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Edge data rates and coverage constraints

There has been some active discussion recently amongst vendors, operators, industry pundits and the trade press regarding realisable data rates with EDGE. The discussion revolves around the additional link budget needed to support 8PSK, variously claimed to be between 4 and 7 dB depending on who you talk to.

This is one of those glass half full, half empty arguments. All adaptive air interfaces, EDGE, W-CDMA, and CDMA2000 are based on the assumption that data rates will be higher the closer you are to the cell site (the glass half full). Put another way, data rates reduce as you move away from the cell site (the glass half empty).

It has always been the case that moving from 2 level modulation to 4 level modulation needs an additional 3 dB of link budget to maintain the same bit error rate in the demodulator, moving from 4 level to 8 level needs another 3 dB and so on. Add in some implementation loss and it's no surprise that you end up with a link budget loss for EDGE of 6 to 7 dB. It could equally be argued that moving to 16 level QAM used in HDR needs another 3 dB over and above the 8PSK used in EDGE.

The principle is the same - higher level modulation schemes provide one way of using whatever link budget is available to maximise user data rates

The argument can be extended to bit error rates. To move from 1 in 10^3 to a 1 in 10^6 bit error rate assuming the same coding overheads and end to end delay needs another 3 dB of link budget **irrespective of the radio air interface being used**.

In practice, it is not the physical layer alone that makes the difference between EDGE and W?CDMA but the combination of the radio layer and the MAC layer.

First a reminder of the EDGE MAC layer

	Modulation and Coding Scheme								
	MCS 1	**MCS 2**	**MCS 3**	**MCS 4**	**MCS 5**	**MCS 6**	**MCS 7**	**MCS 8**	**MCS 9**
Modulation	GMSK	GMSK	GMSK	GMSK	8 PSK	8 PSK	8 PSK	8 PSK	8 PSK
Modulation rate	22.8	22.8	22.8	22.8	69.6	69.6	69.6	69.6	69.6
Code rate	0.53	0.66	0.8	1.0	0.37	0.49	0.76	0.92	1.0
Family	C	B	A	C	B	A	B	A	A

Timeslots	**User Data Rate**								
	MCS 1	**MCS 2**	**MCS 3**	**MCS 4**	**MCS 5**	**MCS 6**	**MCS 7**	**MCS 8**	**MCS 9**
1	8.8	11.2	14.8	17.6	22.4	29.6	44.8	54.4	59.2

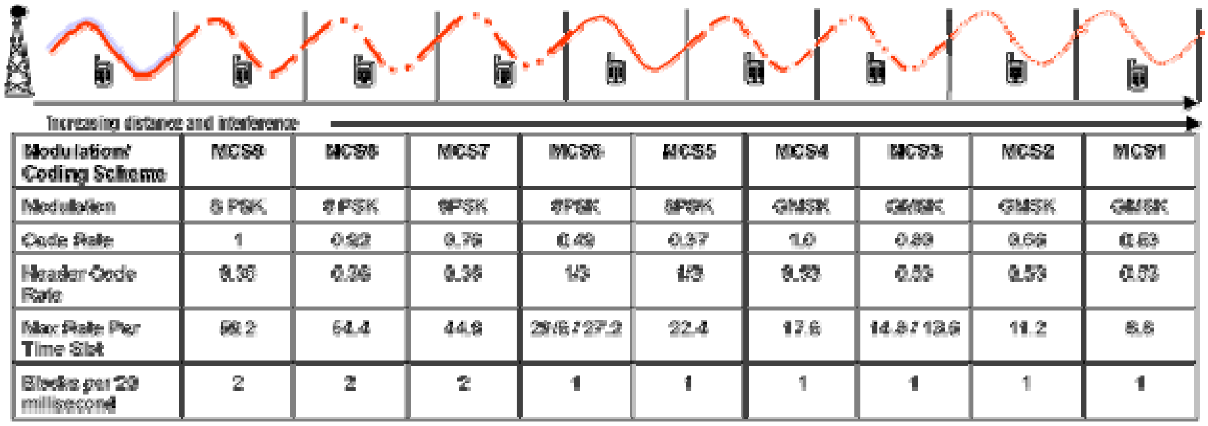
2	17.6	22.4	29.6	35.2	44.8	59.2	89.6	108.8	118.4
3	26.4	33.6	44.4	52.8	67.2	88.8	134.4	163.2	177.6
4	35.2	44.8	59.2	70.4	89.6	118.4	179.2	217.6	236.8
5	44	56	74	88	112	148	224	272	296
6	52.8	67.2	88.8	105.6	134.4	177.6	268.8	326.4	355.2
7	61.6	78.4	103.6	123.2	156.8	207.2	313.6	380.8	414.4
8	70.4	89.6	118.4	140.8	179.2	236.8	358.4	435.2	473.6

Table 1: Modulation and Coding Scheme For Edge

EDGE as you probably know potentially supports 29 handset multi-slot classes and nine modulation and coding schemes (summarised in Table 1).

The underlying principle of the EDGE MAC layer is that the coding scheme will change as the channel conditions change. Put another way, as the channel conditions deteriorate (the user moves away from the base station), the coding overhead increases and/or the user is moved from 8 PSK to GMSK modulation and the user data rate goes down.

Figure 1 illustrates this.



Modulation/ Coding Scheme	MCS9	MCS8	MCS7	MCS6	MCS5	MCS4	MCS3	MCS2	MCS1
Modulation	8 PSK	8 PSK	8PSK	8PSK	8PSK	GMSK	GMSK	GMSK	GMSK
Code Rate	1	0.92	0.76	0.49	0.37	1.0	0.80	0.66	0.53
Header Code Rate	0.36	0.36	0.36	1/3	1/3	0.53	0.53	0.53	0.53
Max Rate Per Time Slot	59.2	54.4	44.8	29.6 / 27.2	22.4	17.6	14.8 / 13.6	11.2	8.8
Blocks per 20 millisecond	2	2	2	1	1	1	1	1	1

Figure 1: Effect of distance on User Data Rate

In comparison, consider the W-CDMA MAC layer and physical layer.

Instead of a multiple slot structure and adaptive coding, W-CDMA uses the OVSF code tree to adapt to changing data rates (see Figure 2). Given that the OVSF code tree is a re-arrangement of the Walsh codes used in CDMA2000, the same principle applies to CDMA2000. Now it could be argued that this is what the multi-slot structure is supposed to do in EDGE and E-GPRS but in practice it is really difficult to realise a sufficiently flexible physical layer with an 8 slot frame. The OVSF code tree supports a 64:1 ratio between the fastest and slowest supportable data rates. EDGE, even assuming a Class 18 eight-slot handset only supports an 8:1 ratio. This is just not enough for real-time multimedia.

So difference number one between EDGE and W-CDMA is that W-CDMA is much more flexible in the way that it can support highly variable data rates which can potentially be changing at the 10 millisecond frame rate.

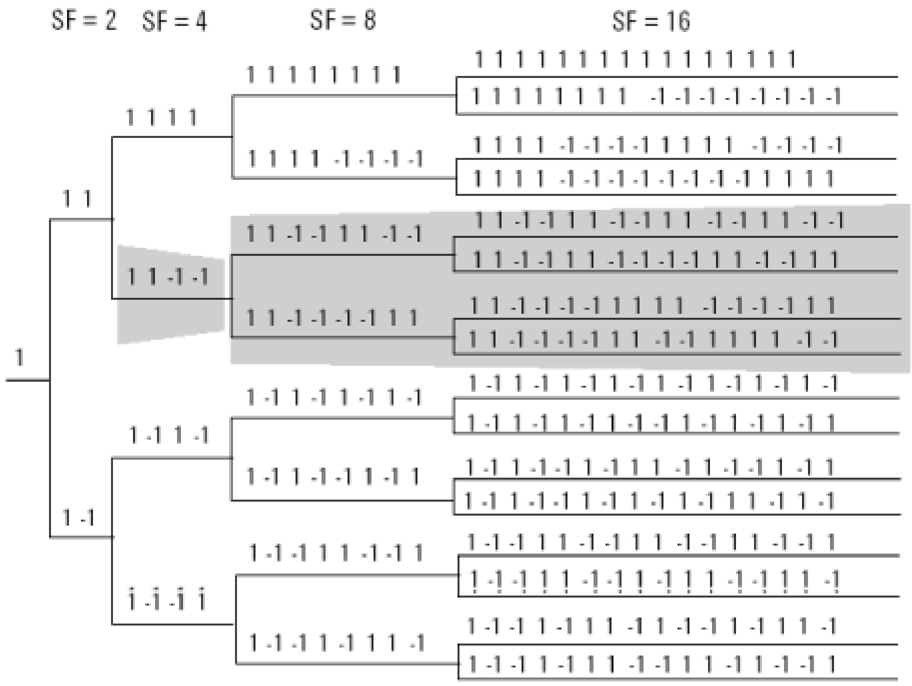


Figure 2: The OVSF Code Tree

Difference number two is the way in which W-CDMA adapts to changing channel conditions. For a start, the 5 MHz channel spacing helps average out some of the fast fading and makes it easier to follow the fast fading envelope with the inner power control loop. In addition, implementing the outer loop power control every 10 milliseconds makes it much easier to match the power needed to the instantaneous data rate (which may be changing on a frame by frame basis). Figure 3 highlights the difference between EDGE and W-CDMA in terms of measurement and power control.

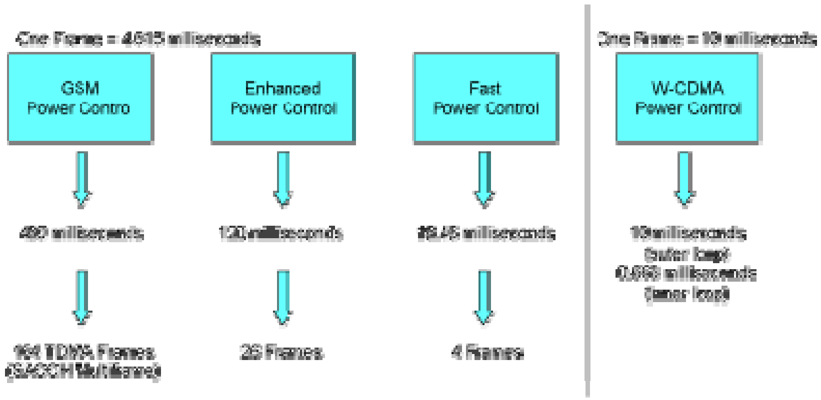


Figure 3: Power Control in GSM, EDGE and W-CDMA

In practice this means that with EDGE, changing channel conditions dictate user data rates. In W-CDMA, user data rates dictate the amount of bandwidth used. A high rate user at SF4 on the OVSF code tree is effectively occupying 25% of the 5 MHz channel, a low rate user at SF 256 is occupying one quarter of one percent of the 5

MHz channel. The net result should be that power gets distributed more efficiently.

Now this might mean that W-CDMA could be described as being more power efficient and possibly more spectrally efficient than EDGE. It might also be more cost efficient in the longer term but this misses the point. The tangible benefits that come from implementing W?CDMA are quality and consistency - a better, more consistent user experience based on variable data rates delivered over a constant quality channel.

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