A FAIR HEARING

IT'S NOT ONLY THE ARRIVAL—OR OTHERWISE—OF WCDMA THAT HAS BEEN PREOCCUPYING THE GSM OPERATOR COMMUNITY. MANY OPERATORS HAVE ALSO BEEN WAITING EXPECTANTLY FOR THE NEXT GENERATION OF SPEECH CODING FOR SOME TIME. NOW, WITH THE ADVENT OF FIRST PHASE (OR NARROWBAND) ADAPTIVE MULTI-RATE (AMR), IT LOOKS LIKE THE WAITING IS OVER. AMR HAS THE POTENTIAL TO OFFER BETTER AVERAGE SPEECH QUALITY AND CAPACITY BENEFITS WITH NO ADDED INVESTMENT IN SPECTRUM. BUT HOW WILL IT DO THIS? ARE THE BENEFITS REALLY WORTH THE INVESTMENT? AND WHAT COMES AFTER NARROWBAND?

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Code mode mode	Number of speech bits delivered per	Number of Class 1 bits per block	Number of Class 2 bits per block	Convolutional coding rate	Punctured bits	Effective coding rate
TCH/WF S23.85	477	-	-	-	-	-
TCH/WF S23.05	461	-	-	-	-	-
TCH/WF S19.85	397	-	-	-	-	-
TCH/WF S18.25	365	-	-	-	-	-
TCH/WF S15.85	317	-	-	-	-	-
TCH/WF S14.25	285	-	-	-	-	-
TCH/WF S12.65	253	253	0	1/2	78	1.69:1
TCH/WF S8.85	177	177	0	1/3	113	2.36:1
TCH/WF S6.60	132	132	0	1/4	128	3.03:1
Full rate speech	260	182	78	1/2	0	1.70:1
EER	244	176	68	1/2	0	1.72:1
TCH/AF S12.2	244	244	0	1/2	60	1.75:1
TCH/AF S4.75	95	95	0	1/5	87	4.08:1
AF/SID_UPDATE & AF/RATSCCH	35	35	0	1/4	0	4.00.1
Half rate speech	112	95	17	1/3	104	1.77:1
TCH/AHS7.95	159	123	36	1/2	78	128:1
TCH/AHS4.75	95	83	12	1/3	73	1.98:1
AH/SID_UPDATE & AH/RATSCCH	35	35	0	1/4	0	4.00:1

Table 1: the new codec rates, and how these are applied to the air interface

The GSM community has known about adaptive multi-rate speech (AMR) since early 2000, and most of the major GSM companies are close to having products available that will support the first phase known as narrowband AMR.

AMR was introduced to provide a way of addressing planning deficiencies within a network, and to make better use of scarce spectrum resources. This is achieved by introducing a new set of codecs, with bit rates ranging from 12.2kbps to 4.75kbps, and a way of rapidly switching between them, with the lowest rates giving the greatest level of protection against errors on the air interface.

Once network upgrades have been completed, and suitable mobiles are available—Q3/Q4 2002 in the US, later in the rest of the world—it won't be long before operators are singing AMR's praises. Although AMR will provide better average speech quality for the end user, the major benefits will be for the network operator as it is anticipated that AMR will finally allow operators to make use of half-rate. And as the number of AMR-capable mobiles within the network grows, the network capacity can be increased without further investment in hardware or spectrum.

Although AMR will improve speech quality, in geographic areas where existing speech quality is good, no improvement will be seen. The 12.2K codec is identical to that used for enhanced full rate (EFR); therefore this will not be like the move from full-rate to EFR, where it would be possible for some listeners to detect a significant difference. This will simply prevent the worst of the drop-offs, where coverage, multi-path or fading conditions would cause full rate or EFR to become unusable.

KEY ISSUE

In attempting to address the key issue of improved quality, wideband AMR takes over where narrowband AMR left off. Prior to wideband AMR, all codecs for GSM (full-rate, half-rate, EFR and narrowband AMR rates 12.2–4.75) are filtered so that only audio components of between 200Hz and 3.4KHz are coded. This compares well with land-based telephony systems, where filters are similarly applied. With wideband AMR, however, audio components of between 50Hz and 7KHz are coded. Clearly this will provide a significant audible difference in speech quality, and will be particularly useful in those parts of the world where the language depends upon the higher frequency components of the voice, or of particular vocal inflections.

In order to carry the additional information required to improve the quality, the raw bit rates of the codecs

Code mode	Number of Class 1a bits per block	% class 1a to total speech bits	Number of parity bits	% parity to class 1a bits	Likelihood of erroneous condition being detected as good
TCH/WF S12.65 & TCH/WF S8.85	64-72	28.4-36.1%	6	8.3-9.4%	1.6%
TCH/WF S6.60	54	40.9%	8	14.8%	0.4%
AF/SID_UPDATE & AF/RATSCCH	35	100%	14	40%	0.006%
Full rate speech	50	19.2%	3	6%	12.5%
EFR	50	20.5%	3(+8)*	6%	12.5%
TCH/AFS	39-81	31.8-47.6%	6	7.4-15.4%	1.6%
Half rate spech	22	19.6%	3	13.6%	12.5%
TCH/AHS	39-67	41.0-47..6%	6	9.0-15.4%	1.6%
AH/SID_UPDATE & AH/RATSCCH	35	100%	14	40%	0.006%

Table 2: the relative levels of importance of absolute error detection for various speech coding techniques

must increase accordingly. Nine new codecs have been introduced with bit rates of 23.85kbps going down to 6.60kbps.

Table 1 shows the new codec rates, and how these are applied to the air interface. Information about existing codecs is provided for comparison while the upper six rates have been included for reference only. Initially it was intended that the lowest seven of the nine rates would be used with GSMK, but because of concerns about the high degree of complexity, this has now been reduced to three. The higher rates will be used with 8PSK modulated bearers (as with EDGE), and ultimately with 3G systems.

CRUCIAL

One point that should be noted here is the well-matched effective coding rates. The highest rate will work in conditions where EFR is functional today, with the lower rates providing reasonable quality under fading conditions. It is anticipated that these two lowest rates will ultimately be crucial to the overall success of wideband AMR—they are also the fallbacks for what would otherwise be a momentary loss of speech.

Table 2, meanwhile, illustrates the relative levels of importance of absolute error detection for various speech coding techniques. The percentage of class 1a bits to total speech bits will normally give an indication of the level of optimisation of the codec in question. Where the total bit rate is lowest, the level of optimisation is high and this means that even the smallest errors in some bits will result in high levels of distortion. It is clear that wideband AMR compares quite favourably with narrowband AMR.

Although not exclusively aimed at AMR, one important introduction happening at the same time as wideband AMR is that of better power control. The network will monitor the level and quality of its received signal, and it may then command a change in

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power transmitted by the mobile in order to keep the receive level and quality optimal. Because of the low data rate of the signalling channel chosen to carry this power control information, the minimum duration between changes is 480ms.

For AMR, it is possible to change the codec rate every 40ms, although in real-world conditions this is likely to be closer to 200ms. Since the codec rate will be changed as a result of received signal quality changes, it is clear that it would be ideal if the power could be modified at a frequency closer to that which can be achieved by the codec.

To address this deficiency enhanced power control (EPC) has been introduced. Basically, this replaces the SACCH/T (Slow Associated Control Channel/Traffic Channel) with a SACCH/TP (Slow Associated Control Channel with embedded enhanced power control) and EPCCH (Enhanced Power Control Channel). The SACCH/TP still carries as much information as the SACCH/T, but in order to make way for the EPCCH, the parity for the frame has been reduced from 40 to 18bits. Each EPCCH piggybacks 40bits in the bursts carrying the SACCH/TP. As a result, the minimum duration between power control messages is reduced to 120ms, which will result in a better fit when the AMR codec rate changes frequency.

With this in mind, the operator stands to gain in a number of ways, the clear benefit being better quality speech, a feature that will be easy to sell to the general public. It will also offer a clear differentiator to early network adopters, and should encourage users to buy new handsets.

Since 3G networks will implement wideband AMR at, or soon after, launch, the deployment of wideband AMR in GSM infrastructure will be crucial in order to provide a level quality of speech between 3G and non-3G areas. In turn this will help disguise the holes in the 3G network, and keep the high-value 3G customers satisfied. In fact wideband AMR can be deployed in any network that offers reasonable performance for EFR today.

There are, however, drawbacks. Because of the higher bit rates of wideband AMR, it is not possible to convey the information with a half-rate bearer, which is limited to 228bits per frame. Although it is technically possible to use the two lowest codec rates (6.60 and 8.85) with half-rate, there would be little or no protection, and their use within a cell would therefore be limited. This is why half-rate wideband AMR has not been specified, and because of this lack of half-rate capability, some of the capacity gains of narrowband AMR will be lost.

As with narrowband AMR, it will become apparent that, because of the greater demands placed upon various parts of the infrastructure, some hardware upgrades will be required. Depending upon the age of some of the equipment in a given network this could prove to be a costly exercise.

CORE NETWORK CONSIDERATIONS

For narrowband AMR, core network considerations appear to have been an afterthought and, ultimately, this will cause delays in the effective implementation of AMR. However, for wideband AMR, the core network considerations are more significant.

Since wideband AMR offers significantly better quality than that of a landline, without changes to landline technology, wideband AMR will only represent improvements in mobile-to-mobile communications. Thus the viability of wideband AMR will rely upon the continued movement of voice-based communications from fixed to mobile networks, and the movement of non-mobile networks towards wideband implementations.

Although wideband AMR builds on the framework already established by narrowband AMR, wideband AMR introduces a whole new set of channel codings. Ultimately, these need to be verified for any given implementation and in addition the new codecs themselves will need to be tested, and although 3GPP does provide a set of test vectors and expected results, this is only applicable to the codec as a stand-alone item. No specific consideration is given to the codec as an integral part of the whole system.

Although the conformance test methods and requirements are not yet published, validation of numerous aspects will still be required. These will include Bit Error Ratio (BER) measurements, layer 3 signalling aspects and link adaptation.

The EPC function will also require significant validation. With the introduction of two new signalling channels (SACCH/TP and EPCCH), and the additional complexities of the two channels operating at different rates, and the layer one frame format being redesigned, validation is a necessity. In fact to further complicate the situation, the existing (slow) power control will operate concurrently with EPC, giving more potential for unanticipated erroneous implementation. ■

> **BECAUSE OF THE GREATER DEMANDS PLACED UPON VARIOUS PARTS OF THE INFRASTRUCTURE [BY AMR], SOME HARDWARE UPGRADES WILL BE REQUIRED. DEPENDING UPON THE AGE OF SOME OF THE EQUIPMENT IN A GIVEN NETWORK THIS COULD PROVE TO BE A COSTLY EXERCISE**