A method and a system for transfering AMR signaling frames on halfrate channels

Field of the invention

The present invention relates generally to the transmission of signaling information. More specifically, the present invention relates to the transference of signaling frames on GERAN (GSM/EDGE Radio Access Network) half rate channels utilizing a modulation scheme.

Background of the invention

Recent development in mobile communications technologies has been towards increased bandwidths and faster data rates. The GSM (Global System for Mobile Communications) has been one of the most successful communications technologies ever. However, as the relatively slow transmission speed of GSM has been a bottleneck for creating better services to the consumer market, a lot of effort has been put into developing new faster technologies for mobile communications. One such example is EDGE (Enhanced Data rates GSM Evolution). The standardization of EDGE was completed at the European Telecommunications Standards Institute in 1997.

For GSM/EDGE Radio Access Network (GERAN), there have been several new challenges to overcome. Higher data rates are achieved in part by changing channel coding. The transmission in a TDMA (Time Division Multiple Access) system takes place in time frames. Each frame can be shared among users by dividing the frame into time slots. A TDMA time frame thus comprises physical channels used to physically transfer information from one place to another. The contents of the physical channels form logical channels, which can be divided into traffic and control channels. The control channels can be further divided into dedicated and common channels. The dedicated channels are used for traffic and signaling between the network and the Mobile Stations (MS), whereas the common channels are used for broadcasting different information to the MS and for setting up signaling channels between the Mobile Switching Center / Visitor Location Register (MSC/VLR) and the MSs. Over the radio path, different types of signaling channels are used to facilitate the discussions between the MSs and the Base Transceiver Stations (BTSs), Base Station Controllers (BSCs), and the MSC/VLR. The logical channels are mapped onto physical channels as de-

scribed in the technical specification 3GPP TS 45.002 (GERAN Multiplexing and multiple access on the radio path).

In the GSM system, the modulation method used is a phase modulation known as Gaussian Minimum Shift Keying (GMSK). In GMSK, the phase of a true bit is shifted 90°, whereas the phase of a false bit is not shifted. With the increasing data rates of EDGE, new 8 Phase Shift Keying (8-PSK) with 8 possible shift values has been introduced (3GPP TS 45.004). Each of the shift values corresponds to a certain symbol consisting of 3 bits.

The two types of speech traffic channels used in the GSM are the Full Rate GMSK Traffic Channel (TCH/F) and the Half Rate GMSK Traffic Channel (TCH/H). For the TCH/F channels, the voice codecs normally used are the Full Rate (FR) and the Enhanced Full Rate (EFR) codecs. The EFR speech coder provides the best quality of voice. For the TCH/H channels a Half Rate (HR) coder is normally used, which consumes less bandwidth as compared to the FR codecs. The HR coder can therefore be used to serve a double number of subscribers on a half rate speech traffic channel as compared to an FR coder on a full-rate speech traffic channel.

In order to achieve a better voice quality, a new Adaptive Multi-Rate (AMR) coder has been introduced (Release 1998). Further, the introduction of AMR on TCH/H channels utilizing 8-PSK (O-TCH/H channels) has been considered. However, there has not been any channel coding for the AMR signaling frames defined for such traffic channels (O-TCH/H). The AMR signaling frames are listed in Table **1**.

Table 1. The different AMR signaling frames used on half rate channels.

AMR signaling frame	**Purpose**
SID_FIRST_P1	indicates end of speech, start of DTX (1st part)
SID_FIRST_P2	indicates end of speech, start of DTX (2nd part)
SID_FIRST_INH	inhibits the second part of a SID_FIRST_P1 if a speech onset occurs
ONSET	tells the codec the mode of the first speech frame after DTX
SID_UPDATE	conveys comfort noise parameters during DTX

SID_UPDATE_INH	inhibits the second part of a SID_UPDATE frame if a speech onset occurs
RATSCCH_MARKER	identifies RATSSCH frames
RATSCCH_DATA	conveys the actual RATSSCH message

It is not possible to use GMSK for the AMR signaling frames and 8-PSK for the traffic at the same time, because some of the signaling frames, such as for the ONSET signaling messages, share the same bursts as the speech.

As the same AMR signaling frames are needed for the new half rate channels using 8-PSK modulation (O-TCH/H), a new channel coding for these frames has to be introduced. A straightforward solution to this problem is now discussed with reference to FIG. **1**. The numbers under the data flow arrows in the figure denote the number of bits included in a bit block used in the system. The reader is kindly referred to the document 3GPP TS 45.003 V5.1.0 (GSM/EDGE Radio Access Network; Channel Coding) and to the references therein about the different messages referenced below.

A crucial part of the system is the Channel Coder **100** in FIG. **1A**. Usually a block to be transmitted includes Inband Data **101** consisting of two bits. These bits are coded in a coding block **102** using predefined code words, which must be 48 bits in length in order to correspond to the reserved block length. Occasionally, the bits to be transmitted further include Identification Marker Sequences **103** consisting of 9- or 11-bit sequence. Eleven bits are used for the RATSSCH_MARKER, for which a repetition of 58 times in the repetition block **104** is required to get the correct total block length of 636 bits. For the other AMR signaling frames a repetition of 71 times is required in the repetition block **104**. For the AMR signaling frames SID_UPDATE, which convey Comfort Noise parameters during a Discontinuous Transmission (DTX) period, and for the RATSCCH_DATA AMR signaling frame the Comfort Noise parameters **105** also need to be coded. A Cyclic Redundancy Check (CRC) is performed in the check block **106** to protect the Comfort Noise against transmission errors. This checksum (14 bits) is added to the Comfort Noise parameters (49 bits total), and the result is fed through a convolutional encoder block **107**, which increases the block length to 636 bits.

All signals coming from the Channel Coder **100** are multiplexed in a multiplexing block **108**. The total number of bits to be sent in a block is either 684 bits or 1368, depending on the AMR signaling frame. The AMR signaling frames are mapped in the mapping block **109** to 8-PSK symbols, which modifies the block size to 228 or 456 symbols. The symbols resulting from the signaling frames are then interleaved in the interleaving block **110** together with blocks from other frames, which may be speech frames, for example. After the interleaving a burst will be formatted in the burst formation block **111**. Then the burst is modulated in a modulation block **112** and directed to the transmission block **113**.

In FIG. **1B**, after receiving a signal in a receiving block **129**, the signal must be demodulated in the demodulation block **130**. The content of the original burst has to be recovered in the recovery block **131**. Because the burst consists of interleaved symbols, they must first be fed through the de-interleaving block **132** and then converted back to bits in the converting block **133**. Before the messages can be passed to the Channel Decoder **120**, the signaling must be de-multiplexed in the de-multiplexing block **134** so that the Inband Data part **136** is decoded in the codeword decoder block **135**, and the Identification Marker Sequence **138** in the Identification Marker decoder block **137.** If the AMR signaling frame includes Comfort Noise parameters, they are then decoded in the corresponding decoding block **139**, and the CRC bits are verified in the verification block **140**. Only after this are the Comfort Noise parameters **141** obtained.

The drawback of the solution described above is that both high rate convolutional codes and high rate block codes are required. The convolutional coder **107** encodes the 49 bits sequence into 636 bits, and the block coder **102** encodes the 2 bits into 48 bits. In the reverse direction, the convolutional decoder **139** decodes the 636 bits into the 49 bits, and the code word decoder **135** decodes the 48 bits into the 2 bits. These so-called fast-rate conversions are not desirable, as they increase the development cost and demand larger coding tables in the network elements and terminals. They are also computationally heavy and consume a lot of memory.

The rate of the convolutional encoder **107** for the Comfort Noise is 1/12, which is more demanding than the ¼ for the GMSK. The constraint length can also be increased from k=5 to k=7, as is done for speech, and the existing polynomials G4-G7 can be used. The interested reader may find

descriptions of the polynomials and the constraint lengths in the document 3GPP TS 45.003 V5.1.0 (GERAN Channel Coding). As explained above, the shorter 9 bit sequence of the identification marker has to be repeated 71 times.

The purpose of the present invention is to address the problem discussed above. This can be achieved using a method and system for processing AMR signaling frames as described in the independent claims.

Summary of the invention

In order to be able to utilize the existing channel coding developed for channels with different modulations and to avoid high rate convolutional and block codes, the channel coding has to be performed in a novel way for channels that use a modulation scheme carrying several bits in one symbol. The present invention provides such a novel mechanism, particularly for traffic channels utilizing the 8-PSK modulation method referred to above. Using a modulation scheme carrying several bits in one symbol, n bits can be represented with one symbol if there are 2^n possible modulation states.

The idea of the invention is that by using bit repetition the current channel encoders and interleavers defined for the use of corresponding GMSK channels can be utilized when transmitting AMR signaling frames on the GERAN half rate channels utilizing 8-PSK.

Thus, a coding procedure identical to the one already standardized for the GMSK channels can be used for the AMR signaling frames. In the method of the invention, in each block of m bits coded by means of said standardized coding process, each bit c(i) is first repeated 3 times {c'(3(i-1)+1), c'(3(i-1)+2), c'(3(i-1)+3)}. These 3 bits are then converted into one symbol C(i). After converting all m signaling bits, the resulting symbols C(1), ..., C(m) are interleaved. After interleaving, the symbols are modulated and then transmitted.

In the receiver, the signal has to be demodulated. The received symbols {C(1), C(2), C(3)} are then de-interleaved, after which the symbol C(i) is converted into 3 bits {c'(3(i-1)+1), c'(3(i-1)+2)), c'(3(i-1)+3)}. The 3-multiple bit sequence has to be converted back to the original bit c(i). The soft value of c(i) can be computed by combining the soft values of the 3-multiple bit sequence received.

Brief description of the drawings

FIG. **1A** and **1B** show a straightforward solution for transfering AMR signaling frames on a GERAN half rate channel,

FIG. **2A** and **2B** illustrate the method of the invention, and

FIG. **3A** and **3B** illustrate the system of the invention.

Detailed description of the invention

FIG. **2A** illustrates the transmission side of the system of the invention. Each bit c(i) transmitted from the existing channel encoder block **21,** which is defined for the corresponding GMSK channel, is repeated in a repetition block **22** n times to correspond to the number of bits carried by one symbol. The value of n depends on the keying algorithm used; for the 8-PSK n=3.The n bits {c'((i-1)n+1), ..., c'((i-1)n+n)} generated on the basis of c(i) are then converted to a symbol C(i) in a conversion block **23**. The symbols are then interleaved using an interleaver **24**, which is also already defined for the corresponding GMSK channel. It is important not to map one bit directly onto one symbol but to repeat them first, as, depending on the modulation, every time a bit is marked on a symbol there may be a rotation on the constellation. For example, the 8-PSK symbols are continuously rotated with $3\pi/8$ radians per symbol before pulse shaping.

The receiving side of the system, as seen from FIG. **2B**, is the reverse of the sending side. The received symbols C(i) have to be de-interleaved using a known de-interleaver **25** defined for the corresponding GMSK channel. After this, the n bit sequence {c'((i-1)n+1), ..., c'((i-1)n+n)} is obtained using the normal symbol to bit conversion in the conversion block **26.** The n bit sequence is combined in a combination block **27** to form a bit value corresponding to the original bit value c(i). Preferably, this is done by combining the soft values of the received n-multiple bit sequence. In this way the bit sequence is reduced to one bit, which is ready to be fed into the channel decoder **28**. The channel decoder **28** is substantially the same as the one defined for the corresponding GMSK channel.

In the following, the application of the invention on the AMR signaling frames of an 8-PSK modulated HR AMR Speech Traffic Channel (O-TCH/AHS) is described. On the transmission side (FIG. **3A**), the Inband Data

301 to be transmitted is encoded in the coder block **302** of the channel coder part **300**. The Identification Marker sequence **303** is repeated in the repeating block **304**. Also for the Comfort Noise **305**, if included in the signaling frame, a CRC is calculated in the calculation block **306** and then the resulting bit sequence is convolutionally encoded in the corresponding coding block **307**. Blocks **304**, **306**, and **307** are identical to the respective blocks already standardized for the corresponding GMSK channel (see 3GPP TS 45.003 GERAN Channel Coding).

Thanks to the solution according to the invention, the code words block **302** can be selected to correspond to the already existing TCH/AHS 16 bit code words, for example. Consequently, the tables in the Channel Coder **300** need not include longer high-rate codes, thus saving memory. Another benefit of the invention is that if already existing code words are selected, there are only minor changes required in the network elements and in the terminal equipment. The 9-bit sequence of the Identification Marker **303** need not be repeated 71 times but 24 times, and for the AMR signaling frame RATSCCH the 11-bit sequence of the Identification Marker **303** needs to be repeated only 20 times. After the repetition in the repetition block **304**, the Identification Marker block consists of 212 bits. The Comfort Noise parameters **305** can be convolutionally encoded in the coder block **307** with a shorter code, which results in 212 bits. This is computationally cheaper, and, also saves memory. As the convolutional encoder block **307** and the encoder block **302** are identical to the ones already standardized for the corresponding GMSK channels, the rate of the convolutional encoder will be ¼. The constraint length value k=5 and, similarly, the already existing polynomials G1, G2, and G3 can be used.

The multiplexing block **308** functions similarly to the solution described above. In the repetition part **309**, when the invention is applied to O-TCH/H, the available bandwidth for the AMR signaling frames is threefold (stretched from 228 bits to 684 bits, or from 456 bits to 1368 bits). Each bit is therefore repeated three times: a bit c(i) will be mapped to a bit triplet {c'(3(i-1)+1), c'(3(i-1)+2), c'(3(i-1)+3)}. The repeating ensures a correct block length for the AMR signaling frames. When all bits have been repeated, the bit triplets are mapped in a mapping block **310** to 8-PSK symbols C(i) according to Table 1 in 3GPP TS 45.004 (GERAN Modulation).

The symbols are then interleaved in the interleaving block **311** together with other symbols, and then a burst is formatted in the formation block **312**. The bursts are transmitted by the transmission block **314** after modulation in the modulation block **313**.

In the receiving part (FIG. **3B**) the received signal **320** is first demodulated in a demodulating block **321**. The content of the original burst is recovered in the recovery block **322** and de-interleaved in the de-interleaving block **323**. At this stage the signals are symbols C(i), which need to be converted back to bit triplets {c'(3(i-1)+1), c'(3(i-1)+2), c'(3(i-1)+3)}. The conversion is performed using the ordinary 8-PSK conversion table. The triplet has to be combined in the combining block **325** to correspond to one bit. The probable soft value of c(i) can be decided, for example, by combining the soft values of the received bit triplet, for instance c(i)=0.4*c'(3(i-1)+1)+0.4*c'(3(i-1)+2)+0.2*c'(3(i-1)+3).

The combined soft values c(i) of the bits are then de-multiplexed in the de-multiplexing block **326**, before the channel decoder **340** processes them. The Inband Data **328** is then decoded in the decoding block **327** using the code word table, whereas the Identification Marker sequence **330** is decoded in the Identification Marker decoding part **212.** If present, the Comfort Noise **333** is obtained after convolutionally decoding the bit sequence coming from the demultiplexer **326** in the decoding block **331** and CRC checking them in the checking block **332**. Again, the decoder **340** and de-interleaver block **323** are the same as those used for the TCH/AHS traffic channels.

Although the invention was described above with reference to the examples shown in the appended drawings, it is obvious that the invention is not limited to these, but may be modified by those skilled in the art without departing from the scope and spirit of the invention. For example, another suitable modulation scheme, such as 16-PSK, can be selected to implement the invention.

Claims

1. A system for processing an AMR signaling frame to be transmitted on a GERAN half rate channel utilizing a modulation scheme carrying n bits ($n \geq 2$) in one symbol, the system comprising:

- coding means (300), compatible with coding means defined for a GSM half rate channel utilizing a GMSK modulation scheme, said coding means being adapted to output a coded bit stream,

- repeating means (309), responsive to the coding means, for repeating each bit of the coded bit stream n times, whereby a repeated bit stream is obtained, and

- symbol-forming means (310), responsive to said repeating means, for forming symbols to be transmitted from said repeated bit stream.

2. A system for processing an AMR signaling frame received on a GERAN half rate channel utilizing a modulation scheme carrying n bits ($n \geq 2$) in one symbol, the system comprising:

- conversion means (324), for converting a received symbol stream to a first bit stream,

- processing means (325), for segmenting the first bit stream into successive blocks, each block consisting of n bits, and for converting each block into one bit, whereby a second bit stream is obtained, and

- decoding means (340), compatible with decoding means defined for a GSM half rate channel utilizing a GMSK modulation scheme, said decoding means being adapted to decode said second bit stream.

3. A method for processing an AMR signaling frame to be transmitted on a GERAN half rate channel utilizing a modulation scheme carrying n bits ($n \geq 2$) in one symbol, the method comprising the steps of:

- coding the AMR signaling frame using a coding procedure defined for a GSM half rate channel utilizing a GMSK modulation scheme, the coding procedure outputting a coded output stream,

- in response to said coding, repeating each bit of the coded output stream n times, whereby a repeated bit stream is obtained, and

- forming symbols to be transmitted from the repeated bit stream.

4. A method for processing an AMR signaling frame received on a GERAN half rate channel utilizing a modulation scheme carrying n bits ($n \geq 2$) in one symbol, the method comprising the steps of:

- converting a received symbol stream into a first bit stream,

- segmenting said first bit stream into successive blocks, each block consisting of n bits,

- converting each block into one bit, whereby a second bit stream is obtained, and

- decoding said second bit stream using a coding procedure defined for a GSM half rate channel utilizing a GMSK modulation scheme.

5. A system for transferring an AMR signaling frame on a GERAN half rate channel utilizing a modulation scheme carrying n bits ($n \geq 2$) in one symbol, the system comprising

- at a transmitting end:

-coding means (300), compatible with coding means defined for a GSM half rate channel utilizing a GMSK modulation scheme, said coding means being adapted to output a coded bit stream,

- repeating means (309), responsive to the coding means, for repeating each bit of the coded bit stream n times, whereby a repeated bit stream is obtained, and

- symbol forming means (310), responsive to said repeating means, for forming symbols to be transmitted from said repeated bit stream, and

- at a receiving end:

- conversion means (324), for converting a received symbol stream to a first bit stream,

- processing means (325), for segmenting the first bit stream into successive blocks, each block consisting of n bits, and for converting each block into one bit, whereby a second bit stream is obtained, and

- decoding means (340), compatible with decoding means defined for a GSM half rate channel utilizing the GMSK modulation scheme, said decoding means being adapted to decode said second bit stream.