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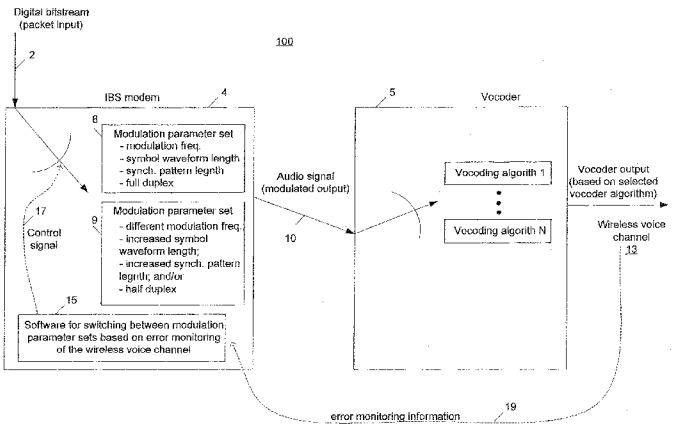

FIG. 3A

(57) **Abstract**: In one example, a modulation device (4) encodes a digital bitstream (2) using a particular set of modulation parameters (8) that is optimized for a subset of a plurality of vocoding modes without a priori knowledge of which one of the vocoding modes is currently operated by the vocoder (5). The modulation device (4) conducts transmissions over the wireless telecommunications network through the vocoder (5) using the particular set of modulation parameters (8), and monitors (19) these transmissions for errors. If the errors reach a threshold, then the vocoder (5) may be using one of the vocoding modes that are not included in the subset for which the particular set of modulation parameters (8) is optimized, and accordingly, the modulation device (4) switches from the particular set of modulation parameters (8) to a different set (9) of modulation parameters.

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ADAPTIVE DATA TRANSMISSION FOR A DIGITAL IN-BAND MODEM OPERATING OVER A VOICE CHANNEL

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[0003] Background of the Invention

[0001] Wireless telecommunication coverage has become nearly ubiquitous in much of the world, especially in industrialized countries. In some developing countries as well, whole regions that lack traditional copper-wired telecom infrastructure have skipped over that technology to deploy wireless instead. Modern wireless networks provide a range of voice and data services. Technical details of those services can be found in many places, for example, the 3GPP standards group web site www.3gpp.org.

[0002] Some wireless data services, however, are slow, and coverage is spotty. "SMS" (short message service) is one example. Wireless *voice* services, by contrast, tend to be of generally good quality and are available almost everywhere people travel. Therefore, voice services are a good choice where reliable, broad coverage is important, for example in the implementation of emergency services, such as requests for police, fire, medical or other emergency services. When people are traveling, especially in motor vehicles, effective wireless communication to reach emergency services is essential.

[0003] We refer to "in-band" communications as meaning in the voice channel, as distinguished from a data channel, control channel or other non-voice wireless service. Importantly, voice channels, although optimized for efficient transmission of actual human voice traffic, in fact can be used to transmit relatively small amounts of *data* as well (e.g., tens or hundreds of bits, rather than megabits.) Voice

channels are characterized by special performance characteristics. For example, only a relatively narrow range of audio frequencies needs to be transceived, based on the normal human voice. In fact, sophisticated compression and coding techniques are known to enable sending and receiving human voice very efficiently over digital wireless networks. However, these voice coders or "vocoders" –typically implemented in software, DSP chips and the like –do not transmit non-voice sounds well at all. To the contrary, they are carefully designed to filter out non-voice signals.

[0004] **FIG. 1** is a simplified block diagram illustrating the typical speech path for a wireless voice call; i.e., a telephone call over the wireless telecommunications network. Analog voice signals from a microphone are digitized by an A/D converter, and then fed to a vocoder encoding algorithm (at 8000 samples/sec). The encoder produces packets of compressed data (typically one packet per 20-ms frame of audio) and feeds this data stream to a radio transceiver. On the other side, a radio receiver passes the packets to the decoding algorithm, which then reconstructs (imperfectly) the original voice signal as a PCM stream. This PCM stream is eventually converted back into an analog voltage which is then applied to a speaker.

[0005] Using this type of system, modest amounts of data (here we mean user data, not vocoder speech data) can be transmitted "in-band" through careful selection of frequencies, timing, and the use of special techniques that "trick" a vocoder into transmitting information by making that information "look like" human voice data. This type of data communication, using the voice channel of a wireless system, is sometimes called "in-band signaling." It can be implemented in hardware and or software referred to as an "in-band signaling modem," borrowing the old *modem* term (modulator-demodulator) familiar in traditional "land line" telecommunications.

[0006] Several issued patents disclose in-band signaling technology that communicates digital data over a voice channel of a wireless telecommunications network. In one example, an input receives digital data. An encoder converts the digital data into audio tones that synthesize frequency characteristics of human speech. The digital data is also encoded to prevent voice encoding circuitry in the telecommunications network from corrupting the synthesized audio tones representing the digital data. An output then outputs

the synthesized audio tones to a voice channel of a digital wireless telecommunications network. In some cases, the data carrying "tones" are sent along with simultaneous voice. The tones can be made short and relatively unobtrusive. In other implementations, sometimes called "blank and burst," the voice is cut off while data is transmitted through the voice channel. In still other implementations, portions of the audio frequency spectrum are used for voice, while other portions are reserved for data. This aides in decoding at the receiving side.

[0007] Today, many vehicles have some capability for communications over a wireless network. We refer to these vehicle systems as a telematics client system. **FIG. 2** is a simplified block diagram of an illustrative In-Vehicle System (IVS). It shows an example of the relevant portion of a typical telematics client system. This client system consists of embedded hardware and software designed to operate in an automobile environment.

[0008] In FIG. 2, the telematics software includes a "customer application," which may be almost any application, in particular one that employs data transfer via the wireless network. For example, the customer application may relate to navigation or entertainment. In operation, the customer application conveys data (preferably data packets) to an in-band signaling modem. The in-band modem converts the data (along with packet headers and other overhead as appropriate) into audio tones. The audio "data tones" are encoded, much like voice content, and transmitted to a remote receiver.

[0009] As in any communication system, errors can occur in the process of in-band signaling. For example, the receiver will attempt to recover data packets from the transmitted data tones, but the recovery process could fail or the recovered packets could be incorrect representations of the original packets. Although there are schemes available to conduct a re-transmission from the transmit side in the event of an error, as well as schemes to correct errors on the receive side, what is needed is a scheme to reduce the number of errors to be resolved by the re-transmission and/or error correction schemes. The disclosure that follows solves this and other problems.

[0010] Summary of the Invention

[0011] The following is a summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not intended to identify key/critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

[0012] In one example, a mobile device encodes a digital bitstream using a particular set of modulation parameters to generate an audio signal that has different audio tones selected to pass through a vocoder of the mobile device. The particular set of modulation parameters is optimized for a subset of a plurality of vocoding modes without a priori knowledge of which one of the vocoding modes is currently operated by the vocoder. The mobile device conducts transmissions over the wireless telecommunications network through the vocoder using the particular set of modulation parameters, and monitors these transmissions for errors. If the errors reach a threshold, then the vocoder may be using one of the vocoding modes that are not included in the subset for which the particular set of modulation parameters is optimized, and accordingly, the modulation device switches from the particular set of modulation parameters to a different set of modulation parameters. Additional aspects and advantages of this invention will be apparent from the following detailed description of preferred embodiments, which proceeds with reference to the accompanying drawings.

[0013] Brief Description of the Drawings

[0014] FIG. 1 is a simplified block diagram illustrating the typical speech path for a wireless voice call.

[0015] FIG. 2 is a simplified block diagram of an illustrative In-Vehicle System (IVS) with an embedded mobile phone module.

[0016] FIG. 3A illustrates an In-Band Signaling (IBS) modem configured to switch between modulation parameter sets.

[0017] FIG. 3B illustrates a flow chart showing operation of the IBS modem of FIG. 1.

[0018] FIG. 4 illustrates a signaling diagram showing how the IBS modem shown in FIG. 1 can determine when to switch between modulation parameter sets.

[0019] FIG. 5A illustrates a signaling diagram showing how an IBS modem on the receiving side can determine when to switch between modulation parameter sets and signal the IBS modem of FIG. 1.

[0020] FIG. 5B is a flow chart illustrating error counting on the receiver side.

[0021] Detailed Description of Preferred Embodiments

[0022] FIG. 3A illustrates an In-Band Signaling (IBS) modem configured to switch between modulation parameter sets.

[0023] The system 100 includes an In-Band Signaling (IBS) modem 4 of a mobile device (also referred to as a "client") to communicate with a remote IBS modem such as an IBS modem of a server (not shown). The IBS modem 4 is configured to modulate packet data using a first set of modulation parameters 8. The software 15 of the IBS modem 4 monitors for errors associated with transmission to the remote IBS modem (not shown) over the wireless voice channel 13 and, according to said error monitoring, controls whether the system 100 (including the IBS modem 4) "falls back" to a second set of modulation parameters 9 during transmission.

[0024] By way of background, the vocoders such as vocoder 5 process voice data according to a vocoding algorithm, or vocoding codec, configured thereon. There are many known vocoding algorithms and the vocoders do not always reveal which particular vocoding algorithm they use. To further complicate matters, some vocoders such as the illustrated vocoder 5 are configured with a plurality of vocoding algorithms and will dynamically switch between which vocoding algorithm is currently utilized at any time for reasons that are outside the scope of this discussion (such dynamic switching may not necessarily be advertised by the vocoder either).

[0025] As explained previously, the modulation of packet data by an IBS modem into an audio signal 10 is to get the information of the packet data into a form that will not be filtered out by vocoders of the wireless voice channel. However, different vocoding algorithms process inputs in different ways, and in some cases so differently that a modulation scheme that can pass information sufficiently accurately

through one vocoding algorithm will not pass information sufficiently accurately through another vocoding algorithm.

[0026] In the system 100, the IBS modem 4 is configured with at least two sets of modulation parameters, e.g. 8 and 9, which each represent a modulation scheme. The modulation schemes can differ in one or more of the following parameters: modulation frequency, symbol waveform length, synchronization pattern length, or full/half duplex transmission. One of the modulation schemes 8 and 9 is optimized for use with a subset of known vocoding algorithms, meaning that this modulation scheme will typically be able to pass information through the vocoding algorithms of the subset at high performance, but not necessarily through other vocoding algorithms. Another one of the modulation schemes 8 and 9 is either optimized with a different subset of known vocoding algorithms, or not optimized with any particular vocoding algorithms (characterized by wide compatibility with vocoding algorithms at a lower performance).

[0027] The IBS modem 4 utilizes a particular one of the modulation schemes 8 and 9 in a "default mode" without analyzing which particular vocoding scheme is currently used by the vocoder 5. For example, in the example system 100 the high performance modulation scheme that is optimized for a subset of the vocoding algorithms 1-N is used initially for transmission. The use of this particular modulation scheme can be referred to as "a priori" because the IBS modem 4 does not have actual information as to which one of the vocoding algorithms 1-N (or for that matter which one of any known vocoding algorithms) the vocoder 5 is currently using.

[0028] The software 15 then continuously monitors transmission utilizing the particular one of the modulation schemes 8 and 9. In other words, actual error monitoring information 19 is fed back to the software 15. If the error monitoring information 19 indicates that a threshold amount of errors has been reached, the software 15 causes the IBS modem 4 to switch modulation schemes, which is represented logically in FIG. 3 by the control signal 17. In the particular example shown, the IBS modem 4 "falls back" to a modulation scheme that has one or more of the following parameters with respect to the default modulation scheme: different modulation frequency, greater symbol waveform length, greater

synchronization pattern length, and half duplex transmission instead of full duplex transmission. Changing modulation frequency can prevent data from being filtered out by the utilized vocoding algorithm. A modulation scheme with a greater symbol waveform length supplies more waveform information to the receiver for the purposes of identifying the transmitted symbol, and such symbols are typically more likely to be recovered correctly in a "bad channel" environment, e.g. a vocoder using a vocoding scheme that is hostile to packet data. In one example, in one modulation scheme the symbols are four times longer than in another modulation scheme. A modulation scheme with a greater synchronization pattern length uses longer synchronization patterns to signal the remote IBS modem of the start of a payload, which is less likely to result in false or missed detections on the receive side in a "bad channel" environment. Using half duplex can avoid cross-talk between the IBS modems.

[0029] One particular example of the modulation schemes 8 and 9 is as follows. A first one of the modulation schemes has a data symbol rate of 400 baud with modulation frequencies F1/F2 and F3/F4 for the transmitter and receiver, respectively. Since the transmitter and receiver sides use different frequencies, there is no (or minimal) interference between the waveforms despite the temporal overlap, and full-duplex operation is possible. A second fallback one of the modulation schemes has a data symbol rate of 100 baud with a symbol length four times that of the first modulation scheme. The modulation frequencies are F1/F2 for both the transmitter and the receiver, and half duplex transmission mode is used. Unlike the first modulation scheme, the second fallback modulation scheme does not use the F3/F4 modulation frequencies as the 4.8kbps EVRC-B vocoding algorithm suppresses these modulation frequencies.

[0030] If the IBS modem 4 does switch from a default modulation scheme to a fallback modulation scheme, the IBS modem 4 in turn signals the remote IBS modem to begin demodulating according to the fallback modulation scheme. As a result, errors resulting from the use of a modulation scheme that does not correspond to the currently utilized one of the vocoding algorithms can cease, reducing re-transmissions and processing associated with error correction. It should be understood that the more robust fallback modulation scheme can also addresses errors attributable to conditions of the wireless

voice channel medium, e.g. dropped calls and lost packets, and/or errors attributable to another network such as a circuit switched medium.

[0031] It should be understood that the software 15 can also be configured to switch back to the default modulation scheme after utilizing the fallback modulation scheme for some period of time. For example, the software 15 could automatically switch back if a threshold minimum of errors are observed over a preset period of time.

[0032] As explained previously, vocoders typically do not reveal which particular vocoding algorithm they use. However, there are some "hostile" vocoders, e.g. vocoders that aggressively filter out non-speech data, which have characteristics revealing their vocoding algorithm. One particular example is the 4.8 kbps EVRC-B vocoding algorithm used by some vocoders. Accordingly, the IBS modem 4 can be configured to, when paired with a vocoder using these particular vocoding schemes, initially modulate the digital bitstream using the fallback modulation scheme. For example, if the identified vocoding algorithm is not included in the subset of vocoding algorithms for which the high performance modulation scheme is optimized, a bad channel can be declared immediately, and as a result the IBS modem 4 modulates the initial portion of the digital bitstream 2 using the fallback modulation scheme.

[0033] The modulation scheme described above can utilize a frequency modulation scheme such as Frequency-Shift Keying (FSK) modulation. If a frequency modulation scheme is used, information can be encoded with a selected pair of frequencies, or encoded with a larger set of frequencies, i.e. sets of more than two frequencies. It should be apparent that the principles described above can be applied to other modulation schemes, such as those where information is encoded using other signal characteristics including but not limited to phase or amplitude of the carrier frequency.

[0034] FIG. 3B illustrates a flow chart showing operation of the IBS modem of FIG. 1.

[0035] In block 301, the IBS modem 4 attempts to identify a vocoding algorithm currently used by the vocoder. If a vocoding algorithm is identified in diamond 302, then in block 303A the IBS modem 4 selects between a first modulation scheme and a second fallback modulation scheme according to the identification. Otherwise, in block 303B the IBS modem 4 modulates an initial portion of a digital

bitstream using the first modulation scheme to generate an audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a wireless voice channel of the wireless telecommunication network unobstructed by the vocoder.

[0036] In block 304, the IBS modem 4 monitors transmissions over the wireless telecommunications network. Examples of such monitoring will be discussed later in greater detail with respect to FIGS. 4 and 5A-B. If errors are less than a preset threshold in diamond 305, then in block 306A the IBS modem 4 modulates a subsequent portion of the digital bitstream using the first modulation scheme. If errors reach the preset threshold in diamond 305, then in block 306B the IBS modem 4 modulates a subsequent portion of the digital bitstream using the second fallback modulation scheme. As discussed previously, as compared to the first modulation scheme, the second fallback modulation scheme has at least one of different modulation frequency, greater symbol waveform length, greater synchronization pattern length, and half duplex transmission instead of full duplex transmission.

[0037] If the entire bitstream is fed to the vocoder in block 307, then the process ends in block 308. Otherwise, the process returns to monitoring in block 304.

[0038] FIG. 4 illustrates a signaling diagram showing how the IBS modem shown in FIG. 1 can determine when to switch between modulation parameter sets.

[0039] In the system 200, a transmitting IBS modem determines when to switch between modulation schemes based on counting non-acknowledgements. Non-acknowledgements include negative acknowledgements as shown in this particular illustration and any other indication of a transmission error such as a failure to receive a positive acknowledgement within a preset amount of time.

[0040] For example, the transmitting IBS modem modulates a first packet using a first modulation scheme and transmits the modulated packet. For purposes of illustration, assume that the modulated packet is successfully recovered and an acknowledgement is received back at the transmitting IBS modem.

[0041] The transmitting IBS modem modulates a second packet using the first modulation scheme. For purposes of illustration, assume that the modulated packet is not successfully recovered. The receiving

IBS modem sends a negative acknowledgement, which as discussed previously is a type of non-acknowledgement. The transmitting IBS modem increments a counter for non-acknowledgements. The transmitting modem then re-transmits the second packet modulated using the first modulation scheme.

[0042] As subsequent non-acknowledgements are received (again either negative acknowledgements or any other indication of a transmission error) the counter continues to increment on the transmitting IBS. After the counter reaches a preset threshold of errors, a bad channel is declared and subsequent transmissions are made using the second fallback modulation scheme. For example, in this particular illustration the threshold is reached while still attempting to communicate the second packet, so the second packet is modulated according to the second fallback modulation scheme and then transmitted. It should be understood that hysteresis can be used in counting to avoid premature switchover to the second fallback modulation scheme.

[0043] As explained previously, the transmitting IBS modem also signals the receiving IBS modem to switch modulation schemes. It is preferable to send such signaling using the second fallback modulation scheme. Of course, this means that the receiving IBS modem is configured to demodulate signaling sent with the second fallback modulation scheme even when operating on packet data using the first modulation scheme. The transmitting IBS modem can wait to initiate modulation according to the second fallback modulation scheme until the receiving IBS modem positively indicates that the receiving IBS modem has begun operating in fallback modem.

[0044] It should be understood that, in the case of a download from the server to the mobile client, the server performs the functions of the transmitting IBS modem. Conversely, in the case of an upload from the mobile client to the server, the mobile client performs the functions of the transmitting IBS modem.

[0045] After some period of time, the transmitting IBS modem can initiate switchover back to the first modulation scheme. The switchover back to the first modulation scheme can occur automatically after the passage of a preset amount of time, or after the passage of the preset amount of time but only if less a particular amount of errors were detected in that time, etc. If the errors were resulting from temporarily problems with the wireless telecommunications network medium, it is possible that transmission using

the first modulation scheme can be relatively error free at that time. Also, if the errors were resulting from a temporary use of a particular vocoding algorithm by a vocoder along the call path, it is possible that transmission using the first modulation scheme can be relatively error free at that time.

[0046] FIG. 5A illustrates a signaling diagram showing how an IBS modem on the receiving side can determine when to switch between modulation parameter sets and signal the IBS modem of FIG. 1.

[0047] In the system 300, a receiving IBS modem determines when to switch between modulation schemes based on counting errors detected using Cyclic Redundancy Check (CRC) error detecting or some other form of error detection.

[0048] For example, the receiving IBS modem receives a first packet modulated according to a first modulation scheme. The receiving IBS modem then performs a CRC on the recovered data of the first packet. For purposes of illustration, it is assumed that no errors are identified during this CRC. The receiving IBS modem may send an acknowledgement that the first packet was successfully recovered.

[0049] The receiving IBS modem then performs a CRC on a second packet modulated according to the first modulation scheme. For purposes of illustration, it is assumed that this CRC identifies errors. The receiving IBS modem then updates a counter. The receiving IBS modem may send a negative acknowledgement.

[0050] As subsequent errors are discovered, the counter continues to increment on the transmitting IBS. After the counter reaches a preset threshold of errors, a bad channel is declared. It should be understood that hysteresis can be used in counting to avoid premature switchover to the second fallback modulation scheme.

[0051] The receiving IBS modem then sends a request to switch modulation schemes, causing the transmitting modem to re-transmit a packet using the second fallback modulation scheme (or begin sending not yet transmitted packets using the fallback modulation scheme). As before, the request itself is modulated according to the second fallback modulation scheme. Of course, this means that the transmitting IBS modem is configured to demodulate signaling sent with the second fallback modulation scheme even when operating on packet data using the first modulation scheme.

[0052] FIG. 5B is a flow chart illustrating error counting on the receiver side.

[0053] In the flowchart 400 the Forward Error Correction (FEC) parity bits are used to correct the packet data before the CRC calculation is performed. It should be apparent that any form of error correction can be performed before conducting the CRC or other error detection process. The error detection can be performed on the header, the payload (marked "data" in the figure), or both.

[0054] It should be understood that the packets are typically segmented for transmission. Accordingly, the counter may be incremented once for each erroneous segment (a segment is combination of a header and a payload that corresponds to a portion of a packet).

[0055] In one example, a processor readable medium is encoded with specialized instructions that, if executed, result particular operations. One operation includes processing a received digital bitstream using a particular modulation parameter set to generate an audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a wireless voice channel of a wireless telecommunication network unobstructed by a vocoder, and wherein the particular modulation parameter set is optimized for a subset of a plurality of vocoding modes without a priori knowledge of which one of the plurality of vocoding modes is currently operated by the vocoder for vocoding the audio signal. Another operation includes monitoring transmissions over the wireless telecommunications network to identify when an amount of errors associated with transmission over the wireless voice channel reaches a preset threshold. Another operation includes switching from the particular modulation parameter set to a different modulation parameter set if the monitoring indicates the error amount reaching the preset threshold. In some cases, at least some of the errors result from the vocoder operating a vocoding mode that is not included in the subset to which the particular modulation parameter set is optimized in association with the erroneous transmission.

[0056] The different modulation parameter set can be designed for wider compatibability than the particular modulation parameter set, and wherein the different modulation parameter set is non-optimized with said subset of vocoding modes and/or optimized with a different subset of vocoding modes.

[0057] Another operation can include, if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type.

[0058] Another operation can include, if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first frequency pair to encoding using a second lower frequency pair, wherein the first higher frequency pair is used with the erroneous transmissions.

[0059] Another operation can include, if the monitoring indicates the error amount reaching the preset threshold, encoding into the audio signal a first pattern, wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second pattern encoded into the audio signal before the erroneous transmission is identified.

[0060] Another operation can include, if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type, transitioning from encoding using a first frequency set to encoding using a second different frequency set, and encoding into the audio signal a first pattern, wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second pattern encoded into the audio signal before the erroneous transmission is identified.

[0061] Another operation can include, if the monitoring indicates the error amount reaching the preset threshold, switching from a full-duplex transmission mode to a half-duplex transmission mode.

[0062] Another operation can include counting a number of non-acknowledgements, wherein the switching is based on said counting.

[0063] Another operation can include processing signaling generated by a receiving endpoint, wherein the switching is based on said signaling.

[0064] In another example, a particular process is provided. One step in the process includes processing a received digital bitstream using a particular modulation parameter set to generate a audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a

wireless voice channel of a wireless telecommunication network unobstructed by a vocoder, wherein the particular modulation parameter set is optimized for a subset of a plurality of vocoding modes without a priori knowledge of which one of the plurality of vocoding modes is currently operated by the vocoder for vocoding the audio signal. Another step in the process includes feeding back actual error information from a demodulation endpoint for the transmissions. Another step in the process includes switching from the particular modulation parameter set to a different modulation parameter set when the fed back error information indicates errors reaching a preset threshold. In some cases, the different modulation parameter set is non-optimized with said subset of vocoding modes and/or optimized with a different subset of vocoding modes.

[0065] Another step in the process includes transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type when the fed back error information indicates errors reaching the preset threshold.

[0066] Another step in the process includes transitioning from encoding using a first frequency set to encoding using a second lower frequency set when the fed back error information indicates errors reaching a preset threshold, wherein the first higher frequency set is used with the erroneous transmissions.

[0067] Another step in the process includes encoding into the audio signal a first pattern , wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second pattern encoded into the audio signal before the preset threshold is reached.

[0068] In another example, a processor readable medium is encoded with specialized instructions that, if executed, result particular operations. One operation includes determining whether a vocoder is currently operating a particular one or ones of a plurality of vocoding modes. Another operation includes processing a received digital bitstream using a particular modulation parameter set to generate a audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a wireless voice channel of a wireless telecommunication network unobstructed by the vocoder; wherein if the determination indicates that the vocoder is currently operating the particular one or ones of

a plurality of vocoding modes, the particular modulation parameter set has a first set of parameters, and wherein otherwise the particular modulation parameter set has a second different set of parameters. Another operation includes monitoring transmissions over the wireless telecommunications network to identify when an amount of errors associated with transmission over the wireless voice channel reaches a preset threshold. Another operation includes, if the monitoring indicates the error amount reaching the preset threshold, adapting processing of the received digital bit stream.

[0069] Another operation includes, if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type.

[0070] Another operation includes, if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first frequency set to encoding using a second lower frequency set.

[0071] Another operation includes, if the monitoring indicates the error amount reaching the preset threshold, encoding into the audio signal a first pattern, wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second bit length encoded into the audio signal before the erroneous transmission is identified.

[0072] Another operation includes counting a number of non-acknowledgements or processing signaling generated by a receiving endpoint, wherein the adapting is based on said counting or said signaling

[0073] It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

[0074] Most of the equipment discussed above comprises hardware and associated software. For example, the typical navigation device is likely to include one or more processors and software executable on those processors to carry out the operations described. We use the term *software* herein in its commonly understood sense to refer to programs or routines (subroutines, objects, plug-ins, etc.), as well as data, usable by a machine or processor. As is well known, computer programs generally comprise

instructions that are stored in machine-readable or computer-readable storage media. Some embodiments of the present invention may include executable programs or instructions that are stored in machine-readable or computer-readable storage media, such as a digital memory. We do not imply that a "computer" in the conventional sense is required in any particular embodiment. For example, various processors, embedded or otherwise, may be used in equipment such as the components described herein.

[0075] Memory for storing software again is well known. In some embodiments, memory associated with a given processor may be stored in the same physical device as the processor ("on-board" memory); for example, RAM or FLASH memory disposed within an integrated circuit microprocessor or the like. In other examples, the memory comprises an independent device, such as an external disk drive, storage array, or portable FLASH key fob. In such cases, the memory becomes "associated" with the digital processor when the two are operatively coupled together, or in communication with each other, for example by an I/O port, network connection, etc. such that the processor can read a file stored on the memory. Associated memory may be "read only" by design (ROM) or by virtue of permission settings, or not. Other examples include but are not limited to WORM, EPROM, EEPROM, FLASH, etc. Those technologies often are implemented in solid state semiconductor devices. Other memories may comprise moving parts, such as a conventional rotating disk drive. All such memories are "machine readable" or "computer-readable" and may be used to store executable instructions for implementing the functions described herein.

[0076] A "software product" refers to a memory device in which a series of executable instructions are stored in a machine-readable form so that a suitable machine or processor, with appropriate access to the software product, can execute the instructions to carry out a process implemented by the instructions. Software products are sometimes used to distribute software. Any type of machine-readable memory, including without limitation those summarized above, may be used to make a software product. That said, it is also known that software can be distributed via electronic transmission ("download"), in which case there typically will be a corresponding software product at the transmitting end of the transmission, or the receiving end, or both.

[0077] Having described and illustrated the principles of the invention in a preferred embodiment thereof, it should be apparent that the invention may be modified in arrangement and detail without departing from such principles. We claim all modifications and variations coming within the spirit and scope of the following claims.

Claims:

1. A processor readable medium encoded with instructions that, if executed, result in:

processing a received digital bitstream using a particular modulation parameter set to generate an audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a wireless voice channel of a wireless telecommunication network unobstructed by a vocoder, wherein the particular modulation parameter set is optimized for a subset of a plurality of vocoding modes without a priori knowledge of which one of the plurality of vocoding modes is currently operated by the vocoder for vocoding the audio signal;

monitoring transmissions over the wireless telecommunications network to identify when an amount of errors associated with transmission over the wireless voice channel reaches a preset threshold; and

if the monitoring indicates the error amount reaching the preset threshold, switching from the particular modulation parameter set to a different modulation parameter set.

2. The processor readable medium of claim 1, wherein the different modulation parameter set is designed for wider compatibability than the particular modulation parameter set, and wherein the different modulation parameter set is non-optimized with said subset of vocoding modes and/or optimized with a different subset of vocoding modes.

3. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type.

4. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first frequency pair to encoding using a second lower frequency pair;

wherein the first higher frequency pair is used with the erroneous transmissions.

5. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, encoding into the audio signal a first pattern, wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second pattern encoded into the audio signal before the erroneous transmission is identified.

6. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type, transitioning from encoding using a first frequency set to encoding using a second different frequency set, and encoding into the audio signal a first pattern, wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second pattern encoded into the audio signal before the erroneous transmission is identified.

7. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, switching from a full-duplex transmission mode to a half-duplex transmission mode.

8. The processor readable medium of claim 1, wherein at least some of the errors result from the vocoder operating a vocoding mode that is not included in the subset to which the particular modulation parameter set is optimized in association with the erroneous transmission.

9. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

counting a number of non-acknowledgements, wherein the switching is based on said counting.

10. The processor readable medium of claim 1, wherein the instructions, if executed, result in:

processing signaling generated by a receiving endpoint, wherein the switching is based on said signaling.

11. A method, comprising:

processing a received digital bitstream using a particular modulation parameter set to generate a audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a wireless voice channel of a wireless telecommunication network unobstructed by a vocoder, wherein the particular modulation parameter set is optimized for a subset of a plurality of vocoding modes without a priori knowledge of which one of the plurality of vocoding modes is currently operated by the vocoder for vocoding the audio signal;

feeding back actual error information from a demodulation endpoint for the transmissions; and

switching from the particular modulation parameter set to a different modulation parameter set when the fed back error information indicates errors reaching a preset threshold.

12. The method of claim 11, wherein the different modulation parameter set is non-optimized with said subset of vocoding modes and/or optimized with a different subset of vocoding modes.

13. The method of claim 11, further comprising:

transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type when the fed back error information indicates errors reaching the preset threshold.

14. The method of claim 11, further comprising:

transitioning from encoding using a first frequency set to encoding using a second lower frequency set when the fed back error information indicates errors reaching a preset threshold;

wherein the first higher frequency set is used with the erroneous transmissions.

15. The method of claim 11, further comprising:

encoding into the audio signal a first pattern , wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second pattern encoded into the audio signal before the preset threshold is reached.

16. A processor readable medium encoded with instructions that, if executed, result in:

determining whether a vocoder is currently operating a particular one or ones of a plurality of vocoding modes;

processing a received digital bitstream using a particular modulation parameter set to generate a audio signal that has different audio tones for different bit values, wherein the audio tones are selected to pass through a wireless voice channel of a wireless telecommunication network unobstructed by the vocoder;

wherein if the determination indicates that the vocoder is currently operating the particular one or ones of a plurality of vocoding modes, the particular modulation parameter set has a first set of parameters, and wherein otherwise the particular modulation parameter set has a second different set of parameters;

monitoring transmissions over the wireless telecommunications network to identify when an amount of errors associated with transmission over the wireless voice channel reaches a preset threshold;

if the monitoring indicates the error amount reaching the preset threshold, adapting processing of the received digital bit stream.

17. The processor readable medium of claim 16, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first symbol type to encoding using a second symbol type having a greater duration than the first symbol type.

18. The processor readable medium of claim 16, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, transitioning from encoding using a first frequency set to encoding using a second lower frequency set.

19. The processor readable medium of claim 16, wherein the instructions, if executed, result in:

if the monitoring indicates the error amount reaching the preset threshold, encoding into the audio signal a first pattern, wherein the first pattern supplies more waveform information for the receiver to use in identifying a symbol than a second bit length encoded into the audio signal before the erroneous transmission is identified.

20. The processor readable medium of claim 16, wherein the instructions, if executed, result in:

counting a number of non-acknowledgements or processing signaling generated by a receiving endpoint, wherein the adapting is based on said counting or said signaling.

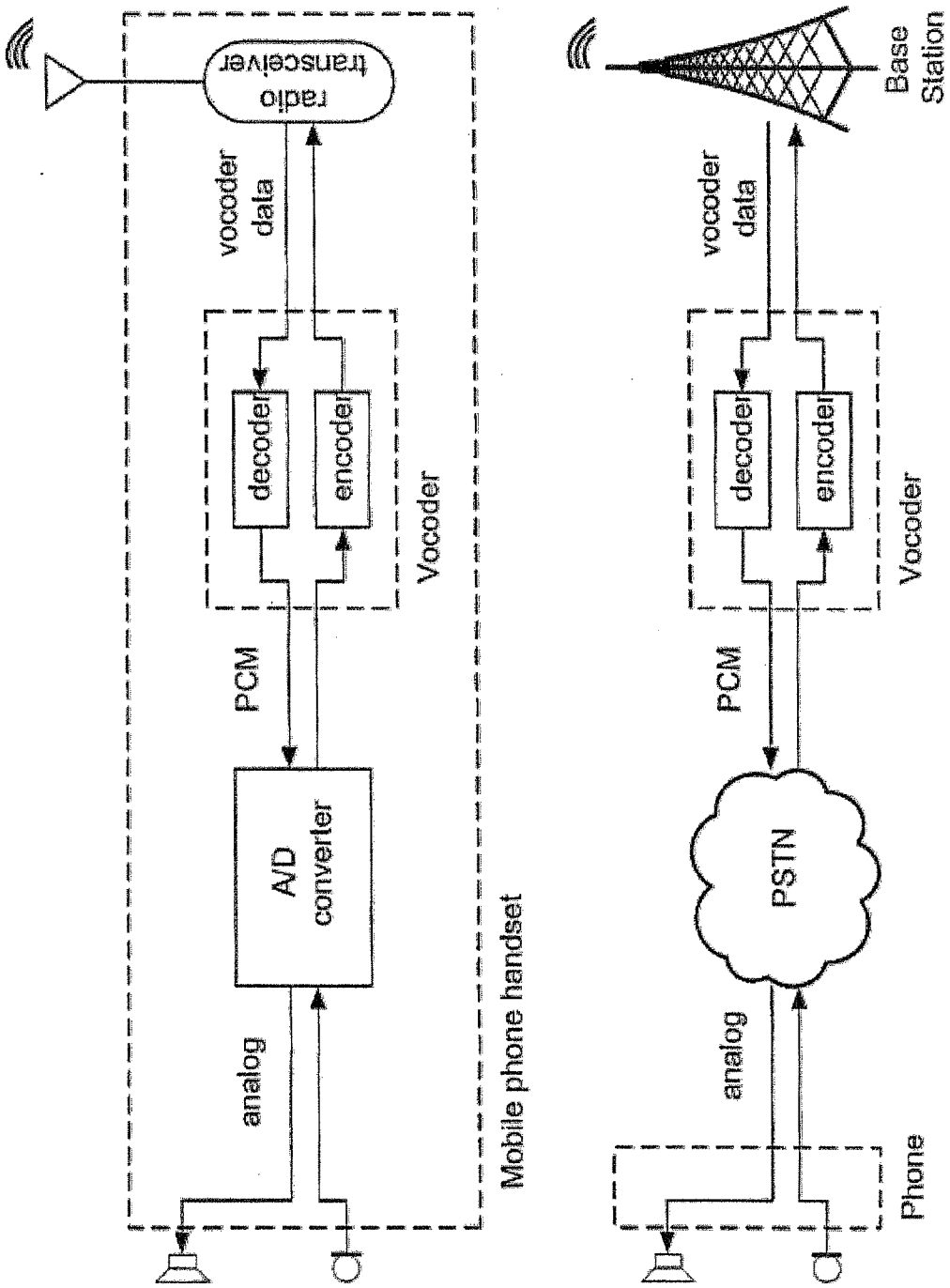


FIG. 1 (Background)

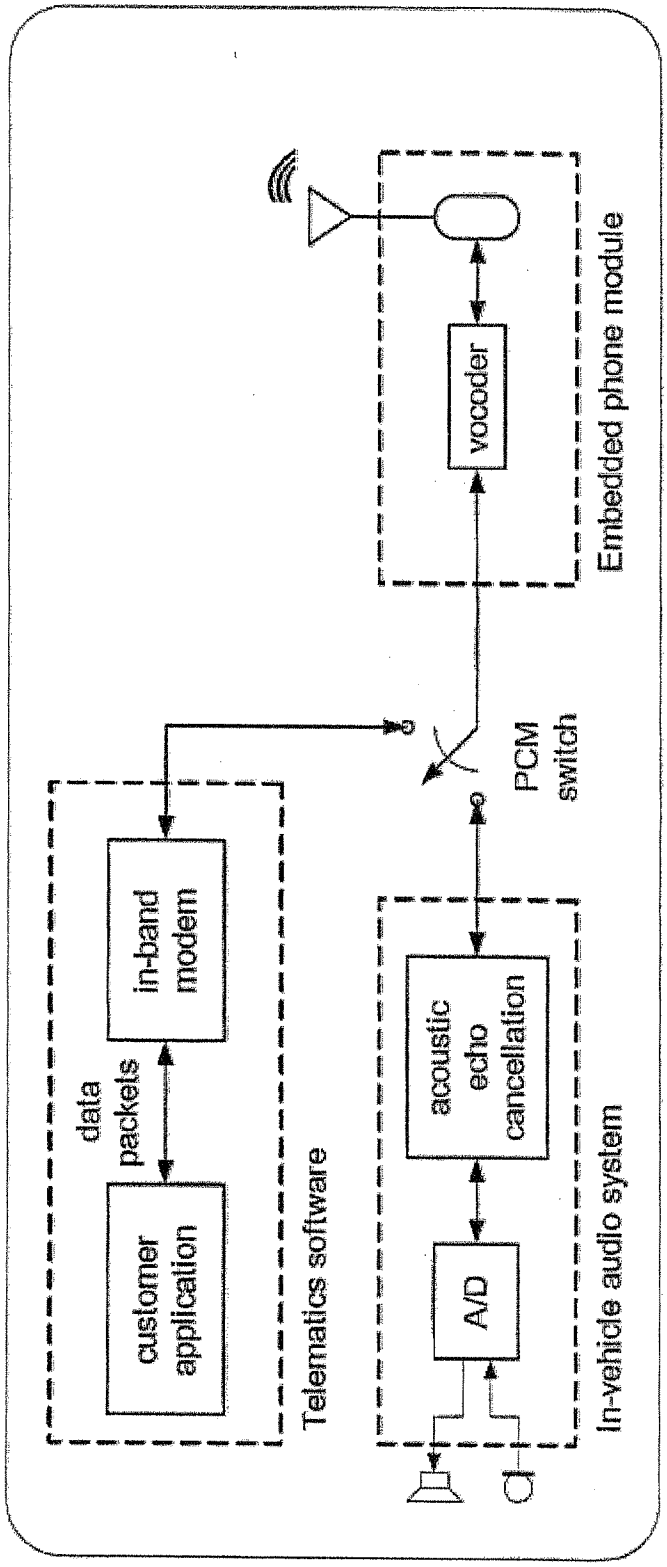


FIG. 2 (Background)

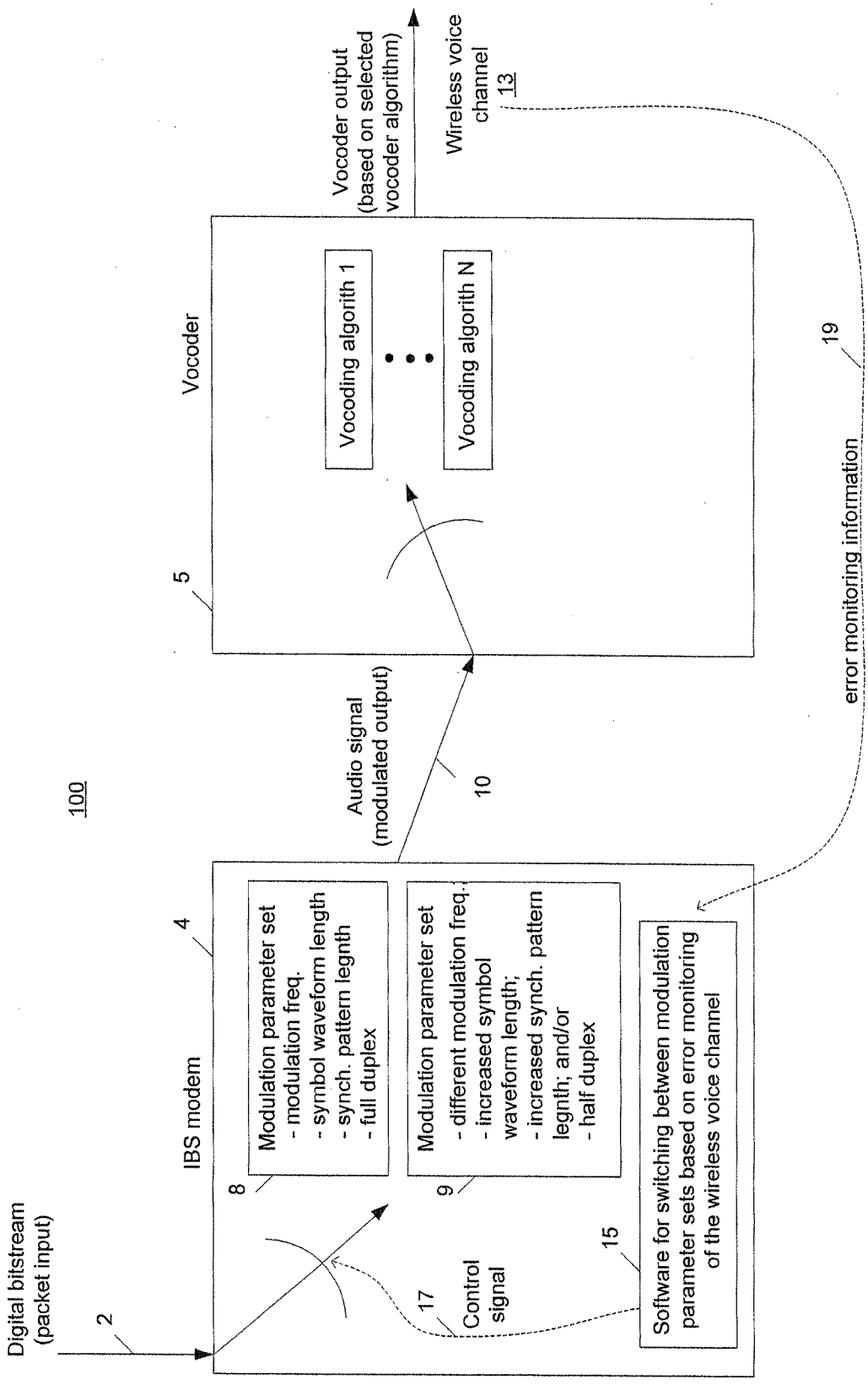

100
Digital bitstream (packet input)
2
IBS modem
4
Modulation parameter set
- modulation freq.
- symbol waveform length
- synch. pattern legnth
- full duplex
8
Modulation parameter set
- different modulation freq.;
- increased symbol waveform length;
- increased synch. pattern legnth; and/or
- half duplex
9
Control signal
17
Software for switching between modulation parameter sets based on error monitoring of the wireless voice channel
15
Audio signal (modulated output)
10
Vocoder
5
Vocoding algorith 1
Vocoding algorith N
Vocoder output (based on selected vocoder algorithm)
Wireless voice channel 13
error monitoring information
19

FIG. 3A

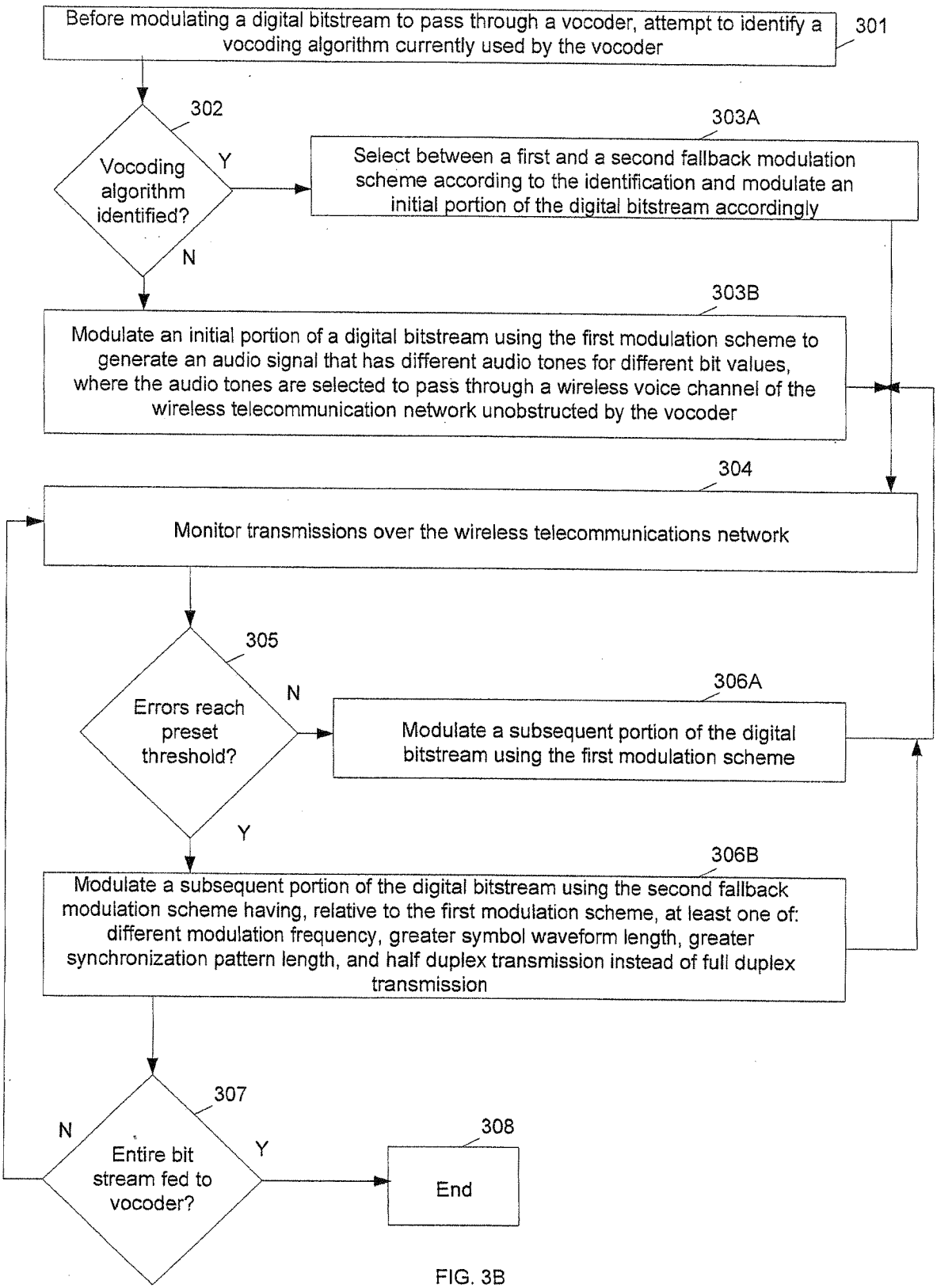

Before modulating a digital bitstream to pass through a vocoder, attempt to identify a vocoding algorithm currently used by the vocoder
301
302
Vocoding algorithm identified?
Y
N
303A
Select between a first and a second fallback modulation scheme according to the identification and modulate an initial portion of the digital bitstream accordingly
303B
Modulate an initial portion of a digital bitstream using the first modulation scheme to generate an audio signal that has different audio tones for different bit values, where the audio tones are selected to pass through a wireless voice channel of the wireless telecommunication network unobstructed by the vocoder
304
Monitor transmissions over the wireless telecommunications network
305
Errors reach preset threshold?
N
Y
306A
Modulate a subsequent portion of the digital bitstream using the first modulation scheme
306B
Modulate a subsequent portion of the digital bitstream using the second fallback modulation scheme having, relative to the first modulation scheme, at least one of: different modulation frequency, greater symbol waveform length, greater synchronization pattern length, and half duplex transmission instead of full duplex transmission
307
Entire bit stream fed to vocoder?
N
Y
308
End

FIG. 3B

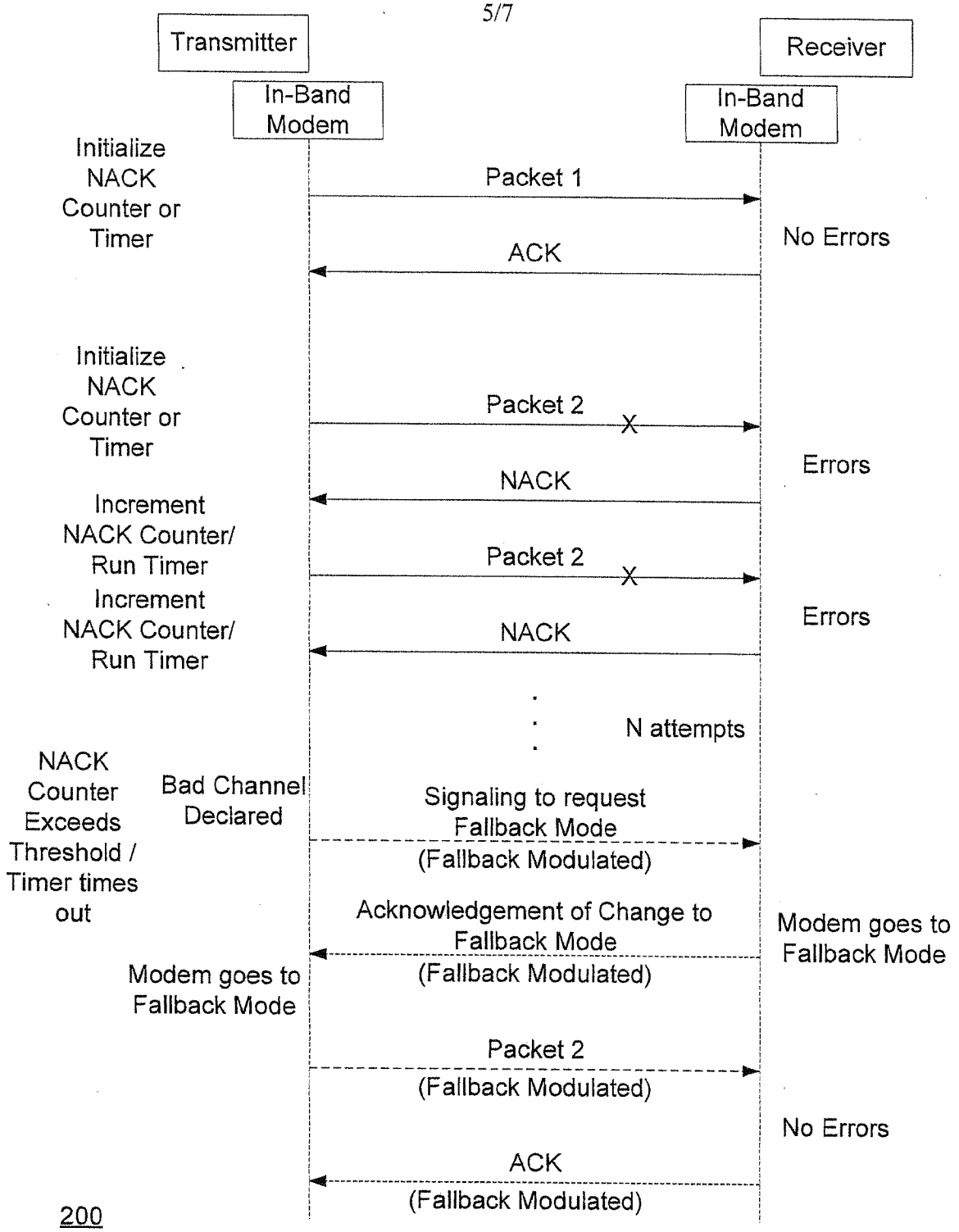
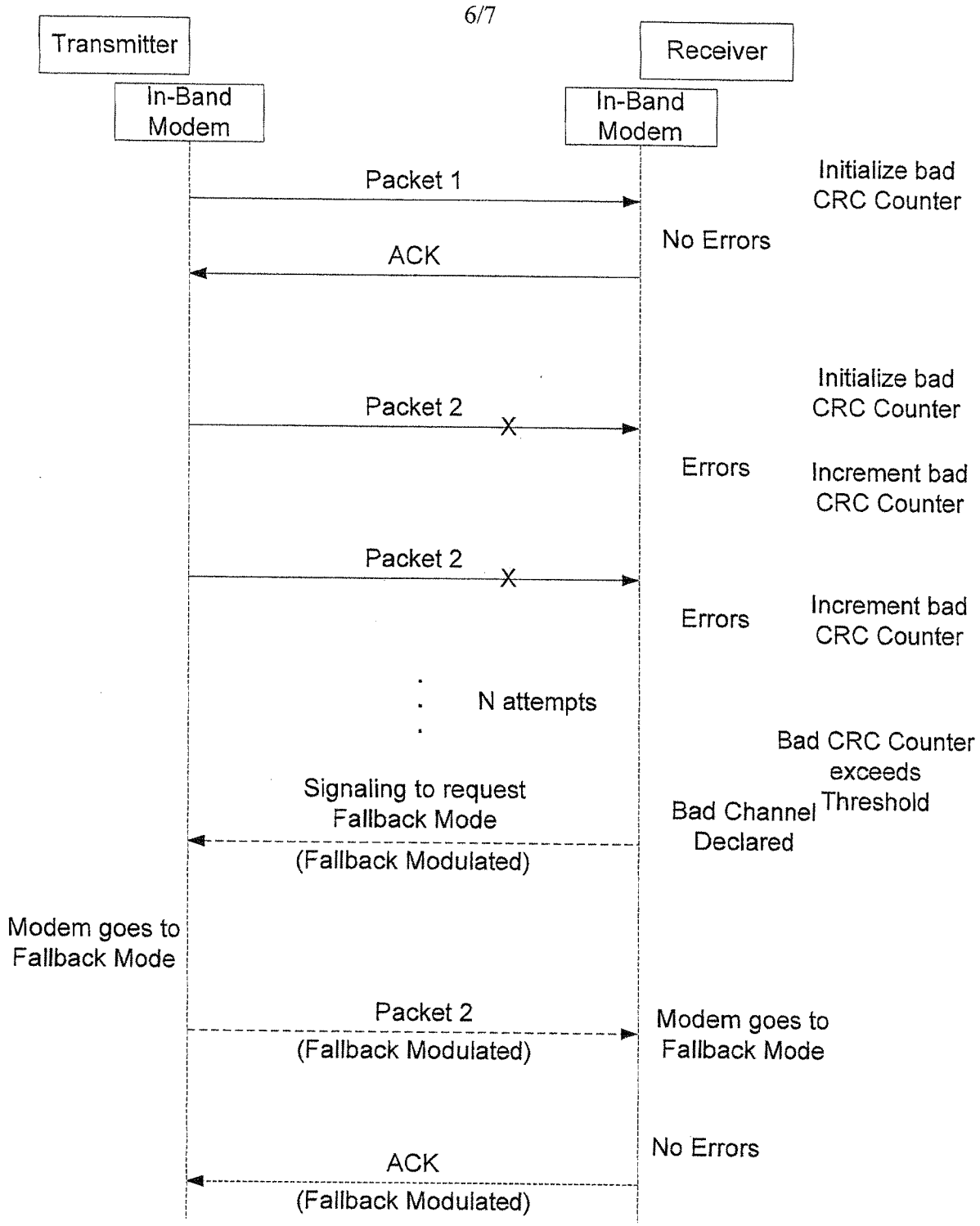

Transmitter
Receiver
In-Band Modem
In-Band Modem
Initialize NACK Counter or Timer
Packet 1
No Errors
ACK
Initialize NACK Counter or Timer
Packet 2
Errors
NACK
Increment NACK Counter/ Run Timer
Packet 2
Increment NACK Counter/ Run Timer
Errors
NACK
N attempts
NACK Counter Exceeds Threshold / Timer times out
Bad Channel Declared
Signaling to request Fallback Mode
(Fallback Modulated)
Acknowledgement of Change to Fallback Mode
(Fallback Modulated)
Modem goes to Fallback Mode
Modem goes to Fallback Mode
Packet 2
(Fallback Modulated)
No Errors
ACK
(Fallback Modulated)
200

FIG. 4


Transmitter
In-Band Modem
Receiver
In-Band Modem
Packet 1
Initialize bad CRC Counter
No Errors
ACK
Initialize bad CRC Counter
Packet 2
X
Errors
Increment bad CRC Counter
Packet 2
X
Errors
Increment bad CRC Counter
N attempts
Bad CRC Counter exceeds Threshold
Bad Channel Declared
Signaling to request Fallback Mode
(Fallback Modulated)
Modem goes to Fallback Mode
Packet 2
(Fallback Modulated)
Modem goes to Fallback Mode
No Errors
ACK
(Fallback Modulated)

300

FIG. 5A

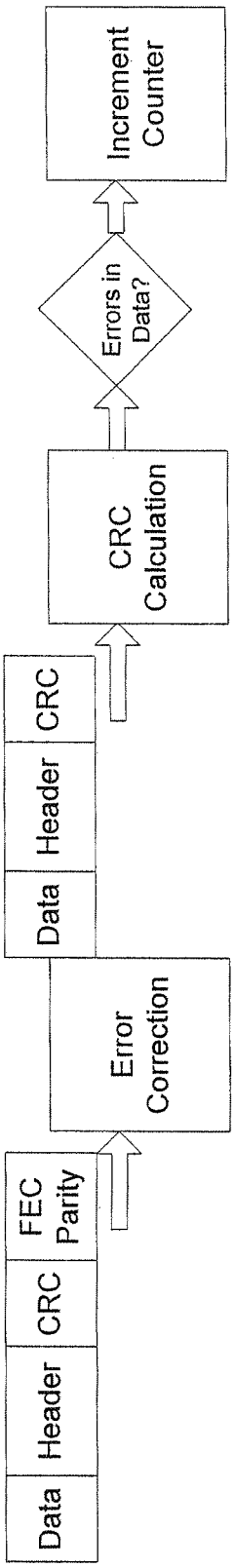

Data
Header
CRC
FEC Parity
Error Correction
Data
Header
CRC
CRC Calculation
Errors in Data?
Increment Counter

FIG. 5B

400

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/053006

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2009/149356 A2 (QUALCOMM INC [US]; WERNER MARC W [DE]; PIETSCH CHRISTIAN [DE]; SGRAJA) 10 December 2009 (2009-12-10) figures 3A,22 paragraphs [0006], [0007], [0086], [0092] - [0095], [0115] -----	1-3,5,6, 8-13, 15-17, 19,20
A	US 2005/207511 A1 (MADHAVAN SETHU K [US] ET AL) 22 September 2005 (2005-09-22) figure 5 paragraphs [0003], [0041], [0045], [0048] claims 9,11 -----	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 February 2011	14/02/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Borges, Pedro

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/053006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009149356 A2	10-12-2009	AU 2009256058 A1	10-12-2009
		CA 2726820 A1	10-12-2009
		US 2009304057 A1	10-12-2009
US 2005207511 A1	22-09-2005	NONE	