

TITLE OF THE INVENTION

Voice Paging Protocol

5

BACKGROUND OF THE INVENTION

The present invention relates to communications protocols. In particular, the present invention relates to a protocol particularly suited for effectively
10 implementing feature rich voice paging.

Virtually unknown several years ago, paging has today become one of the fastest growing segments of the telecommunications industry. Some industry sources indicate, in fact, that there are over 55 million pagers
15 in service and that by the year 2000, nearly 70 million pagers will enter service generating billions of dollars in revenue for the service providers.

Generally, paging provides a mechanism by which one entity sends a message to another entity equipped with a
20 wireless receiver (i.e., a pager). The wireless nature of the pager allows its carrier to move freely in a predefined service area and still remain accessible. Initially, pagers were only capable of rudimentary beeping to indicate that the carrier should return a call
25 (using a conventional telephone) to a certain number, or call a pager service provider to retrieve a voice mail message.

Recently, however, the pager capabilities (driven by consumer demand) have expanded to encompass text
30 messaging. A text messaging pager (often referred to as

an alphanumeric pager) receives numerous individual alphanumeric characters that form a text message of limited length. Thus, for example, the alphanumeric pager may provide potentially important information to its carrier immediately, rather than requiring the carrier to call in for a message.

With the advent of alphanumeric pagers, pagers left behind functionality restricted to simple alerting. Rather, pagers now provide full (unidirectional) communications capabilities, including the reception, for example, of stock quotes and e-mail. Although consumer demand for alphanumeric pagers is increasing rapidly, even more sophisticated pagers known as voice pagers may soon supplant the demand for alphanumeric pagers.

Voice pagers are capable of receiving, much like an answering machine, actual voice messages for audio playback. The benefits of voice pagers are numerous, and allow their owner, for example, to store multiple messages, review messages, and recognize the voice (and emotional characteristics) of the caller. In the past, however (and due in part to their recent emergence), the functionality provided by voice pagers and their communications protocols has been somewhat limited.

As an example, InfoTelecom provides the MobiDARC protocol (an extension of the DARC protocol) that is able to transmit digital voice messages. The MobiDARC protocol, however, provides only a relatively slow transmission rate, 6.8 Kbps. Although a 9.7 Kbps rate is

available using a non-interleaved code, the lack of interleaving dramatically decreases message and voice quality due to omnipresent fading effects. Of course, the amount of time required to transmit any message
5 increases with decreasing transmission rate.

Furthermore, in existing protocols, address and message information is typically placed very close together and is not repeated. Thus, a pager that misses a (typically) short addressing portion misses messages
10 altogether. As a result, the bandwidth used to transmit the message has been wasted, important messages are not received, and the system transmitter must more frequently retransmit messages. Furthermore, service subscribers paying for paging services are not likely to tolerate
15 such unreliable reception.

With the advent of voice pagers in particular, missed messages are more than a minor inconvenience. Because voice messages may be many seconds and many thousands of bits in length, the amount of system
20 resources required to retransmit missed voice messages is quite significant. Furthermore, with such long messages, the amount of time between which messages can be repeated is often very lengthy. Thus, a missed message results in a significant delay until a (potentially emergency)
25 message is received. Even though voice paging is poised to become a major market segment, previous protocols supporting voice paging have not provided enhanced message reception over that of simple alphanumeric

paggers. User dissatisfaction, wasted bandwidth, and undelivered messages result.

5 An additional consideration of great importance is pager battery life. Longer battery life, of course, is desirable from a marketing standpoint, but also plays a role in the mechanical longevity of the pager, and the frequency at which battery backed up information in the pager is lost. All paggers, of course, must activate their reception circuitry to receive messages. The
10 particular technique used by the pager to determine that it will receive a message has a profound impact on battery life. In the past, however, voice paging protocols required paggers to remain active for extended periods of time to determine whether they were to receive
15 a message.

A need has long existed in the industry for an improved voice paging protocol that supports sophisticated paging functions.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to provide a voice paging protocol.

5 It is another object of the present invention to provide a voice paging protocol incorporating diversity transmitting and receiving techniques.

Another object of the present invention is to provide a voice paging protocol that incorporates
10 diversity transmitting techniques within a single frame.

A still further object of the present invention is to provide a voice paging protocol that incorporates diversity transmitting techniques over multiple frames.

15 It is yet another object of the present invention to provide a voice paging protocol that reduces power consumption for the pagers it supports.

Yet another object of the present invention is to provide a voice paging protocol that provides advance alert notice of incoming messages to a pager.

20 Another object of the present invention is to provide a voice paging protocol that allows long voice messages to be transmitted to a pager over multiple frames.

Another object of the present invention is to
25 provide a voice paging protocol that provides group messaging capabilities.

A still further object of the present invention is to provide a voice paging protocol that accommodates

roaming pagers.

One preferred embodiment of the present voice paging protocol provides a method of transmitting information to a receiver using a selective call message. The selective
5 call message includes an indicator signal indicative of at least one receiver and a data signal destined for the receiver. The indicator signal may be, for example, an alert signal (as small as a single bit) assigned to one or more pagers or an address corresponding to one or more
10 pagers, or a combination of both alert and address information.

The method first transmits the indicator signal a first time and delays for a predetermined time interval. Subsequently, the method transmits at least a portion of
15 the first indicator signal a second time and a message signal for the receiver a first time. Thus, a portion of the indicator signal is repeated after a time interval to provide indicator signal time diversity before transmission of the actual message.

20 The method may periodically transmit frames and transmit the indicator signal, for example, in a first frame, while repeating a portion of the indicator signal and message signal in a subsequent frame. As one example, the entirety of an alert and address indicator
25 signal may be repeated in a subsequent frame. Additionally, the portion of the indicator signal corresponding to the address may be repeated yet again in the subsequent frame to provide three or more repetitions

of an address across multiple frames.

The present invention further provides a method of transmitting information to a receiver that, among other things, helps the receiver reduce power consumption. The method of transmitting information uses a selective call message including an indicator signal indicative of at least one receiver and a message signal destined for the receiver. The method proceeds by setting an alert signal indicative of a receiver and transmitting the alert signal. Additionally, an address corresponding to the receiver is set and transmitted, and subsequently, a message signal destined for the receiver is transmitted. The alert signal may, for example, be a single alert bit.

The method may transmit additional messages to additional receivers by contemporaneously setting and transmitting additional alert signals, address signals, and message signals (which may be interleaved and pseudo-randomly distributed in a voice data section of a frame, for example). Receiver groups (sets of pagers sharing common addresses) are also supported. To transmit a group message, the method may, for example, additionally set and transmit several additional alert bits that are indicative of a receivers in a receiver group. A single group message signal destined for each receiver in the receiver group is also transmitted.

Alternative steps may be taken to transmit messages to receiver groups. For instance, for receiver groups without a common address, the method may set and transmit

individual alert bits corresponding to receivers in the group, set and transmit each address for each receiver in the group, then transmit the message signal destined for each receiver in the group.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates one embodiment of an alert packet format.

5 Figure 2 shows one example of a pointer packet format.

Figure 3 illustrates one example of housekeeping packets.

10 Figure 4 depicts one embodiment of a protocol frame structure.

Figure 5 illustrates one example of the format of a stream header.

15 Figure 6 shows one example of a receiver decision tree that determines the queries and resulting actions that a receiver may perform in receiving messages according to the current paging protocol.

Figure 7 illustrates one high level flow diagram of transmission according to the present protocol.

20 Figure 8 shows one high level flow diagram of reception according to the present protocol.

Figure 9 depicts a high level block diagram of transmitter and receiver hardware that may be used to implement the present voice paging protocol.

DETAILED DESCRIPTION OF THE INVENTION

The present discussion proceeds in several steps. First, the present application presents general background information useful for understanding the protocol. Next, the present discussion turns to several of the structural aspects of the protocol. After the structural aspects, the present application then presents several operational characteristics of the protocol.

BACKGROUND

The present protocol is built from a number of individual pieces. At the highest level, the protocol uses a repetitive frame structure, with each frame generally following the same format as the previous frame. Each frame, in turn, is constructed from packets of information. As an example, a frame may include 2922 packets. Packets, in turn, are a collection of predetermined numbers of symbols. As an example, each packet may include 128 symbols. Symbols, in turn, are formed using modulation of a carrier frequency. The modulation, for example, may be Phase Shift Keying at 4 or 8 levels (QPSK and 8-PSK, respectively). The above examples are not presented in a limiting sense, but only provide one specific example of how the protocol may be structured.

The packets, discussed in more detail below, group

symbols into packet types, including Alert packets, Pointer packets, and Housekeeping packets. Additionally, data is generally transmitted in a separate voice data section using voice data packets.

5 One environment in which the present protocol may be used effectively is that of the standard FM radio broadcasting infrastructure. Generally, the FM radio infrastructure provides numerous 200 KHz spaced channels over the 87.5 to 108 MHz frequency range. The baseband
10 FM signal itself, however, uses 100 KHz of bandwidth in which approximately 53 KHz is used for stereo audio information and the remaining 47 KHz of which is typically divided into two Subsidiary Communications Authorization (SCA) channels centered at approximately 67
15 KHz and 92 KHz. Each of the SCA channels is independently suitable for carrying information according to the protocol discussed below.

 While FM broadcasting infrastructure provides, in conjunction with the present protocol, an existing,
20 worldwide transport mechanism for information, the present protocol may be applied to virtually any other available frequency band or communications infrastructure. Furthermore, while the protocol below is described particularly with reference to a paging system,
25 the protocol is not limited to any particular use.

STRUCTURAL ASPECTS

As noted above, the packets from which frames are partially composed preferably include Alert packets, Pointer packets, and Housekeeping packets.

5 Alert Packets

Turning now to Figure 1, that figure shows an alert packet format 100. The format 100 includes a pilot mark 102, a packet sequence number 104, and a system ID 106.
10 Additionally, the format 100 includes an alert bit field 108, Cyclic Redundancy Check (CRC) field 110, and a flush field 112.

As illustrated in Figure 1, the pilot mark 102 is formed from four symbols of Binary Phase Shift Keying (BPSK) modulated carrier. The sequence of symbols in the
15 pilot mark 102 form a predetermined sequence of phase changes used by pagers for clock and packet synchronization. To this end, the transmitting station and the receiving pagers establish, beforehand, the pilot
20 mark 102 to be transmitted (and therefore to synchronize to during reception). Preferably, a pilot mark is inserted every 128 symbols to present a consistent synchronization reference to receiving pagers. Thus, the
25 pilot marks in the pointer packet format 100 (and other formats discussed below) are not technically integral parts of the pointer packet, but simply reappear every 128 symbols.

The packet sequence number 104 is formed, like the

pilot mark 102, from four symbols of modulated carrier. The packet sequence number 104, however, is preferably QPSK modulated resulting in 8 bits of information present in the packet sequence number 104. Switching to QPSK modulation aids in the synchronization process noted above with respect to the pilot mark (by providing four symbols, each which better withstands a given amount of noise than the more closely spaced eight symbols of 8-PSK).

10 The packet sequence number 104 indicates the position and type of the packet with which it is associated. As will be described in more detail below, the alert, pointer, and housekeeping packets form a 202 packet (in one embodiment) short message section in a frame. Each packet is numbered sequentially from 0 to 15 201 using the packet sequence number fields. Thus, for example, the first 80 alert packets are numbered 0-79, the following 10 pointer packets 80-89, and so on. Because the format of the short message section is 20 expected to remain fixed, a receiver pager may determine, using the packet sequence numbers, the type of packet currently being received and its position within the frame.

25 Still with reference to Figure 1, the system ID 106 is formed from 6 symbols of 8-PSK modulated carrier. The system ID 106 thus carries 18 bits of raw data. The system ID (like the alert bit field 108, CRC field 110, and flush field 112 discussed below) are convolutionally

coded, preferably, at a rate of 2/3. Thus, for every three bits of raw data output by the convolutional encoder, two bits represent unencoded (i.e., original) information. The system ID 106, therefore, includes 12 bits that actually represent the system ID (i.e., there are 4096 system IDs).

When used with an FM transmission infrastructure, for example, the present protocol may use the system ID to designate particular FM stations. In most instances, each station uses a different system ID, and each pager is assigned to a particular station. The system ID, therefore, may be considered part of the pager's address. It is noted, however, that a single system ID may be shared among several FM stations. In particular, in areas with significant interference, (major cities, for example), several FM stations may share the same system ID and transmit duplicate sets of frames on different frequencies to provide a pager with at least one alternate FM station for reception.

The alert bit field 108, as shown in Figure 1, extends over 103 symbols of 8-PSK modulated carrier. After 2/3 rate coding, the alert bit field 108 provides 206 bits of information. Each pager supported by a service provider assigns the pager at least one bit in an alert bit field (of which many are provided in the overall frame structure described below). If a particular alert bit is set, a message will be placed in one of the voice data sections that follow in the present

or next frame, thereby providing an indicator signal to the receiver that a message is forthcoming.

In general, the alert bits may be used as either unique bits or shared bits. Unique bits identify only a single pager. Shared bits designate more than a single pager, and may, for example, be used for roamers and system expansion. The use of the alert bits in both capacities is described in more detail below.

Next, the CRC field 110 is formed from 8 symbols of 8-PSK modulated carrier. The CRC field, after 2/3 rate encoding thus represents 16 bits of CRC information. The CRC in the CRC field 110 may be computed, for example, over the system ID 106, the alert bit field 108, and the CRC field 110 itself. Finally, the flush field 112 is formed from 3 symbols of 8-PSK modulated carrier and 2/3 rate coded. The flush field 112 thus provides 6 bits which may be used to reset a convolutional decoder to a known state, in preparation for the next packet.

20

Pointer Packets

Turning now to Figure 2, that figure shows one example of a pointer packet format 200, short address pointer 202, and a long address pointer 204. The pointer packet format 200 includes a pilot mark 206, a packet sequence number 208, and a system ID 210. Further included is a roaming flag 212, a message pointer field 214, CRC field 216, and a flush field 218.

The pilot mark 206, packet sequence number 208, system ID 210, CRC field 216, and flush field 218 are formed and function substantially as described above with respect to the identical fields in the alert packet format 100. In particular, the CRC field 216 preferably
5 computes a CRC over the system ID 210, roaming flag 212, message pointer field 214, and the CRC field 216 itself.

The roaming flag 212 is a single bit that indicates the type of pointers present in the message pointer field
10 214. As an example, the roaming flag 212, when 0, may indicate that short address pointers 202 are present in the message pointer field 214. When 1, the roaming flag 212 may indicate that long address pointers 204 are present in the message pointer field 214.

The message pointer field 214 generally contains
15 pointers including address information that allow a pager to determine when a message is being sent to the pager and where to find the message in the voice data section to follow. The pointers thus provide an indicator signal
20 to the pager that a message is forthcoming. In one embodiment, the message pointer field contains 205 bits of actual (before 2/3 rate coding) pointer information.

Turning to specific examples of pointers, the short address pointer 202 includes a first reserved bit 220, a
25 second reserved bit 222, a stream ID 224, a reserved field 226, and a short address 228. The reserved bits 220, 222 and the reserved field 226 provide room for future expansion of the present protocol and therefore

have no specific function.

The stream ID 224, in one embodiment of the present protocol, is three bits and determines one of eight unique streams. As will be explained in more detail below, messages are assigned to one of eight streams for transmission. As an initial step in reception, the pager decodes the stream ID 224 and retrieves its message from the appropriate stream.

The short address 228 contains an address assigned to a particular pager (e.g., a "home" address assigned to the pager in its assigned service area). As an example, the short address 228 may be 16 bits in length, thus identifying one of 65,536 pagers or groups. In most instances, a pager will respond to at least one unique address assigned to it. Optionally, the short address 228 may contain a group address (by which a predetermined group of pagers are selected). As an example, a group address may be allocated to each pager in a set of pagers for a local sales team. Thus, when the sales team needs to share information, a message may be sent to the sales team group address. A single message may thereby update all the pagers in the sales group.

An additional use for the group address includes a reserved broadcast address, used to send a message to all pagers. As another example, a programming address may be used to send digital programming data to a subset of pagers (for example to update the protocol software itself). Preferably, when used, the group address is

placed at the end of any pointers for individual pagers that may be present in the message pointer field 214.

Another example of a pointer is the long address pointer 204. The long address pointer, like the short address pointer includes a first reserved bit 230, a second reserved bit 232, a stream ID 234, a reserved field 236, and a long address 238. The reserved bits 230, 232, reserved field 236, and the stream ID 234 function as described above with respect to the short address pointer 202.

In the long address pointer 204, however, the long address 238 typically includes additional information over that provided by the short address 228. Thus, for example, the long address 238 may support roaming pagers by using a 12-bit system ID concatenated with a 16-bit home address. A message transmitted to a roaming user therefore typically involves setting the roaming flag 212, and providing additional addressing information (i.e., a long address 238) to select a pager according to its home system ID and its home address). Thus, a roaming pager which uses the same alert bit (and even the same "home" address) as a pager at home in a particular system area may distinguish the message destination by examining the complete long address 238.

Housekeeping Packets

Turning now to Figure 3, that figure shows one

example of two housekeeping packets 300. A first housekeeping packet 302 and a second housekeeping packet 304 are illustrated. In the example shown in Figure 3, housekeeping information is distributed over two packets (256 symbols). Generally included in the housekeeping packet structure 300 are pilot marks 306, 308, a CRC field 310, and flush bits 312. Further included are packet sequence number fields 314, 316 and system ID fields 318, 320. The pilot marks 306, 308, as noted above are present due to their insertion, every 128 symbols, into the transmitted information stream. The system ID fields 318, 320 and flush bits 312 operate as described above with respect to the pointer packets and alert packets.

The CRC field 310, on the other hand, is computed over all the bits in both housekeeping packets 300, except for the two packet sequence number fields 314 and 316. The pilot marks 306 and 308 are not used to convey information in bit form and are also excluded from the CRC computation in the housekeeping packets 300. As will be described in more detail below, in one embodiment of the present protocol, two housekeeping packets are placed at the end of a 202 packet section in a frame. Thus, the packet sequence numbers 314 and 316 may represent the numbers 200 and 201 (i.e., packets sequence numbers range from 0-201).

As shown in Figure 3, the housekeeping packets 300 span 256 symbols. Nineteen symbols are used for the

pilot marks 306 and 308, CRC field 310, and the flush bits 312. Twenty symbols are used for the packet sequence number fields 314 and 316 and system ID fields 318 and 320. The remaining 217 symbols (434 bits at rate
5 2/3 8-PSK coding) are used for the actual housekeeping information.

The housekeeping information may include any type of information generally useful to the receiving pagers. Thus, for example, the housekeeping information may
10 include 32 bits of system transmitter time information, 16 bits of system transmitter date information, and 16 bits of information representing the current system frequency. Additional examples include a system channel list (formatted, for example, as eight 16-bit channel
15 IDs), a roaming channel list formatted in the same or different fashion, and an 8-bit protocol system revision. The examples provided above, and particularly the number of bits used to implement the examples, may, of course, vary considerable from implementation to implementation.

20 Of particular interest are the system channel list, roaming channel list, and the current system frequency. By providing the frequencies in the lists (as well as the current system frequency) in digital form, the pager may use the digital information to tune directly, precisely,
25 and rapidly to the correct frequency. In other words, the pager need not execute an inefficient frequency sweep to find available channels. The system channel list may be used to inform the pager of the possible redundant

frequencies over which its messages will be transmitted.

Thus, in a major metropolitan area, with considerable interference caused by numerous sources, the pager may switch between channels identified in the system channel list for best reception. Furthermore, the roaming channel list provides the pager with an indication of which local radio channels support roaming.

Frame Structure

Turning now to Figure 4, that figure illustrates one way in which the packet types described above may be combined with voice data sections to form frames 400. Figure 4, in particular, breaks down the frame 402 into its component pieces shown in the expanded frame 404. The expanded frame 404 includes a short message section 406 and a voice data section 408. In one embodiment, the frame 402 includes 2922 packets, of which 202 form the short message section 406 and 2720 of which form the voice data section 408.

The short message section 406 generally indicates a section of the frame that includes alerts, pointers, and housekeeping information (as opposed to actual message data). In turn, the expanded short message section 410 illustrates a preferred arrangement of the short message section 406, including the alert packets, pointer packets, and housekeeping packets described above. In particular, the expanded short message section 410

indicates that an alert N section 412 is followed by a pointers N section 414, followed by an alert N+1 section 416. Additionally, a pointers N+1 section 418, a duplicate pointers N section 420, and a housekeeping section 422 follows the alert N+1 section 416. The duplicate pointers N section 420 is so named because it typically provides a copy of the pointers N section 414.

The alert N section 412 is formed from 80 alert packets 100 which contain alert bits corresponding to pagers with messages in the voice data section 408. The pointer N section 414 is formed from 10 pointer packets 200 which provide address information for pagers receiving message in the voice data section 408. The housekeeping section 422 is formed from the housekeeping packets 300.

The duplicate pointers N section 420 repeats the content of the pointers N section 414, thereby providing time diversity in the transmission of the pointers. Furthermore, the alerts N+1 section 416 and pointers N+1 section 418 provide advance alerting and pointer information for messages transmitted in the next frame (frame 424). Furthermore, the pointers N+1 section 418 is typically 20 packets in length, including 10 packets of pointer information and 10 packets of data information, for example. The pointers N+1 section may thereby provide a combined address and data message useful for sending short pieces of data, or long pieces of data over multiple frames.

The preferred format of the short message section 404 provides a pager with numerous chances to recognize that it is to receive a page. If the pager misses the advance alerting information provided by the alerts N+1 section 416 in the frame prior to the one in which the message is sent (the "message frame"), it still may detect the alerting information provided by the alerts N section 412 in the message frame. Similarly, if the pager misses all of its alerts, it may still examine the advance pointer information provided by the pointers N+1 section 416 during the prior frame and the two sets of message pointer information provided by the pointer N section and the duplicate pointers N section in the message frame to find its address.

If the pager recognizes its address from pointer information, it may then prepare itself for reception of the appropriate stream. If the pager recognizes its alert bit, it may then check the pointers to determine if its particular address (as opposed to that of a roamer, for instance) is actually present. The multiple time diversity thus provided by the present protocol enhances the ability of the pagers to correctly receive every message sent to them, while reducing power consumption, and is further discussed in more detail below.

25

Voice Data Section

The voice data section 408 is formed from packets

that are parts of larger data structures. In one embodiment, the voice data section 408 is divided into 8 streams of data each comprising 340 packets. Each stream is convolutionally coded and interleaved over its entire length (which may include multiple messages, one or more of which may be destined for a single pager).

Preferably, sets of four contiguous packets ("pickets") of data from each stream are distributed throughout the voice data section in a deterministically random manner to form the stream. In other words, the pager and system transmitter both generate the same pseudo-random sequence identifying the position of the pickets. This may be accomplished, for example, by identically seeding a random number generator, or by reading picket positions from a pre-generated lookup table. The pager retrieves each of the pickets for a given stream distributed among the voice data section before it reassembles, de-interleaves, and decodes a complete stream. Once the complete stream is decoded, the pager may then extract its particular message from the stream.

Turning to Figure 5, that figure shows one preferred embodiment of a stream header 500 used in the present protocol. The stream header 500 includes a stream ID 502 and a message count 504. The stream ID (which may be, for example, 8 bits) identifies the number of the stream, while the message count 504 identifies the number of messages in the stream itself. Each message may be terminated with a multi-bit flush field to reset a

convolutional decoder to a known state.

For each message in a stream, the stream header 500 provides a message header including a long address 506 (28 bits), a time field 508 (12 bits), a data type field 510 (8 bits) an extended data type field 512 (16 bits), a start location field 514 (16 bits), a length field 516 (16 bits), and a fragment field 518 (8 bits). Also provided for each message is a CRC field 520 (16 bits). A final CRC field 522 (16 bits) that covers all the preceding message headers and a Flush field 524 (6 bits) are provided at the end of all of the message headers.

The long address 506, as noted above in the pointer packet, identifies a particular pager or pager group. The time field 508 provides the time at which the current message was left for the pager at the service provider, and the data type fields 510 and 512 inform the pager as to the type of data included in the voice data section 408. As an example, the data type fields 510 and 512 may indicate digitized voice data, digital programming data, advertising, emergency alert information, weather information, stock data, or any other type of data that the system transmitter chooses to send to the pager. Any data, however, and preferably the stream header, may be convolutionally coded at a 1/3 rate (for example, by bit doubling the input bit stream to a convolutional coder) to provide enhanced error protection and correction capabilities.

The start location field 514 and length field 516

provide the start location and length of the message in the stream for the pager identified by the long address field 506, preferably in units of words (16 bits). The start location field 514 (and stream ID) are two examples
5 of message location information that allow a receiver to determine where its message signal is in the voice data section of a frame. It is further noted, however, that the receiver may also need to collect the pickets or segments of the stream that have been (deterministically)
10 randomly spread through the voice data section.

The fragment field 518 may be used to indicate the number of frames over which the message for the pager is spread. As an example, the 8-bit fragment field 518 may use four bits to indicate the total number of frames used
15 to transmit the message, and another four bits to indicate the current frame (fragment) number of the message. It is further noted that the stream header 500 preferably includes a terminating CRC field and flush field, similar to those illustrated in the packet types
20 described above.

Preferably, the data in the each of the packets is interleaved over the same packet. It is noted that the alert packet, pointer packet, housekeeping packets, and stream header are not limited to the specific
25 implementations described above. Rather, each of the individual fields in each packet or header may be tuned to the application for which the protocol is used. The examples cited above work particularly well in an FM

voice paging system and a summary of the relevant parameters may be found in Table 1.

Table 1	
Subcarrier center frequencies:	68.0625 kHz & 84.5624 KHz (8.25 & 10.25 * 8250)
Modulation type:	8PSK voice pilot symbols
Baud Rate:	8250
Pulse Shaping:	Square Root of $(1+\cos(0.98)f)$
Pilot symbol rate:	4 symbols every 128 baud, 124 symbols/packet
Packet rate:	15.51515 ms./packet
Error correction, voice:	2/3 rate, multiple interleaved convolutional coded modulation in time diversified blocks
Error correction, short message section:	2/3 rate convolutional code interleaved over packet
Frame structure	
Frame length:	2922 packets, 45.3353 sec.
Frame alert section:	Alert block n, followed by Pointer block n, followed by Alert block n+1, followed by Pointer block n+1, followed by Housekeeping
Short Message Section length:	202 packets, 3.13406 sec
Alert block length:	80 packets
Housekeeping:	2 packets
Alert packet header:	4 symbols uncoded QPSK (packet Number) 12-bit system code
Alert bits:	16,480
Pointer block length:	10 packets, 10 additional reserved packets in pointers n+1
Pointer message:	29 bits/home unit, 41

	bits/roaming units
Voice data section:	8PSK coded modulation
Section length:	2720 packets, 42.2021 sec
Stream length:	1/8 data section-340 packets randomly spaced
Alert packet	
Header (all data MSB first):	8-Bit Packet Sequence Number Packet sequence numbers: 0 - 79 = Alerts n 90 - 169 = Alerts n+1 12-Bit System ID
Alert bits:	206 bits
Pointer packet	
Header (all data MSB first):	8-Bit Packet Sequence Number Packet sequence numbers: 80 - 89 = Pointers n 170 - 189 = Pointers n+1 190 - 199 = Pointers n 12-Bit System ID
Roaming flag:	1 bit (0 = Short Addresses follow; 1= Long Addresses follow)
Pointer data:	2-Bits Reserved 3-Bit Stream ID 8-Bit Message Number 16-Bit or 28-Bit Address
Housekeeping Packets	
	System ID (12 bits), Protocol Rev Number (8 bits), Date (16 bits), Time (32 bits), Station Frequency (16 bits), System Station Listing (8 x 16 bits), Designated Area Roaming Station Listing (8 x 16 bits), Reserved bits.

Voice Data Packets	
Note:	Voice data packets are bounded by the pilot marks. The position of the packets in the data epoch may be pseudo random and drawn from a table. The receiver awakens to receive the next burst of packets until the entire stream is stored. The de-interleaving and decoding may then begin.
Packet burst (picket) length:	Four packets, forming 85 power-on periods.
Message termination:	Six flush bits may be appended to each message in the voice data block.
Stream header:	Stream ID (8 bits), Number of Messages (8 bits)
Message information block:	Pager address (28 bits), Time (12 bits), Data Type (8 bits), Extended Type (16 bits), Message Start Byte (16 bits), Message Length (16 bits), Fragment Code (8 bits), Message CRC (16 bits).
Header terminator:	16-Bit CRC 6-Bit Flush

OPERATIONAL CHARACTERISTICS

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The protocol structure established above supports a wide range of capabilities. The discussion below proceeds with respect to basic paging, group paging, and roaming. The protocol is not limited to these capabilities, however, nor to any particular environment in which they are used.

10

Before proceeding, it is noted that a pager is

assigned at least one address that designates the pager as a receiver for a particular message. The address may, for example, be a "home" address, group address, or roamer address. Additionally, when assigned to a service provider, the pager is assigned an alert bit. In an FM voice paging system, for example, each SCA band in each FM frequency may be assigned a system ID and carry the protocol structure identified above. An alert bit in such a system thus associates the pager with a particular SCA band of a particular FM frequency. With respect to the system channel list discussed above, however, a pager may be associated with the same alert bit in a number of different SCA bands and FM frequencies to provide robust reception in a noisy environment.

Basic Paging

In the basic paging operation, the system infrastructure accepts, digitizes, compresses, and stores voice messages left for delivery to a pager. As examples, voice data may be compressed with a Linear Predictive Coder (LPC); Residual Excited Linear Predictive Coding (RELP), Vector Sum Excited Linear Predictive Coding (VSELP), and the like. Data already in digital form, of course, may optionally be compressed and stored for delivery.

At predetermined intervals, the system transmitter retrieves messages from storage and transmits the

messages to the appropriate pager. Preferably, the system transmitter stores numerous messages and packs messages in the frame to minimize slack space (i.e., space in which no message will fit). The system transmitter sets the appropriate alert bit corresponding to the pager, places the pager address in a pointer, assigns the message to a stream, fills in the stream header fields as described above, and sends the message with the appropriate coding and interleaving disclosed above with respect to the message streams. Alert bits (generally, alert portions) and addresses (generally, address portions) may be considered individually or in combination as an indicator signal that a message has been placed in a frame (i.e., a message frame), for a particular pager.

The present protocol may be used, as described in more detail below, to send universal pages. That is, the present protocol supports sending a message signal to the complete set of pagers (i.e., every registered, active pager) supported by the system. In most instances, however, the system transmitter sends message signals to a subset of pagers smaller in number than the complete set of pagers supported by the system. The subset of pagers may be a single pager, for example, or may include several individual pagers and pager groups.

With reference to Figure 4, the present discussion proceeds under the assumption that a message will be transmitted for a pager in the next frame 424.

Preferably, the system transmitter gives advance warning to the pager by setting the pager's assigned alert bit in the alert N+1 field 416, and adding the pager's address and message information to the pointers N+1 field 418.

5 Thus, if the pager recognizes its alert bit or address in the frame 402, it need not waste power searching for an alert bit or address in the next frame 424. On the other hand, if the pager cannot determine whether its alert bit or address is present in frame 402 (e.g., due to
10 reception of corrupted data), the pager has additional opportunities to do so in the next frame 404 (by examining the alert N field, and the two pointers N fields). In one embodiment of the present invention, a null address is defined and is used in a pointer field to
15 indicate that no further pager addresses will follow. Thus, a pager that decodes the null address may save power by disabling its reception circuitry for the remaining portion of the present pointer field under examination.

20 Once the pager recognizes its alert or address, it recovers the stream ID and message number (Figure 2) from the long or short address pointer provided in an available pointer field. The pager then assembles the appropriate stream in the voice data section by gathering
25 and ordering all of the pickets comprising the stream. The pager then de-interleaves and decodes the message stream in its entirety. Subsequently, the pager examines the stream header (Figure 5) to locate the start of its

message and the message length. The pager, once it has recovered the message, may then update its internal list of successfully received messages according to the message number in the pointer.

5 In operation, a pager need only look for its alert bit or address in a pointer to determine whether it will receive a message in the current or next frame. Thus, the pager may save substantial amounts of power by only activating its reception circuitry to receive a single
10 alert packet and examine, typically, a single bit in the alert packet. If the pager's alert bit is not set, it can deactivate its reception circuitry for the entire voice data section 408, or perform a check for its address in the pointers N+1 and pointers N fields. Thus,
15 for example, if the pager could not decode the alert bits due to interference, the pager may still attempt to decode pointer fields in search of its address.

 When the pager matches its predetermined alert bit location with a transmitted alert bit (one example of a
20 selection criteria), it may continue with active reception to examine the pointers N field 414 and optionally pointers N field 422 (if the pager recognized its alert bit set in the alerts N section 412) as well as the pointers N+1 field 418 (if the pager recognized its
25 alert bit set in the alerts N+1 section 416). Note that due to the time diversity of the pointer and alert information (the indicator signals), the pager has numerous chances to determine that the system transmitter

is sending the pager a message in the current frame (e.g. frame 402) or next frame (e.g., frame 424). Again, as soon as the pager matches its address (another type of selection criteria) in any of the pointer sections, it
5 may discontinue searching the remainder of the current pointer section or subsequent pointer sections.

Flexibility in selection criteria allows a pager three opportunities to determine that the system transmitter is sending a message to the pager in the
10 current frame. The pager may examine the contents of the alerts N section 412 for its alert bit, the pointers N section 414 for its address, or the duplicate pointers N section 420, again for its address. Finding its alert bit or address indicates that the current frame includes
15 a message for the pager. Furthermore, the pager has two opportunities to determine that the system transmitter will send the pager a message in the next frame by examining the alerts N+1 field 416 for its alert bit or the pointers N+1 field 418 for its address. Finding its
20 alert bit or address indicates that the next frame includes a message for the pager (and therefore that the pager need not search the short message section at all in the next frame).

If the pager successfully decodes the alert bits or
25 addresses in the pointers (as determined by a CRC check), the pager may determine that it has or has not matched its selection criteria. In such cases, the pager may inhibit reception of any repeated indicator signals (as

the repeated indicator signals contain information the pager has already decoded). If, however, the CRC check indicates that some bits have uncorrectable errors (i.e., they are indeterminate), the pager may enable reception
5 of any repeated indicator signals to have another opportunity to recognize that it will receive a message. Thus, for example, uncorrectable errors in an alert bit may be overcome by examining repeated alert bits (e.g., alerts N section 412), and complete loss of alert bits
10 may be overcome by examining one or more pointer sections, as necessary.

Once the pager has recovered the pointer information, including the stream ID, the pager may then deactivate its reception circuitry (i.e., the pager need
15 not examine other pointer sections after it has found its pointer once). Because, as noted above, the streams in the voice data section 408 are interleaved in a deterministically random manner, the pager may proceed to receive the appropriate stream by activating its
20 reception circuitry only during the times corresponding to the particular stream transmission in the voice data section 408.

Group Paging

25

Group paging may be accomplished in a number of ways, three of which are addressed in this section. First, for relatively small or temporary receiver groups,

the system transmitter may set individual alert bits in alert packets and addresses in pointer packets to cover each pager to which a message will be sent. Thus, each pager recognizes its alert bit and its individual address and each pager proceeds to retrieve the same message from the voice data section of the appropriate frame.

Alternatively, the system transmitter may set the alerts and addresses as noted above, but transmit individual copies of the message for each pager.

A second implementation of group paging may be used, for example, for larger and relatively permanent receiver groups. The second implementation assigns at least one additional address to pagers in the group. Thus, each pager in a set of pagers for a sales team may include a unique address for individual messages and a group address for messages directed to the entire sales team. In transmitting a group message to the sales team, the system transmitter sets multiple alert bits corresponding to each pager in the sales group, but only provides the single group address in the pointer fields. Each pager therefore knows that a message is arriving, and that the message corresponds to the sales group address assigned to the pager.

An additional example of group paging is universal paging. In universal paging, the system transmitter sets a predefined universal address in the pointer fields, and optionally sets all of, or a subset of, the alert bits in the alert packets. Typically, the universal address is

recognized by every pager. Universal addressing, therefore, allows the system transmitter to broadcast emergency information, programming information (e.g., system protocol software updates), and the like to every
5 pager. Preferably, individual and small group addresses are placed at the beginning of the pointer packet, while large group or universal addresses are placed at the end. Pagers thereby receive individual messages in the same frame as messages for large groups without lengthy
10 address lists.

One benefit of group paging according to the present protocol is that in each instance of group paging, a transmission of voice data may communicate information to substantial numbers of pagers. Furthermore, the protocol
15 provides the capability for small group, large group, and universal addressing in its group paging framework.

In general, groups may be defined according to virtually any criteria. As one example, subscription services (e.g., stock quotes, weather updates, news
20 services, and the like) may be assigned a group address. When a pager subscribes to the subscription service, the system transmitter may then transmit to the pager a new group address to which the pager should respond and that corresponds to address used to transmit the subscription
25 service information. Similarly, to unsubscribe, the system transmitter sends the pager a command to delete the subscription service address from its list of responsive addresses. Subscription information is

transmitted in the same fashion as normal paging message data.

Roaming

5

The present protocol allows pagers to roam without losing messages by using the long address pointers 204. To accommodate a roaming carrier, the carrier may, for example, specifically setup the forwarding of messages from the home area to the roaming area. For instance, when in the roaming area, the pager may examine the available frequencies, including those found in the system channel list and roaming channel list to find an available channel. The pager may then display the preferred channel (based on signal strength or other criteria) to the user. Subsequently, the carrier may call the system dispatch center in the home area and report (to a live operator, via a touchtone phone, or by tones generated by the pager) the preferred channel and the roaming area system ID.

20

It is noted that the roaming pager may return to its home area without prior notification to the system dispatch center. Thus, the dispatch center may decide to transmit pages either in the home area or in the roaming area, or both, according, for example, to system loading considerations. Typically, however, the user cancels the roaming at the system dispatch center soon after returning to the home area.

25

When transmitting a message to a roaming user, the system transmitter uses the long address pointers 204. The roaming flag 212 in the pointer packet format 200 is set to indicate that long address pointers follow. The long address pointer 204 provides extended address information used by the pager to resolve the true message destination. For example, if the roaming pager's address was the same as an existing pager's address in the roaming area (where the existing pager is at home). Thus, the long address field 238 provides, in addition to the pager's address, a multi-bit home system ID for the roaming pager (or in general, an extended address). A roaming pager may then easily distinguish itself using the complete system ID and address.

In order to provide an alert bit for the roaming pager, the pager address may be mapped into one bit in a set of reserved roaming alert bits in the alert packet format 100, for example. For example, a modulo function applied against the pager address may map the address into a predefined subset of roaming alert bits. This technique is described below with reference to shared alerts. Thus, the present protocol provides message reception for the roaming pager without conflict between existing home pagers.

25

Shared Alerts

As illustrated in Figure 4, the short message

section 406 provides 16,160 alert bits for each frame (80 packets, each with 202 alerts). Approximately 12,000 of these may be reserved, for example, for home pagers and another 4000 for roaming pagers (allowing a modulo 4000 function to determine which alert bit a roaming pager will use). If a given system requires more than 12,000 pagers, then alert bits may be shared among pagers. In other words, two or more pagers may use the same alert bit.

A particular pager may then determine whether a message is destined for it by examining the address fields in the short address pointers 202 and long address pointers 206, for example. Thus, even though alerts are shared, each pager may distinguish message destination by address. Note also that the modulo function may map two roamers onto the same alert bit. The two roamers similarly distinguish the intended recipient by using the addresses to which they are programmed to respond, compared with the address information in the long address pointers 206. Thus, even in the situation where two pagers share the same alert bit and address, the pager may allow itself to receive only those messages transmitted by its home system transmitter or a roaming system transmitter for a system in which the pager knows it is registered.

Turning to Figure 6, that figure illustrates a receiver decision tree 600 that provides a preferred set of queries and actions performed by a receiver receiving communications formatted according to the present protocol. The discussion of Figure 6 is supported by the frame format shown in Figure 4. Thus, assuming a message will be transmitted to a pager in frame N+1 424, the "early alert" of Figure 6 corresponds to the Alerts N+1 section 416 and the "early pointer" of Figure 6 corresponds to the Pointers N+1 section 418 (in particular, the first 10 (non-reserved) packets). Similarly, the "current alert" of Figure 6 corresponds to an Alerts N section in the frame N+1 424 (i.e., the current frame which includes the actual message), the "current pointer" corresponds to Pointers N section in the frame N+1 424, and the "last chance pointer" corresponds to the duplicate Pointers N section in frame N+1 424. The "data stream" refers to a voice data section 408 in the frame N+1 424.

With specific reference to Figure 6, there are three possible results for each "PROCESS" determination, a "true" result (causing a transition along a left branch), a "false" result (causing a transition along a middle branch), and an "indeterminate" result (causing a transition along a right branch). At "SKIP" points, the processing continues along the associated single arrow until the next PROCESS or SKIP point. As an initial

matter, it is noted that a receiver typically performs CRC checks on the data it receives. In cases where the CRC check indicates uncorrectable errors, the pager generally proceeds under the indeterminate (undefined) branches shown in Figure 6. Otherwise, the pager may accurately determine whether certain conditions are matched (a true result) or not matched (a false result).

A pager may begin at PROCESS point 602 at which the pager determines whether its alert bit is set in the early alert section. If the pager determines that its alert bit is set, processing proceeds under the True branch 604 (labeled "Alert" in Figure 6). If the pager determines that its alert bit is not set, processing proceeds under the False branch 606 (labeled "No Alert"), while in the indeterminate case, processing proceeds under indeterminate branch 608 (labeled "Indeterminate").

Starting first with the False branch 606, the pager has determined that it will not receive a message in the frame N+1 424. The pager, therefore, may skip examination, as shown in Figure 6, of the early pointer, current alert, current pointer, and last chance pointer. The pager thus performs no processing ("SKIP") of the voice data section of frame N+1 424.

It is noted, however, that every frame includes early alerts and pointers for the subsequent frame. The repetition indicator 610 illustrates the point in time, according the frame format of Figure 4, in which the next set of early alerts and pointers occur. Thus, after

every current pointer decision point in Figure 6, a completely new branching structure begins with the examination of an early pointer.

Continuing with the True branch 604, the pager
5 determines, at PROCESS point 612, whether a match exists
in the early pointer (e.g., a short address or long
address corresponding to the pager itself or a pager
group). If a match exists, the pager proceeds through
True branch 614 (labeled "Pointer"), skipping examination
10 (i.e., the pager need not waste power receiving) of the
current alert, current pointer, and last chance pointer,
to process its data stream in the voice data section 408
of the frame N+1 424. Similarly, if the pager recognizes
that the correct address is not present in the early
15 pointer, the pager may assume that its alert is being
shared, for example, and that the message is destined for
another pager. Thus, under the False branch 616 (labeled
"No Pointer"), no stream processing occurs (except, of
course, in the pager for which the message is addressed).

20 Turning to the Indeterminate branch 618, it is
initially noted that the present protocol provides
diversity indicator signals to provide the pager multiple
opportunities to determine that a message for it will
follow. Thus, the pager skips the current alert (because
25 the pager already successfully recovered its alert
information as determined at decision point 602). The
pager, however, enables its receiver to recover and
examine the current pointer section in frame N+1 424, and

proceeds from PROCESS point 620 as noted above upon True or False matching of the pointer, skipping only the remaining last chance pointer.

5 If however, the pager determines that uncorrectable errors exist in its decoding of the current pointer, the pager proceeds through the Indeterminate branch 622. The present protocol provides yet another chance, in the frame N+1 424, for the pager to find its pointer information in a duplicate pointers section (discussed
10 above with reference to duplicate pointers N section 420). If the pager successfully finds its pointer, it may then process the stream, otherwise, the pager does no processing of the stream. It is possible, of course, that the frame may include many more duplicate indicator
15 signals (the tradeoff being between diversity capability and available message bandwidth), each of which may be examined by the pager.

With respect to the Indeterminate branch 608, the pager proceeds by enabling its receiver and examining the
20 current alert at PROCESS point 624. While Figure 6 shows that the current alert is next examined, it is noted that the pager may first examine the early pointers in an attempt to match its address. Continuing from decision point 624, if the pager determines that its alert is not
25 set, it skips the current pointer and last chance pointer and performs no stream processing.

On the other hand, if the pager matches its alert, it proceeds under the True branch 626. Under the True

branch 626, the pager evaluates PROCESS point 628 under the same considerations discussed above with respect to decision point 620. The remaining alternative is illustrated in the Indeterminate branch 630.

5 Under the Indeterminate branch 630, the pager may, for example, skip the current pointer section and proceed to examine the last chance pointer at the PROCESS point 632. While Figure 6 shows that the last chance pointer is next examined, it is noted that the pager may, as an
10 alternative, examine the current pointers in an attempt to match its address. Assuming, however, that the pager proceeds with the last chance pointer, the pager reaches the decision point 632.

 At decision point 632, the pager, if it successfully
15 matches one of the pointers in the last chance pointer, proceeds to process the appropriate data stream (as indicated in the pointer). Otherwise, the pager performs no stream processing, either because it found no match in the last chance pointer, or because it could not decode
20 the last chance pointer.

 Turning now to Figure 7, that figure illustrates a high level flow diagram 700 summarizing transmission of information over a first frame 702 and a second frame 704 according to the protocol discussed above. The diagram
25 700 includes a current indicator step 706, an advance indicator step 708, and duplicate pointer step 710. Also included is an housekeeping step 712, and a message preparation step 714. The streams bearing the messages

are interleaved at step 716 and transmitted at step 718.

Each of the steps 706-718 occurs during a first frame (e.g., frame N 402). A corresponding set of steps 720-732 occurs in a subsequent frame (e.g., frame N+1

5 424). Starting with the current indicator step 706, the system transmitter prepares and transmits an indicator signal, generally including alerts (e.g., alerts N 412), pointers (e.g., pointers N 414), or both in a current frame (e.g., frame N 402). As noted above with respect
10 to group messages, additional alerts and pointers may be set as necessary to send messages to group receivers. Thus, for example, additional alert bits or pointers may be set for every receiver in a particular receiver group.

In the advance indicator step 708, an indicator
15 signal including alerts (e.g., alerts N+1 416) or pointers (e.g., pointers N+1 418) bearing information about the next frame are prepared and transmitted. The advance pointers may include extra packets of data to provide a combined address and data message, separate from voice
20 messages in the voice data section 408.

At step 710, the system generally prepares and transmits duplicate pointers (e.g., duplicate pointers N section 420), followed by housekeeping in step 712 (e.g., housekeeping section 422). With respect to step 714, one
25 or more messages (e.g., voice messages or digital data) are placed in a stream. As discussed above, pseudo-random interleaving is determined (step 716) for each stream, and the streams are transmitted (step 718).

During transmission of the subsequent frame (steps 720-732) the foregoing steps are generally repeated. Note, however, that the current indicator step 720 generally provides a repeated indicator signal (including alerts and pointers) corresponding to at least a portion of the advance indicator signal (including alerts and pointers) prepared at step 708. The intervening signals (e.g., those transmitted in steps 708-718) thus provide a delay of a predetermined delay interval and impart time diversity to the protocol. Intervening signals and a predetermined delay interval also occur between the indicator steps 706, 720, and the duplicate pointer steps 710, 724, respectively. The advance indicator signal step 722 provides advance alerts and pointers for information content in the next frame (e.g., frame N+2). As with the first frame, duplicate pointers, housekeeping, and messages are also transmitted in steps 724-732.

Turning to Figure 8, that figure shows a high level flow diagram 800 summarizing the reception of the protocol discussed above and in detail with respect to Figure 6. The flow diagram.800 includes a selection criteria step 802, an indicator reception step 804, and a condition step 806. An enable reception step 808 and a disable reception step 810 are also illustrated. Under the disable reception step 810, an extract message step 812, a deinterleave stream step 814, and an extract message step 816 are also shown.

In step 802, a selection criteria is established for the receiver. As an example, the selection criteria may be the presence of a particular alert bit or address (pointer) for the receiver, either individually or as a group receiver. Thus, in the reception step 804, the receiver receives an indicator signal or repeated indicator signal (e.g., an alert packet or pointer packet) with which it will establish a match, no-match, or indeterminate condition (step 806) based on the selection criteria. If the receiver is unable to receive the indicator signal correctly (e.g., the CRC indicates uncorrectable errors), an indeterminate condition is established and processing continues at step 808.

In the enable reception step 808, the receiver enables reception of repeated indicator signals, if any. Thus, if reception of the alerts N+1 section 416 is indeterminate, the receiver may enable reception of the subsequent alerts N section in the next frame.

Similarly, if the reception of the pointers N+1 section 418 is indeterminate, the receiver may enable reception of the pointer N section 414 or duplicate pointers N section 420 in the next frame. Generally, however, either a match (e.g., a matched alert or address) or no-match condition is established that indicates that a message is present or absent for the receiver in the current frame or next frame.

Under a match or no-match condition, processing continues at step 810, where reception of repeated

indicator signals is disabled. Furthermore, under the no-match condition, processing continues at step 804 in which the receiver prepares to receive a subsequent indicator signal. Thus, for example, if the receiver
5 determines a no-match condition with respect to the alerts N+1 section 416, it may disable reception of the alerts N section in the subsequent frame, but enable reception of the alerts N+1 section in that frame.

If a match condition is established, the receiver
10 extracts a message location (step 812), typically using a pointer packet 200 and a stream header 500. The receiver may then receive the stream (step 814) and deinterleave it in order to extract the particular message (step 816), as discussed above.

15

Additional Considerations

The present protocol operates independently of numerous other considerations that are addressed when
20 designing a service that uses the protocol. For instance, the system transmitter may be allowed to transmit the messages to a pager once, many times, or a variable number of times depending on system load. In instances where the pager receives multiple copies of the
25 same message, the pager may apply time diversity combination techniques to the received messages. Thus, the pager may combine the symbols of two copies of the same message to produce a single message. Effectively,

the rate $2/3$ convolutional coding, using two copies of the same messages, may be treated as a more robust rate $1/3$ convolutional code. Frequency diversity, in which the system transmitter transmits the same message on two frequencies simultaneously, is also possible, provided that an additional receiver is provided in the pager.

The range of services that may be provided over the present protocol is quite extensive. Thus, for example, the service provider may transmit advertising to the pagers. Predefined voice messages associated with the advertising may be transmitted to the pagers during off peak hours. Thus, local restaurant advertising may be announced at 11:30 am, for example.

Emergency services may also be provided. Thus, as an example, a hospital or police department may select emergency notification as part of a pager service plan. In emergencies, the system transmitter may then preempt ordinary outgoing messages in favor of transmitting the emergency message to one or more hospital or police department pagers.

Turning now to Figure 9, that Figure illustrates one set of hardware components that may be used to implement the present voice paging protocol. Figure 9 illustrates a system transmitter 900 and a receiver 902 (e.g., a voice pager). The system transmitter 900 includes an antenna 904, a signal transmitter 906, a controller 908, a clock generator 910, and a memory 912. The controller 908 includes general purpose I/O 913, an indicator signal

generator 914 and a message signal generator 916. The receiver 902 generally includes an antenna 918, a signal receiver 920, a clock generator 922, a controller 924, and a memory 926. The controller 924 includes a
5 selection comparator 927, a reception controller 928, a message extractor 930, and general purpose I/O 932.

The signal transmitter 906 may include, for example, an amplifier, filter, and modulator. The controller 908 operates in synchronism with the clock generator 910 and
10 may be implemented, for example, as a single ASIC that includes logic implementing the indicator signal (e.g., alerts and addresses) generator 914 and message signal generator 916 which generates (e.g., selects, formats, and encodes) the indicator signals and messages signals
15 discussed above. The clock generator 910 produces the clock signals for overall system control, signal timing, and frame timing. The memory 912 may store, for example, individual and group addresses, alerts, and digitized voice messages for transmission using an appropriate
20 combination of SRAM, DRAM, hard disk storage, Flash memory and the like.

With respect to the receiver 902, its signal receiver 920 may include, for example, a filter and demodulator that allow the receiver 920 to pass received
25 signals to the controller 924 for digital processing. The clock generator 922 produces clock signals for overall system control and frame reception timing, and the memory 926 may be used to store selection criteria

including alert bit and address assignments. The controller 924 may be implemented in an ASIC that includes logic for implementing the selection comparator 927, the reception controller 928, and the message
5 extractor 930.

The selection comparator 927 compares a received indicator signal against a selection criteria to determine whether the receiver 902 will receive a message. In response, the reception controller 928 may
10 enable or disable reception of repeated indicator signals and messages and discussed above. The message extractor 930 retrieves messages from the received signals by examining the indicator information (e.g., the address information), and extracting a message from a stream, as
15 noted above.

While particular elements, embodiments and applications of the present invention have been shown and described, it is understood that the invention is not limited thereto since modifications may be made by those
20 skilled in the art, particularly in light of the foregoing teaching. It is therefore contemplated by the appended claims to cover such modifications and incorporate those features which come within the spirit and scope of the invention.

What is claimed is:

1. A method of transmitting information to a receiver
using a selective call message including an
5 indicator signal indicative of at least one receiver
and a message signal destined for the receiver, the
method comprising the steps of:
 - 10 (a) transmitting a first indicator signal
indicative of at least one receiver a first
time;
 - (b) delaying for a predetermined interval; and
 - (c) transmitting at least a portion of the first
15 indicator signal a second time and a message
signal for the receiver a first time.
2. The method of claim 1, wherein the transmitter
periodically transmits frames and:
20 transmitting step (a) occurs in a first frame; and
transmitting step (c) occurs in a second frame
subsequent to the first frame.
3. The method of claim 2, wherein:
25 transmitting step (c) occurs in a second frame
immediately after the first frame.



4. The method of claim 2, wherein:

transmitting step (c) transmits the entirety of the
first indicator signal.

5

5. The method of claim 4, wherein:

transmitting steps (a) and (c) transmit an address
portion indicative of the receiver in the first
indicator signal.

10

6. The method of claim 5, wherein:

transmitting step (c) transmits the address portion
indicative of the receiver a second time in the
second frame.

15

7. The method of claim 5, wherein:

transmitting steps (a) and (c) additionally transmit
an alert portion indicative of the receiver in
the first indicator signal.

20

8. The method of claim 1, wherein:



25

transmitting step (a) occurs in a message frame; and
transmitting step (c) occurs in the message frame.

9. The method of claim 8, wherein:

transmitting steps (a) and (c) transmit an address
portion indicative of a receiver in the first
5 indicator signal.

10. The method of claim 9, wherein:

transmitting step (a) further transmits an alert
10 portion indicative of the receiver in the first
indicator signal.

11. The method of claim 10, further comprising the step
of transmitting in a current frame the address
15 portion.

12. The method of 11, further comprising the step of
transmitting in the current frame the alert portion.

- 20 13. The method of claim 11, further comprising the step
of:

preparing a combination address and data message;
and
25 transmitting in the current frame the combination
address and data message separately from the
message signal.



14. A method of receiving a message from a transmitter, the message carried in a transmitted signal including diversity indicator signals, the method comprising the steps of:

5

establishing a selection criteria in a receiver;
receiving a first indicator signal in a first frame
of information;

establishing at least one of a match and no-match

10

condition based on the indicator signal in
comparison with the selection criteria;

when the match or no-match condition is established,
disabling the reception of a subsequently
transmitted repeated indicator signal.

15

15. The method of claim 14, wherein the step of
establishing comprises establishing at least one of
a match, no-match, and indeterminate condition, and
further comprising the step of enabling the
reception of at least a portion of the subsequently
transmitted repeated indicator signal when the
indeterminate condition is established.



20

16. The method of claim 14, wherein the step of
receiving the first indicator signal receives an
address portion in the first indicator signal.

25

17. The method claim 16, wherein the step of receiving

the address portion further includes the step of receiving a message location in the first indicator signal.

- 5 18. The method of claim 17, further comprising the step of enabling reception of portions of a frame of information corresponding to the message location.
- 10 19. The method of claim 14, wherein the step of receiving the first indicator signal receives an alert signal.
- 15 20. The method of claim 19, further comprising the steps of receiving an address portion associated with the receiver and disabling the receiver during a repeated address portion of the information.
- 20 21. The method claim 20, wherein the step of receiving the address portion further includes the step of receiving a message location.
- 25 22. The method of claim 21, further comprising the step of enabling reception of portions of a frame of information corresponding to the message location.
23. A messaging protocol signal structure for transmitting a message to a receiver, the messaging protocol signal structure comprising:



a first indicator signal comprising information
indicative of a receiver;

a second indicator signal repeating at least a
portion of the information in the first

5 indicator signal; and

an intervening signal between the first indicator
signal and the second indicator signal, the
intervening signal thereby providing time
diversity between the first indicator signal
10 and the second indicator signal.

24. The messaging protocol signal structure of claim 23,
further comprising a first frame and a second frame,
and wherein the first indicator signal is located in
15 the first frame and the second indicator signal is
located in the second frame.

25. The messaging protocol signal structure of claim 24,
wherein the second frame occurs immediately after
20 the first frame.



26. The messaging protocol signal structure of claim 23,
wherein the second indicator signal comprises the
entirety of the information in the first indicator
25 signal.

27. The messaging protocol signal structure of claim 26,
wherein the first and second indicator signals each

comprise an address indicative of the receiver.

28. The messaging protocol signal structure of claim 24,
wherein the second indicator signal comprises at
least two duplicate sections repeating at least a
portion of the first indicator signal.
29. The messaging protocol signal structure of claim 27,
wherein the first and second indicator signals each
comprise at least one alert indicative of the
receiver.
30. The messaging protocol signal structure of claim 23,
further comprising a current frame and a subsequent
message frame comprising at least a portion of a
message for the receiver, and wherein the first
indicator signal is located in the message frame and
the second indicator signal is located in the
message frame.
31. The messaging protocol signal structure of claim 30,
wherein the first and second indicator signals each
comprise an address indicative of the receiver.
32. The messaging protocol signal structure of claim 31,
the first indicator signal further comprises an
alert indicative of the receiver.



33. The messaging protocol signal structure of claim 32, wherein the current frame comprises a third indicator signal including the address indicative of the receiver.

5

34. The messaging protocol signal structure of claim 33, wherein the third indicator signal further comprises the alert indicative of the receiver.

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35. The messaging protocol signal structure of claim 33, wherein the third indicator signal comprises a combined address and data message.

15

36. A method of transmitting information to a receiver using a selective call message including an indicator signal indicative of at least one receiver and a message signal destined for the receiver, the method comprising the steps of:

20

setting an alert signal indicative of a subset of a complete set of receivers;

transmitting the alert signal;

setting an address corresponding to at least one receiver in the subset;

25

transmitting the address; and

transmitting a message signal destined for at least one receiver in the subset.



37. The method of claim 36, wherein the step of setting an alert signal sets an alert bit.

38. The method of claim 37 for transmitting at least one additional message to at least one additional receiver, wherein:

5 the step of setting an alert signal additionally sets a second alert bit indicative of a second receiver and the step of transmitting the alert signal additionally transmits the second alert bit;

10 the step of setting an address additionally sets a second address corresponding to the second receiver and the step of transmitting the address additionally transmits the second address; and

15 the step of transmitting the message additionally transmits a second message signal destined for the second receiver.



20

39. The method of claim 37 for further transmitting a group message signal to a receiver group, wherein:

25 the step of setting an alert signal additionally sets a plurality of additional alert bits indicative of a receiver group and the step of transmitting the alert signal additionally transmits the plurality of additional alert bits; and

the step of transmitting the message additionally transmits a group message signal destined for the receiver group.

- 5 40. The method of claim 37 for transmitting a message signal to a plurality of receivers that share a group address, wherein:
- the step of setting an alert signal additionally sets at least one additional alert bit
- 10 indicative of at least one additional receiver and the step of transmitting the alert signal additionally transmits the at least one additional alert bit.



- 15 41. The method of claim 37 for transmitting a message signal to a plurality of receivers that share an alert bit, wherein:
- the step of setting an address additionally sets at least one additional address indicative of at
- 20 least one additional receiver and the step of transmitting the address additionally transmits the at least one additional address.

- 25 42. The method of claim 36 for transmitting a message signal to a plurality of receivers that share an alert signal, wherein:
- the step of setting an address additionally sets at least one additional address indicative of at

least one additional receiver and the step of transmitting the address additionally transmits the at least one additional address.

5 43. The method of claim 37 for transmitting a message
signal to a plurality of receivers, wherein:
the step of setting an alert signal additionally
sets at least one additional alert bit
indicative of at least one additional receiver
10 and the step of transmitting the alert signal
additionally transmits the at least one
additional alert bit; and
the step of setting an address additionally sets at
least one additional address indicative of at
15 least one additional receiver and the step of
transmitting the address additionally transmits
the at least one additional address.

20 44. In a selective call receiver, a method of receiving
a message from a transmitter, the message carried in
a transmitted signal including alert information and
address information, the method comprising the steps
of:
receiving, from a transmitted signal, at least alert
25 information corresponding to a predetermined
receiver; and
determining the presence of a message signal for the
receiver based on the alert information and



responsively inhibiting reception of the transmitted signal when the message signal is absent.

- 5 45. The method of claim 44, wherein:
the step of determining further includes the step of
responsively receiving the message when the
message signal is present according to the
following steps:
10 receiving a message location provided in the
transmitted signal; and
receiving the message in the transmitted signal
according to the message location.



- 15 46. The method of claim 44, wherein:
the step of determining the presence of a message
signal determines the presence of the message
signal to be indeterminate when the alert
information contains uncorrected errors, and in
20 response:
receiving at least one address provided in the
transmitted signal; and
determining the presence of a message signal
for the receiver based on the address
25 information and responsively inhibiting
reception of the transmitted signal when
the message signal is absent.

47. The method of claim 44, wherein:

the step of determining the presence of a message

signal determines the presence of the message

signal to be indeterminate when the alert

5 information contains uncorrected errors, and in
response:

receiving at least one address provided in the
transmitted signal;

determining the presence of the message signal

10 for the receiver based on the address

information and receiving the message

signal when the message signal is present

according to the following steps:

receiving a message location provided in the

15 transmitted signal; and

receiving the message in the transmitted signal

according to the message location.



48. A frame structure for transmitting information to a
20 receiver, the frame structure comprising:

a first alert section comprising at least one alert
indicative of a subset of a complete set of
receivers;

25 a first address section comprising at least one
address for at least one receiver in the
subset; and

a first message section comprising at least one
message destined for the receiver.

49. The frame structure of claim 48, wherein the alert comprises an alert bit.

5 50. The frame structure of claim 49 for transmitting at
least one additional message to at least one
additional receiver, wherein the first alert section
comprises at least two alerts, the first address
section comprises at least two addresses, and the
10 first message section comprises at least two
messages.



15 51. The frame structure of claim 49 for further
transmitting a group message to a receiver group,
wherein the first alert section further comprises at
least two alerts indicative of receivers in a
receiver group and wherein the first message section
further comprises a group message signal for the
receiver group.

20 52. The frame structure of claim 49 for transmitting a
message to a plurality of receivers that share a
group address, wherein the first alert section
comprises at least two alerts indicative of
25 different receivers in a receiver group.

53. The frame structure of claim 49 for transmitting a
message to a plurality of receivers that share an

alert, wherein the first address section comprises at least two addresses indicative of different receivers in a receiver group.

- 5 54. The frame structure of claim 48 for transmitting a message to a plurality of receivers that share an alert, wherein the first address section comprises at least two addresses indicative of different receivers in a receiver group.
- 10
- 15 55. The frame structure of claim 49 for transmitting a message to a plurality of receivers using individual alerts and addresses, wherein the first alert section comprises at least two alerts indicative of different receivers in a receiver group, and wherein the first address section comprises at least two addresses indicative of the receivers.
- 20 56. The frame structure of claim 48, further comprising a current frame and a message frame and wherein the first alert section and the first address section are located in the current frame and the first message section is located in the message frame.
- 25 57. The frame structure of claim 56, wherein the message frame further comprises a second alert section duplicating the first alert section and a second address section duplicating a portion of the first



address section.



58. The frame structure of claim 57, further comprising
a duplicate second address section duplicating the
5 second address section located in the message frame.

59. The frame structure of claim 48, further comprising
a current frame and wherein the first alert section,
the first address section, and the first message
10 section are located in the current frame.

60. The frame structure of claim 49, further comprising
a duplicate address section duplicating the first
address section located in the current frame.

61. A voice paging transmitter for transmitting
information to a receiver using a selective call
message including an indicator signal indicative of
at least one receiver and a message signal destined
20 for the receiver, the transmitter comprising:

an indicator signal generator for producing a
indicator signal;

a message signal generator for producing a message
25 signal;

a clock generator for generating timing signals; and
a transmitter synchronized in accordance with the
timing signals, the transmitter transmitting

the indicator signal a first time, delaying, and transmitting at least a portion of the indicator signal a second time and the message signal a first time.

5

62. A voice paging receiver for receiving a message from a transmitter, the message carried in a transmitted signal including diversity indicator signals, the receiver comprising:

10

a memory storing a selection criteria;

a receiver for receiving an indicator signal;

a selection comparator for comparing the selection

criteria to the indicator signal and

establishing one of a match/no-match condition;

15

and a reception controller for disabling the

reception of repeated indicator signals by the

receiver in response to the match/no-match

condition.



20

63. A voice paging transmitter for transmitting information to a receiver using a selective call message including an indicator signal indicative of at least one receiver and a message signal destined for the receiver, the transmitter comprising:

25

an alert signal generator for generating an alert

signal indicative of a subset of a complete set

of receivers;

an address signal generator for generating an
address signal corresponding to at least one
receiver in the subset;

a message signal generator for producing a message
5 signal;

a clock generator for generating timing signals; and
a transmitter synchronized in accordance with the
timing signals, the transmitter transmitting
the alert signal, the address signal, and the
10 message signal.

64. A selective paging receiver for receiving a message
from a transmitter, the message carried in a
transmitted signal including alert information and
address information, the receiver comprising:

15 a memory storing a selection criteria;

a receiver for receiving an alert signal;

a selection comparator for comparing the selection
criteria to the alert signal and establishing
the presence/absence of a message signal;

20 and a reception controller for disabling the
reception of repeated indicator signals by the
receiver when the message signal is absent.

