by base station 24 for transmission to one or more subscriber stations 28 and buffered until a sufficient amount of data is received to fill a frame 100. In this example, data packets 166 are received at base station 24, either via backhaul 56 or from other subscriber stations 28 that have transmitted the packets to base station 24, and microprocessor-router assembly 52 buffers data packets 166 for subsequent assembly into frame 100. As will now be apparent to those of skill in the art, the amount of data which is sufficient to fill a frame 100 is dependent upon the selected encoding operations 158 and 174 and the selected modulation operations 162 and 178. Thus, the determination of the receipt of a sufficient amount of data is made assuming the best (i.e. most data rate efficient) encoding and modulation operations or when a preselected time period has expired from the receipt of the earliest data packet 166, this latter parameter being employed to ensure that a frame 100 is assembled and transmitted before a preselected maximum latency period is exceeded. Any received data which cannot be placed into the assembled frame 100, due to the encoding and/or modulation operations being less data rate efficient, is buffered and assembled in due course into the next frame 100 to be assembled.

When a sufficient amount of data is received to fill frame 100, a determination is made at step 204 of the ring 36 with the lowest reception-quality which contains a subscriber station 28 to which at least one received data packets is addressed. Step 204 is performed by microprocessor-router assembly 52 which examines the destination address of each of the received data packets 166 to determine the ring 36 with the lowest reception-quality from base station 24 that has a subscriber station 28 which is the destination for at least one of the data packets 166.

At step 208 payload packets 112 are assembled and inserted into frame 100. An appropriate encoding operation 174 and modulation operation 178 is applied to the received data packets 166, appropriate flush-bits 170 are added and the result is inserted into one or more of payload packets 112. Data packets 166 that are intended for the same subscriber station 28 can be grouped for insertion into one or more common payload packets 112.

The modulation operation 178 can be selected for all processed packets 166, according to the ring 36 determined in step 204 (i.e. – if ring 36a is the determined ring, 256QAM is used on all packets, or if ring 36b is the determined ring, 64QAM is used on all packets), or, as previously discussed, it is also contemplated that the modulation operation employed to process packets can be changed, from packet-to-packet, if desired. In a similar fashion, the encoding operation 174 can be selected for all processed packets 166, according to ring 36 determined in step 204 (i.e. – if ring 36a is the determined ring, rate ½ coding is used on all packets, or if ring 36b is the determined ring, rate ¼ coding is used on all packets), or, also as previously discussed, the encoding operation employed to process packets can be changed from packet-to-packet if desired. It is presently contemplated that a single modulation operation 178 will be selected for all packets 166 in a frame 100, but that encoding operation 174 will be changed according to differences in the reception-qualities of subscriber stations

28 within rings 36 and/or according to desired packet error probability rates.

Once payload packets 112 are assembled, header packet 108 is assembled and inserted into frame 100 at step 212. Header packet 108 is assembled as previously discussed, whereby the destination subscriber station 28 for each respective payload packet 112 is inserted into each address field 136; the format (i.e. the modulation and/or encoding) of each respective payload packet 112 is inserted into format fields 140; and the length of each respective payload packet 112 is inserted into each length field 144. Finally, a CRC code is generated, according to these identifier-packets 132, and inserted into CRC field 148. Flush bits 152 are then added, and at this point, fields 132 and 148 and flush bits 152 are encoded according to encoding operation 158 and modulated according to modulation operation 162. Encoding operation 158 and modulation operation 162 are selected such that header packet 108 is robustly packaged for the reception-qualities of all subscriber stations 28 in the ring 36 determined in step 204.

Next, at step 216, ring packet 104 is assembled. The outermost destination ring 36 determined at step 204 is inserted into destination ring field 116, and the frame length, in terms of the number of payload packets 'x', is inserted into frame length field 120. Fields 116 and 120 are then forward error corrected using operation 124, modulated using modulation operation 128, and then inserted into ring packet 104. Operations 124 and 128 are selected such that ring packet 104 is robustly packaged for a high level of probability of reception by all subscriber stations 28 served by base station 24.

Next, at step 220, the now-assembled frame 100 is transmitted over channel 32 to subscriber stations 28a, 28b ... 28n. The transmission can occur in the usual manner, using known techniques.

It is to be understood by those of skill in the art that modifications can be made to the above-described method without departing from the present invention. For example, if modulation operation 178 and encoding operation 174 are preselected for given destination rings 36 determined at step 204, then determining the amount of received data which is sufficient to fill a frame 100 is a simple matter and can be determined as each data packet 166 is received. In such a case step 204 is performed when each packet 166 is received and the lowest reception-quality ring 36 is determined for all packets received to that time. The received data packets 166 are scaled according to the defined modulation and encoding operations and the resulting scaled data size is compared to the selected maximum size of frame 100. If the defined maximum frame size, or if the predefined maximum latency period, is not exceeded the next received packet 166 is examined, the lowest reception-quality ring 36 updated, if necessary, the scaling operation re-performed and the size (and/or latency time) examined again.

Referring now to Figure 6, a method for recovery of the transmitted frame 100 by a subscriber station 28 is shown, in accordance with an embodiment of the present invention. At step 300, frame 100 is received by a subscriber station 28. Radio 64 receives frame 100, where it is transferred to modem 68.

At step 304, destination ring packet 104 is recovered. In a present embodiment, this is accomplished by modem 68 which uses a demodulation operation complementary to modulation operation 128, and by microprocessor-assembly 72 which uses a decoding operation complementary to forward error correction operation 124. In a present embodiment, the demodulation operation and decoding operation are predefined for all subscriber station stations 28 and are intended to allow the recovery of ring packet 104 even under the lowest reception-quality within network 20. When ring packet 104 is recovered, destination ring field 116 and frame length field 120 are now available to microprocessor-assembly 72 to assist in the further processing of frame 100, as described below.

At step 308, a determination is made as to whether the subscriber station 28 is within or on the destination ring 36 indicated in destination ring field 116 (i.e. – the subscriber station 28 has a reception-quality at least equal to that of the ring indicated in destination ring packet 116). If, at step 308, it is determined that the receiving subscriber station 28 has a lower reception-quality than that indicated in destination ring field 116, the method discards the frame at step 312 and returns to step 300 to receive and process the next frame 100.

If, however, at step 308, it is determined that the receiving subscriber station 28 has a reception-quality at least equal to that corresponding to the ring 36 indicated in destination ring field 116, then one or more of payload packets 112 within frame 100 can be addressed to the subscriber station 28 and the method advances to step 316.

At step 316, destination header packet 108 is recovered. In a present embodiment, this is accomplished by modem 68 which uses a demodulation operation complementary to modulation operation 162, and by microprocessor-assembly 72 which uses a decoding operation complementary to encoding operation 158. In a present embodiment, the appropriate demodulation operation and/or decoding operation can be determined based on the information contained in destination ring 116 recovered at step 304 or can be preselected and fixed within network 20. These operations are intended to allow the recovery of header packet 108 with a high probability of success at even the subscriber station 28 with the lowest reception-quality in the ring 36 indicated by destination ring field 116.

The method then advances to step 320, where it is determined whether the recovered CRC packet 148 from header packet 108 is valid for the recovered header packet 108. If CRC packet 148 is not valid for recovered header packet 108, (i.e. a reception error has occurred), then the receiving the subscriber station 28 determines that it has not correctly recovered header packet 108 and the method advances to step 324 for exception handling. Any exception handling protocol can be used, as will occur to those of skill in the art, including sending a NACK or taking no explicit exception handling action.

If, at step 320, the recovered CRC is valid, then the receiving subscriber station 28 determines that it has correctly recovered header packet 108, and the method advances to step 328. At step 328, payload packets 112 addressed to the receiving subscriber station 28 are recovered. Microprocessor-assembly 72 refers to respective identifier-packets $132_1 \ldots 132_x$ in order to determine which payload packets 112_1, $112_2 \ldots 112_x$ are addressed to the receiving subscriber station 28. Those payload packets 112 which are addressed to the receiving subscriber station 28 are recovered from frame 100, using a demodulation operation complementary to modulation operation 178, and a decoding operation complementary to encoding operation 174 which is indicated in format fields 140 in packets 132 or which can have been predefined in network 20.

The method then returns to step 300 to process the next received frame 100.

It is contemplated that the present invention can be particularly suitable for carrying conferencing data, either voice or video, as one or more payload packets 112 within a frame 100 can be addressed (by, for example, including addressing information that indicates all subscriber stations 28 within the call that should recover the payload packet 112) for recovery by a plurality of subscriber stations 28 participating in the conference. Such payload packets 112 can contain conferencing data. It will be now apparent that the packaging of the data can be robustly-packaged for guaranteed recovery by subscriber stations at some intermediate level of reception-quality, allowing for some acceptable level of loss of payload data 112 by subscriber stations having a lower level of reception-quality, but guaranteed recovery by subscriber stations at a higher level of reception-quality. Alternatively, a channel 32 can be set up simply for one conference of a set of subscriber stations 28 participating in the conference call.

While the embodiments discussed herein are directed to certain exemplary implementations of the invention, it will be understood that combinations, sub-sets and variations of the embodiments are within the scope of the invention. For example, data packets 166 received via backhaul 56 or from other subscriber stations 28 can be buffered in base station 24 to organize frames in any desired fashion, such as grouping frames according to rings 36a, 36b ... 36n.

Buffering of data packets 166 in base station 24 can also allow the selection of frame size (i.e. the amount of symbols within a frame of a given predetermined time-length), as the amount of modulation and/or encoding and/or forward error correction actually needed to assemble each packet in the frame can be chosen as desired.

It is also contemplated that additional channels can be provided in network 20, as desired. For example, one channel can be dedicated to one group of rings 36a... 36c, while a second channel can be dedicated to rings 36d ... 36n. In addition, or in the alternative, an additional channel can be encrypted in order to improve the security of transmissions on network 20.

Additional channels can be added to accommodate subscriber stations having newer and/or faster radios than other subscriber stations on network 20. In this embodiment, the newer/faster subscriber stations 28 can be backward compatible, to include the capability of receiving the older channel and the capability of receiving the additional channel.

It is also contemplated that additional channels can be provided simply to improve latency on network 20, thereby increasing the overall throughput of data from the base station to the subscriber stations. Further, buffering of packets in base station 24 can be performed to manage latency according to the type of data, and it's associated quality of service (QoS) requirements. For example, data associated with web browser activities can be buffered and transmitted when possible, with relatively unlimited latencies, while data associated with a VOIP connection can be transmitted on a priority basis to reduce the latency to the required low levels for such connections.

Additional base stations 24 can also be added to network 20, whereby known soft-handoff or similar techniques are incorporated into network 20, in order to further improve throughput and overall capabilities of network 20.

It is contemplated that the network can be divided into a plurality of service-classes (or rings) and one or more subservice-classes (or sub-rings) within each service-class. In this situation, a given level of modulation can be used for each service-class, and a given level of error correction can be used for each subservice-class.

While the embodiments discussed herein use combinations of encoding and modulation to robustly package frames and/or portions thereof according to different desired reception-quality at different subscriber stations, it is contemplated that any means of robust packaging can be used, as desired.

It is contemplated that various methods can be used to determine the format of robust packaging (i.e. modulation and/or encoding) used to package packets within frame 100. For example, each subscriber station 28 can report its reception-quality (either as an exact measurement or by indicating the ring 36 in which the subscriber 28 is currently resident) to base station 24. In turn, payload packets 112 can be packaged (i.e. encoded and/or modulated) according to a predetermined format, known to both base station 24 and subscriber stations 28, according to the reported reception-quality. In this manner, base station 28 need not provide format field 140 to each subscriber station 28, as the subscriber station 28 can simply decode the relevant payload packet 112 according to the predetermined format. In the foregoing scenario, it will thus be apparent that format fields 140 can be eliminated.

Alternatively, format fields 140 can be included within frame 100 which further incorporate a control-bit to indicate that the payload packet 112 addressed to a given subscriber station 28 is packaged according to a predetermined format based on a subscriber station's 28 reception-quality, or the control-bit can indicate that the payload packet 112 is packaged according to some other format, which is indicated in the following bits within the format field 140.

It is also contemplated that format fields 140 can be eliminated, as the format of robust packaging can be determined by receiving subscriber stations 28 using "blind detection", i.e. a receiving subscriber station 28 can simply attempt to decode a payload packet 112 at various levels of demodulation and decoding until the data packets 116 are meaningfully recovered. Other combinations and variations for choosing and detecting the type of robust packaging will now be apparent to those of skill in the art.

While the embodiments discussed herein are directed to multiple-access schemes conducted over wireless, it will be understood that the present invention can be applied to a variety of multiple-access schemes, such as over twisted-pair or coaxial links, and that various methods can be used such as TDMA, FDMA or CDMA.

The present invention provides a novel data channel in a network having at least one base station and a plurality of subscriber stations. The data channel can be composed of a plurality of frames having at least one packet that is readable by all subscriber stations which indicates whether the receiving subscriber station is an intended addressee for all or part of the frame. The frame and/or portions thereof are robustly packaged in any appropriate manner, to ensure and/or assist the intended addressee subscriber station(s) is capable of recovering the any data addressed thereto, and that the unintended addressees subscriber stations are capable of determining that they need not recover all or part of the data contained in the frame. By only robustly-packaging the frame, and/or portions thereof, according to different reception-quality requirements of different subscriber stations, less complex robust packaging can be used for stations that have lower reception-quality requirements, thereby packaging more data into each frame, yet ensuring that the network is capable of reaching subscriber stations having greater reception-quality requirements by packaging the frame in a more robust manner.

The above-described embodiments of the invention are intended to be examples of the present invention and alterations and modifications may be effected thereto, by those of skill in the art, without departing from the scope of the invention which is defined solely by the claims appended hereto.

Appendix I

Table I

Ec/No (dB)	Spreading Factor (chips/symbol)	Modulation symbols	Coded bits/symbol	Code rate	Symbol Repetition Factor	Bit/symbol	Bits/frame	Es/No for 10^-3 FER (dB)	Eb/No (dB)
-9.06	2	4	2	0.328	3	0.22	4198.4	-6.05	0.55
-8.81	2	4	2	0.357	3	0.24	4569.6	-5.8	0.43
-8.31	2	4	2	0.392	3	0.26	5017.6	-5.3	0.53
-7.56	2	4	2	0.435	3	0.29	5568	-4.55	0.83
-7.26	2	4	2	0.328	2	0.33	6297.6	-4.25	0.59
-7.01	2	4	2	0.357	2	0.36	6854.4	-4	0.47
-6.51	2	4	2	0.392	2	0.39	7526.4	-3.5	0.57
-5.76	2	4	2	0.435	2	0.44	8352	-2.75	0.87
-5.01	2	4	2	0.488	2	0.49	9369.6	-2	1.12
-4.51	2	4	2	0.556	2	0.56	10675.2	-1.5	1.05
-4.26	2	4	2	0.328	1	0.66	12595.2	-1.25	0.58
-4.01	2	4	2	0.357	1	0.71	13708.8	-1	0.46
-3.51	2	4	2	0.392	1	0.78	15052.8	-0.5	0.56
-2.76	2	4	2	0.435	1	0.87	16704	0.25	0.85
-2.01	2	4	2	0.488	1	0.98	18739.2	1	1.11
-1.51	2	4	2	0.556	1	1.11	21350.4	1.5	1.04
-0.51	2	4	2	0.646	1	1.29	24806.4	2.5	1.39
1.49	2	4	2	0.770	1	1.54	29568	4.5	2.62
4.49	2	16	4	0.435	1	1.74	33408	7.5	5.09
4.99	2	16	4	0.488	1	1.95	37478.4	8	5.10
5.74	2	16	4	0.556	1	2.22	42700.8	8.75	5.28
6.99	2	16	4	0.646	1	2.58	49612.8	10	5.88
8.74	2	16	4	0.770	1	3.08	59136	11.75	6.86
12.99	2	64	6	0.646	1	3.88	74419.2	16	10.12
15.24	2	64	6	0.770	1	4.62	88704	18.25	11.60
16.99	2	256	8	0.556	1	4.45	85401.6	20	13.52
17.99	2	256	8	0.646	1	5.17	99225.6	21	13.87
20.49	2	256	8	0.770	1	6.16	118272	23.5	15.60

We claim:

1. A system for transmitting data comprising:
a base station having a microprocessor, a modem, and an output device for outputting a signal;
a plurality of subscriber stations having a microprocessor, a modem and an input device each operable to a receive said signal at a different reception-quality than at least one other said subscriber station;
said signal including a frame having an identifier recoverable by all of said subscriber stations regardless of said reception-qualities, and a remaining portion recoverable by at least one of said subscriber stations, said identifier indicating whether said subscriber station need recover said remaining portion.

2. The system according to claim 1 wherein said output device is a radio and said input device is a radio and said signal is a wireless transmission.

3. The system according to claim 1 wherein said signal is transmitted over a CDMA channel.

4. The system according to claim 1 wherein said identifier indicates a range of reception-qualities and said remaining portion includes a header having address information, said header being recoverable by said subscriber stations within said range, said remaining portion further including at least one payload packet being recoverable by a subscriber station corresponding to said address information.

5. The system according to claim 2 wherein said payload packet is packaged according to an addressee subscriber station's reception-quality.

6. The system according to claim 1 wherein said reception-quality is a measurement of signal-to-noise ratio.

7. The system according to claim 1 wherein said identifier is packaged into said frame using a modulation operation.

8. The system according to claim 1 wherein said identifier is packaged into said frame using an encoding operation.

9. The system according to claim 1 wherein said remaining portion is packaged into said frame using a modulation operation.

10. The system according to claim 1 wherein said remaining portion is packaged into said frame using a combination of an encoding operation and a modulation operation.

11. The system according to claim 10 wherein said encoding operation is rate 1/N convolutional encoding.

12. The system according to claim 10 wherein said modulation operation is M-ary QAM.

13. The system according to claim 1 wherein said remaining portion is packaged into said frame using an encoding operation.

14. A system for transmitting data comprising:

a base station having a microprocessor, a modem, a radio and an antenna;

a first subscriber station having a microprocessor, a modem, a radio and an antenna, said first subscriber station operable to a receive a transmitted radio signal from said base station at a first reception-quality;

at least one additional subscriber station having a microprocessor, a modem, a radio and an antenna, said at least one additional subscriber station operable to receive said transmitted radio signal at a second reception-quality different from said first reception-quality;

said base station operable to robustly-package a frame of data over a channel for reception by all of said subscriber stations, wherein a portion of said frame is recoverable by all of said subscriber stations to indicate whether a receiving subscriber station is intended to recover a remaining portion of said frame.

15. A subscriber station comprising:
an antenna-radio assembly for receiving a radio-signal at a reception-quality, said radio-signal carrying a frame transmitted from a base station;
a modem-microprocessor assembly connected to said antenna-radio assembly and operable to recover an identifier from said frame regardless of said reception-quality, said identifier for indicating whether said microprocessor should recover a remaining portion of said frame that is packaged according to said reception-quality.

16. A method of packaging a frame for transmission to at least one of a plurality of subscriber stations over a multiple-access link, each of said subscriber stations having a reception-quality associated with an ability to receive a transmission over said link, said method comprising the steps of:
receiving and buffering a sufficient amount of data to fill said frame;
assembling said data into at least one payload packet addressed to said at least one subscriber station, said at least one payload packet being robustly-packaged according said at least one subscriber station's reception-quality;
assembling an address of said at least one subscriber station into a header packet that is robustly-packaged at least according said at least one subscriber station's reception-quality;
assembling an identifier indicating the poorest reception-quality of the at least one subscriber stations having said at least one payload packet addressed thereto, said identifier being recoverable by all subscriber stations regardless of said reception-qualities;
assembling said payload packets, said header and said class-identifier into a frame; and,
transmitting said frame over said link.

17. The method according to claim 18 further comprising the step of, prior to said transmitting step,

assembling format information into said header, said format information indicating how said at least one payload packet is robustly-packaged.

18. A method of recovering a frame transmitted from a base station to a plurality of subscriber stations over a multiple-access link, each of said subscriber stations having a reception-quality associated with said multiple-access link, said method comprising the steps of:

receiving said transmitted frame;

recovering an identifier using a recovery operation corresponding to a lowest reception-quality of said subscriber stations;

recovering a header when said identifier indicates that said receiving subscriber station is within a range of reception-qualities, said header packet recovered using a recovery operation corresponding to a lowest reception-quality indicated by said identifier packet; and,

recovering payload packets when said header packets indicate that said payload packets are addressed to said receiving subscriber station, said payload packet recovered using a recovery operation corresponding to a reception-quality of said receiving subscriber station.

19. A frame for transmission a plurality of subscriber stations each having a reception-quality corresponding to an ability to recover said transmission, said frame comprising:

an identifier packaged for recovery regardless of said reception-qualities and including information representing whether a receiving subscriber station is within a range of reception-qualities;

a header packaged for recovery by subscriber stations within said range and including address information; and,

at least one payload packet packaged for recovery by at least one of said subscriber stations that are indicated by said address information.

20. The frame according to claim 19 wherein said header further includes formatting information indicating a packaging format of said at least one payload packet.

21. The frame according to claim 19 wherein said header further includes formatting information consisting of one of: a) a packaging format of said at least one payload packet; and b) an indicator that said at least one payload packet is formatted according to a predetermined packaging format known to said subscriber stations.

22. The frame according to claim 21 wherein said packaging format includes at least one of a modulation operation and an encoding operation used to package said at least one payload packet.

23. The frame according to claim 19 wherein said identifier is packaged for recovery according to an error rate one order of magnitude lower than a target error rate for said frame.

Fig. 1

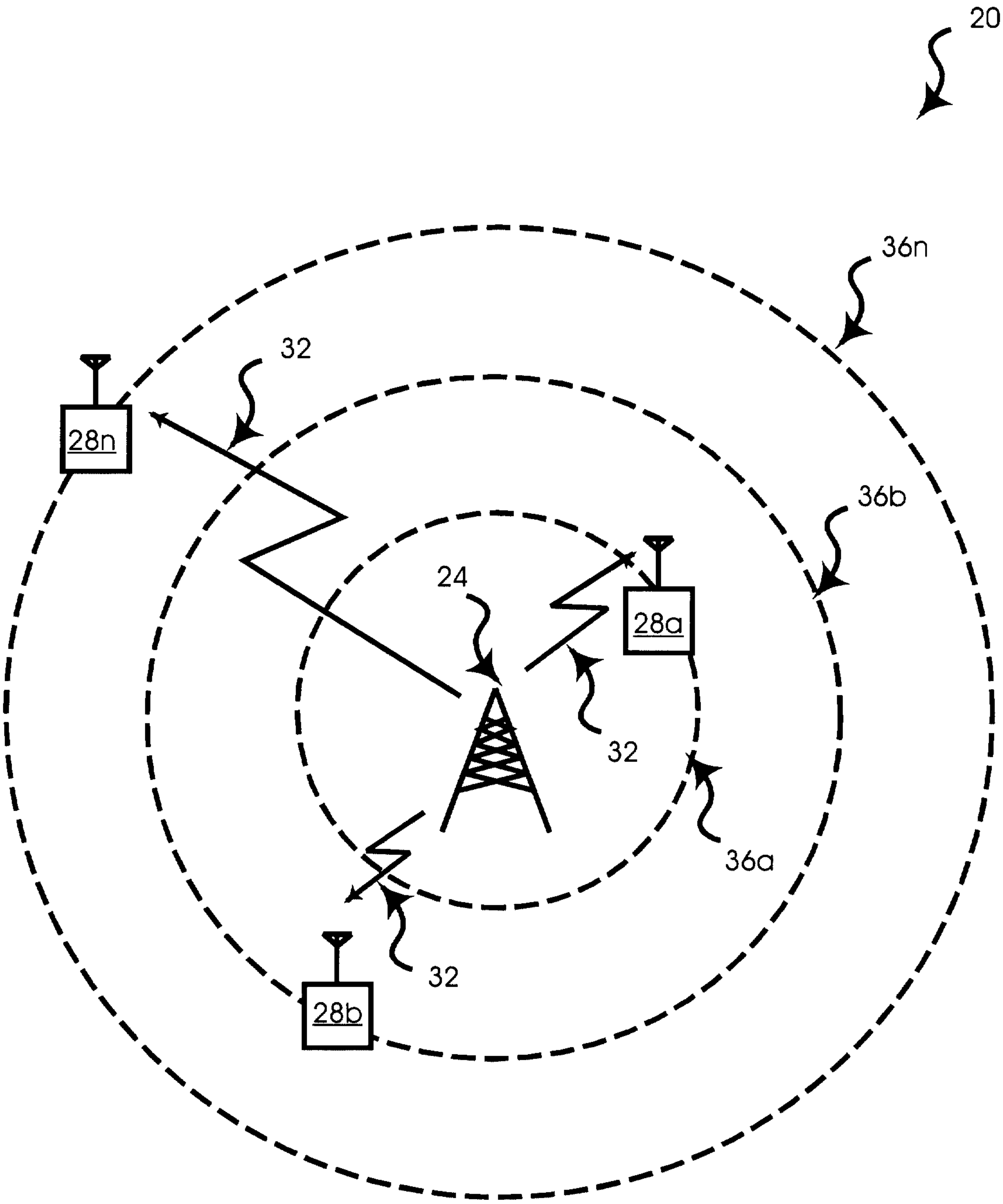


Fig. 2

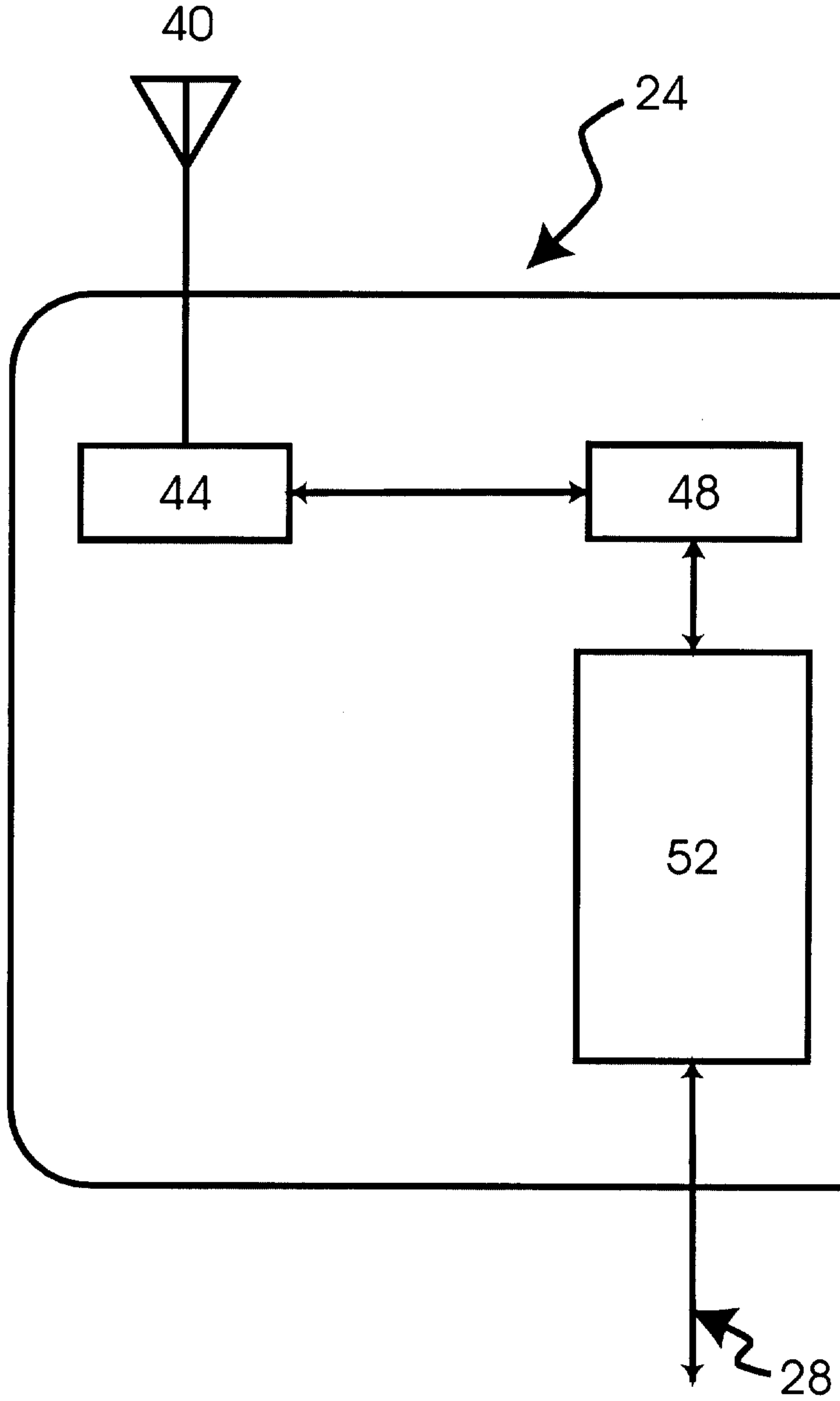


Fig.3

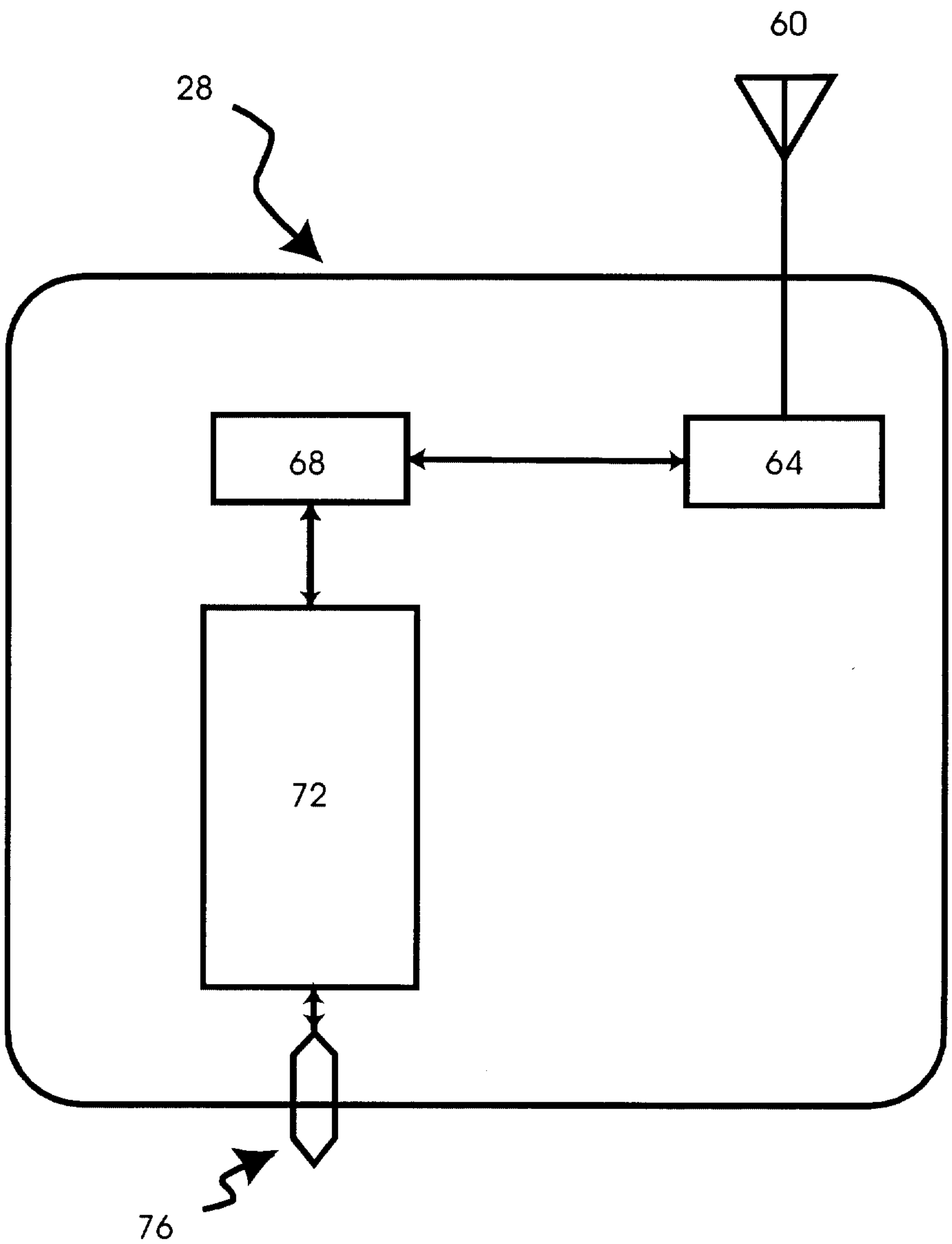
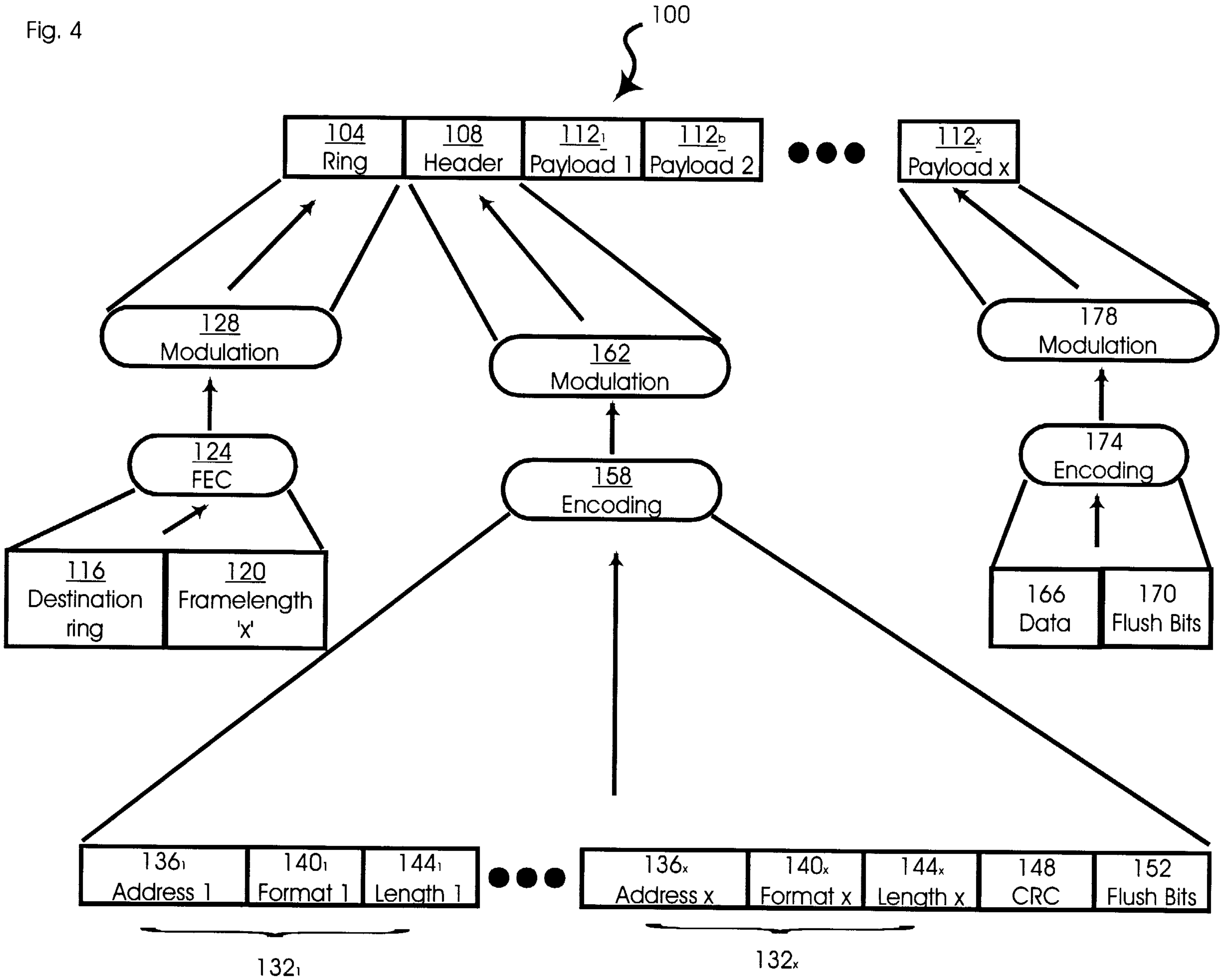


Fig. 4


100
104 Ring
108 Header
112₁ Payload 1
112b Payload 2
112x Payload x
128 Modulation
162 Modulation
178 Modulation
124 FEC
158 Encoding
174 Encoding
116 Destination ring
120 Framelength 'x'
166 Data
170 Flush Bits
136₁ Address 1
140₁ Format 1
144₁ Length 1
136x Address x
140x Format x
144x Length x
148 CRC
152 Flush Bits
132₁
132x

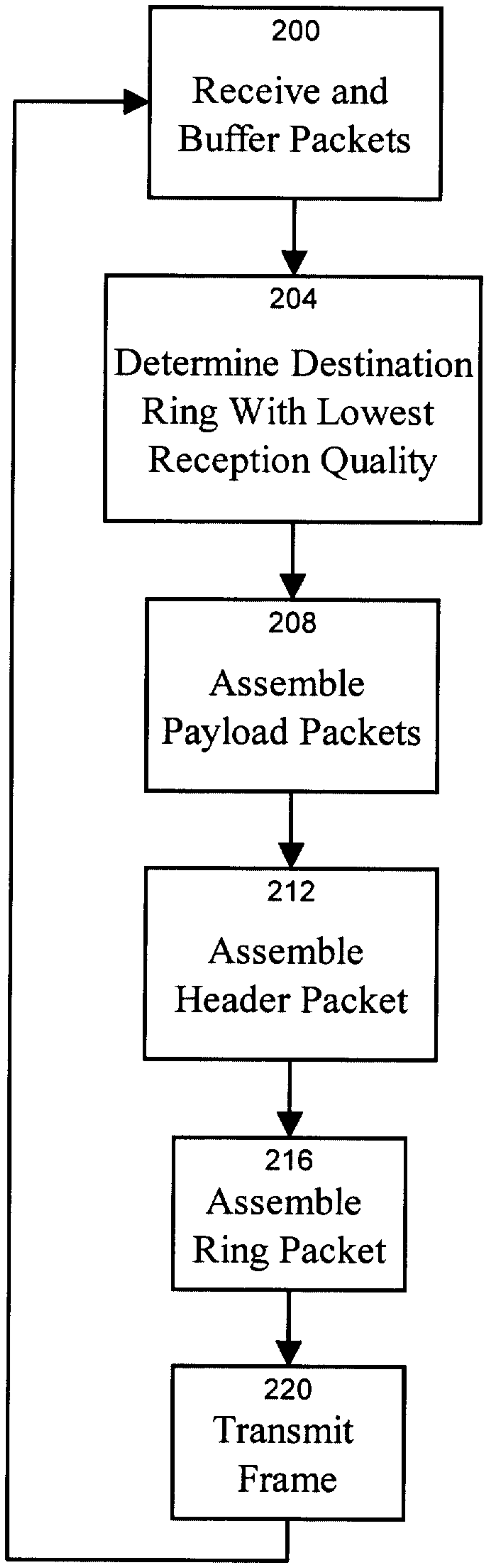

200
Receive and
Buffer Packets
204
Determine Destination
Ring With Lowest
Reception Quality
208
Assemble
Payload Packets
212
Assemble
Header Packet
216
Assemble
Ring Packet
220
Transmit
Frame

Fig. 5

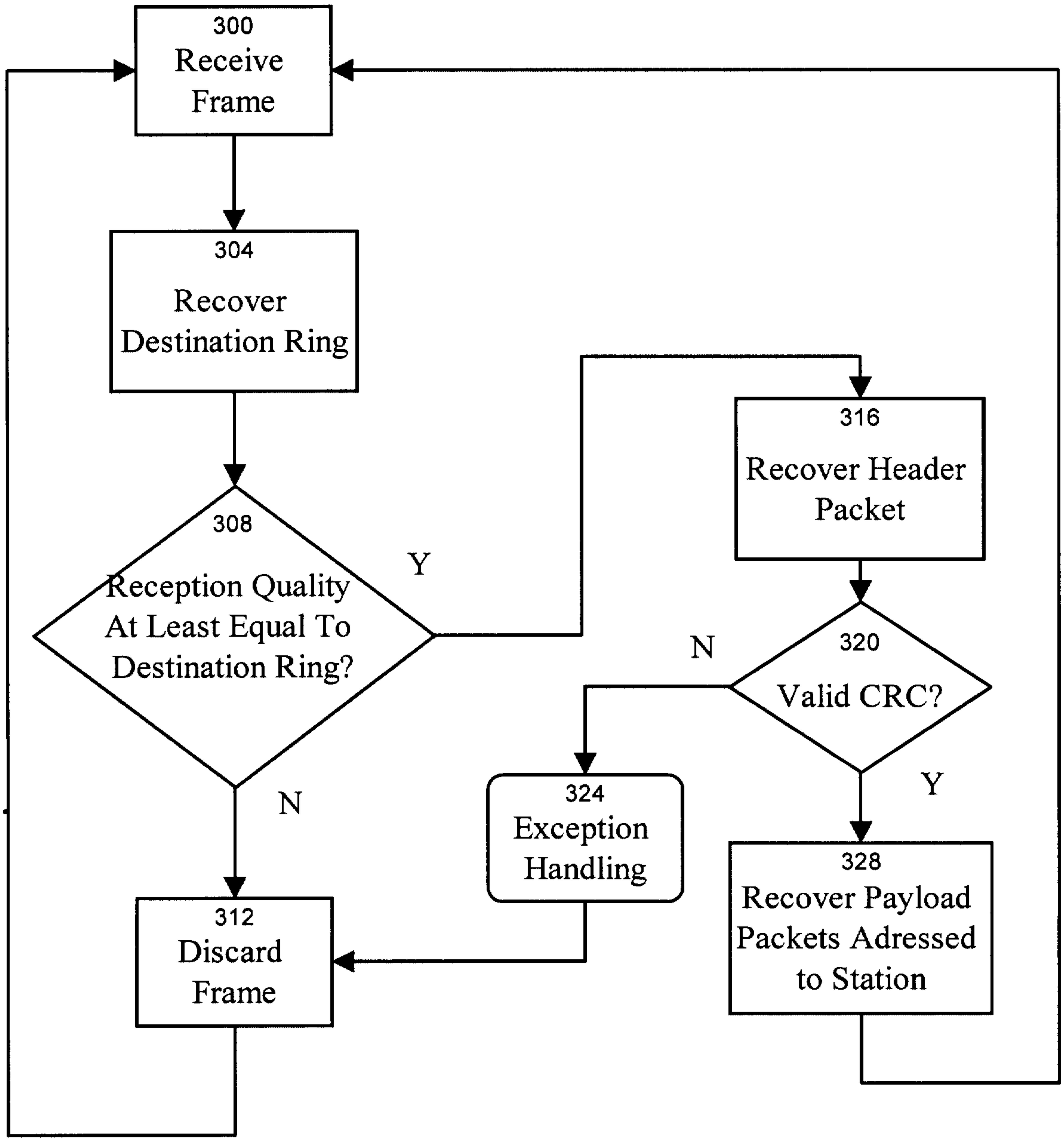
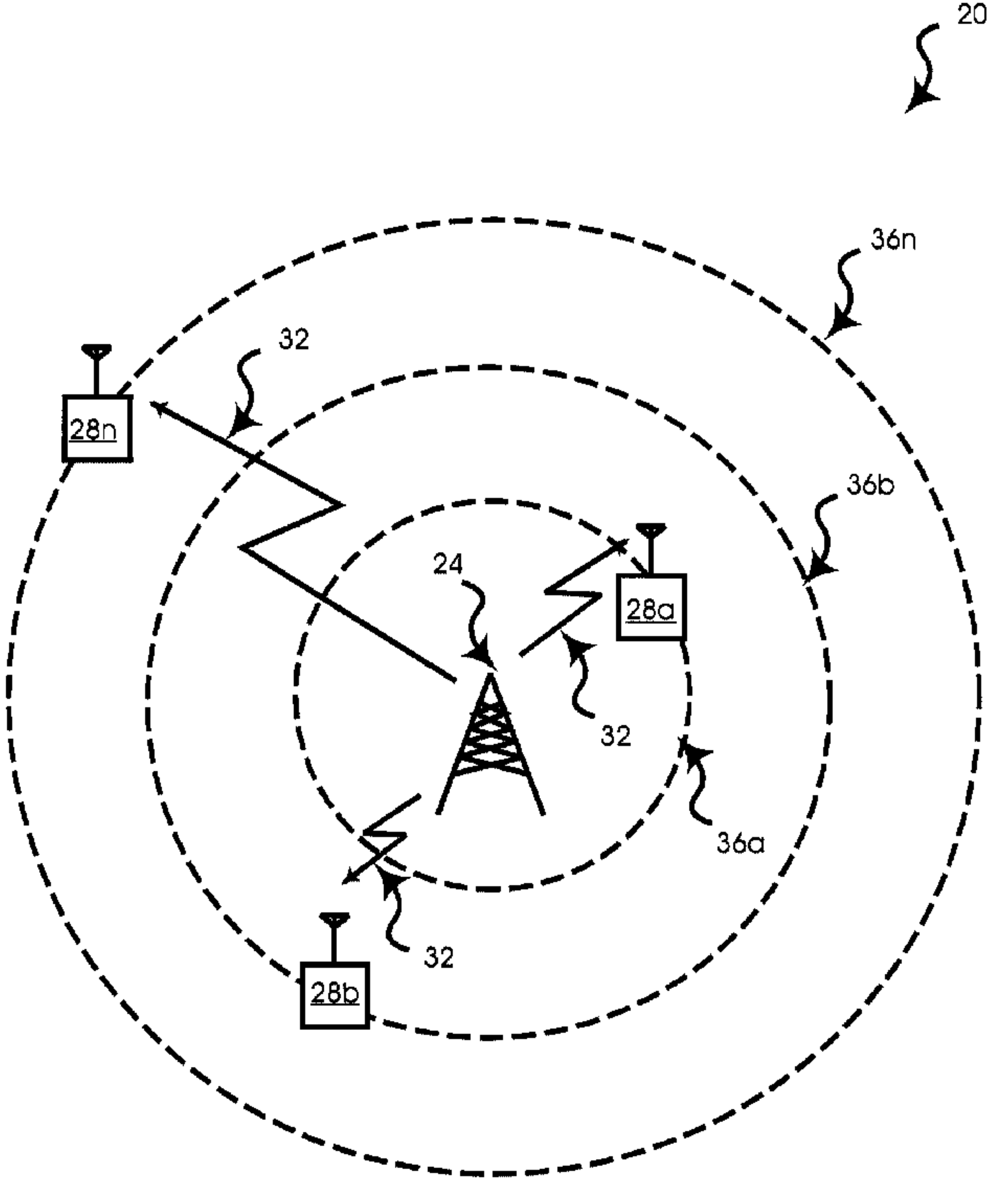

300
Receive Frame
304
Recover Destination Ring
308
Reception Quality At Least Equal To Destination Ring?
Y
N
312
Discard Frame
316
Recover Header Packet
320
Valid CRC?
N
Y
324
Exception Handling
328
Recover Payload Packets Adressed to Station

Fig. 6


20
36n
32
28n
36b
24
28a
32
36a
32
28b