Understanding EDGE Evolution and its Measurements

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This article summarizes new features—along with the changes in channel operation and coding functions to achieve that higher performance—in GSM-based Evolved EDGE (E-EDGE) wireless transmission

There is little wonder why GGE/EDGE networks will continue to form the basis for global mobile voice and data in the foreseeable future. One only needs to consider the lack of licensed spectrum and resources in some regions of the world. In such an environment, GGE/EDGE networks are highly desirable due to their relatively low retail price and wealth of viable services which are available around the globe in a roaming context. As a result, operators are today highly motivated to further enhance the performance of their existing GGE/EDGE networks.

Evolved EDGE (E-EDGE) is intended to further enhance GSM/EDGE network capabilities. Standardized in Release 7 of the GSM specification, E-EDGE introduces a bundle of features that boost system capacity, which allows the network to handle increased data volumes, while also providing an increase in mean and minimum data rates and a decrease in latency—all of which makes applications work better for everyone.

In general, the four optional features that comprise E-EDGE include:

- Latency reduction via two specified approaches: Fast Ack/Nack Reporting (FANR) and Reduced Transmission Time Interval Configuration (RTTI)
- Downlink Dual Carrier
- Higher Order Modulation (HOM) and Higher Symbol Rate (HSR)
- Mobile Station Receive Diversity.

These features do not affect the operation of legacy mobiles and do not need extra frequency planning. Additionally, they have no impact on either the core network or the base transceiver station (BTS) hardware, unless the HOM has to be configured with the HSR. These features do, however, result in new challenges to developers as well as vendors of design and test tools. To get a better understanding of these challenges and how to address them, let's take a closer look at the E-EDGE features.

Reduced Transmission Time Interval

In E-EDGE, the ability to reduce the transmission time interval (TTI) on Enhanced GPRS (EGPRS) connections is achieved by pairing two packet data traffic channel (PDTCH) physical channels on different timeslots for data transfer. Usually the pairing timeslots have all frequency characterization in common. In this RTTI configuration, a PDTCH block interleaved over 4 bursts is transmitted on both PDTCHs in the PDTCH-pair across 2 frames (Figure 1). Since the number of frames required for transmission is halved, the TTI is itself halved to approximately 10 ms.

RTTI configurations can be operated with either one of two uplink state flag (USF) modes: Basic TTI (BTTI) USF mode or RTTI USF mode. The BTTI USF mode for an RTTI channel configuration is shown in Figure 1. In this configuration, a given USF is interleaved over the 4 bursts associated with a packet data channel (PDCH), as is the case for BTTI channel configurations. The USF on the lowest PDCH of a PDCH pair allocates resource in the first reduced radio block period of the

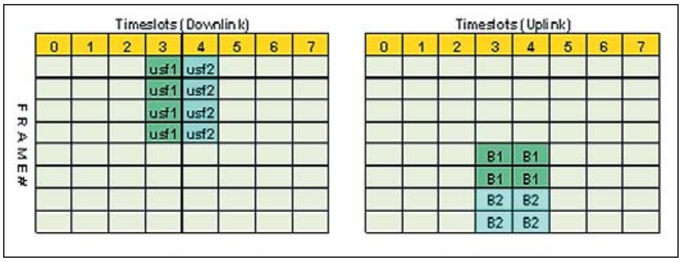

Figure 1 · BTTI USF mode.

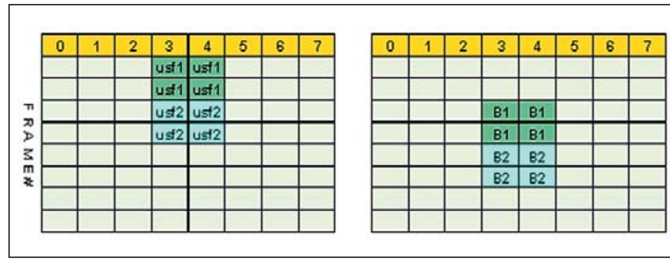

Figure 2 · RTTI USF mode.

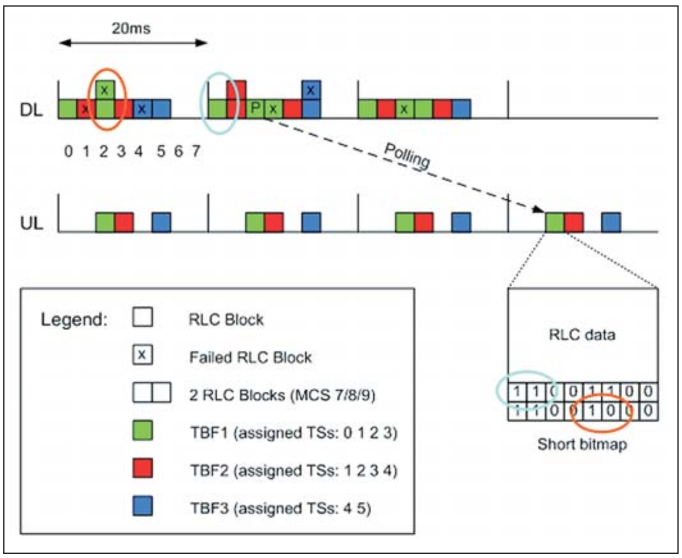

Figure 3 · Fast Ack/Nack Reporting operation example.

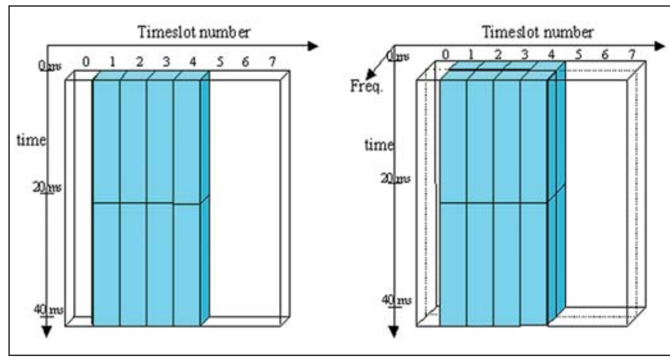

Figure 4 · Example of a downlink dual carrier operation.

Radio Block				
RLC/MAC Header	HCS	RLC Data	BCS	PAN & PCS (opt.)

Table 1 · Radio block structure.

next basic radio block period. The USF on the highest PDCH of a PDCH pair allocates resource for the second reduced radio block period of the next basic radio block period. This allows for a different USF to be allocated to the mobile for each basic radio block.

The RTTI USF mode for an RTTI channel configuration is shown in Figure 2. In this configuration a separate USF is associated (and interleaved) over each reduced radio block on the downlink (DL). The USF assigned in the first reduced radio block period on the DL assigns resource for the second reduced radio block period on the uplink (UL) in the same basic radio block period. The USF assigned during the second reduced radio block period on the DL assigns resource for the first reduced radio block period on the UL in the next reduced radio block period. With this configuration, each PDCH pair can have a different USF.

Fast Ack/Nack Reporting

The FANR is part of the reduced latency procedures in the 3GPP Release 7 specification. Given a radio block for data transfer in one direction, FANR allows for the possible inclusion of piggybacked Ack/Nack information relative to the data transfer (e.g., relative to the temporary block flow or TBF) in the other direction. This is achieved by inserting a fixed-size piggy-backed Ack/Nack (PAN) field in the radio link control (RLC) radio block. Therefore, a radio block for data transfer consists of one RLC/medium access control (MAC) header, one or two RLC data block(s) and, optionally, one PAN field. The radio block structure is shown in Table 1.

To better understand the concept of FANR, consider the example in Figure 3 of a DL TBF allocated on timeslots 0, 1, 2, and 3 (TBF1) and multiplexed with other TBFs (TBF2 and TBF3). In this case, the length of the short bitmap is assumed to be of only 2 octets.

Downlink Dual Carrier

The most obvious benefit of Downlink Dual Carrier (DLDC) is that it overcomes one limitation of the GSM radio interface, the 200-kHz carrier bandwidth. The peak data rate for DLDC is close to 1 Mbps.

DLDC means that the two carriers on independent carrier frequencies (or MAIOs, in the frequency hopping case), are received or transmitted by the same terminal. An example of this is shown in Figure 4. The left side of

Modulation Scheme	Modulation Type	RLC blocks/ Radio blocks	Data Rate per slot (kb/s)
MSC-1	GMSK	1	8.8
MSC-2	GMSK	1	11.2
MSC-3	GMSK	1	14.8/13.6
MSC-4	GMSK	1	17.6
MSC-6*	8PSK	1	29.6/27.2
MSC-7	8PSK	2	44.8
MSC-8	8PSK	2	54.4
DAS-5	8PSK	1	22.4
DAS-6	8PSK	1	27.2
DAS-7	8PSK	1	32.8
DAS-8	16-QAM	2	44.8
DAS-9	16-QAM	2	54.4
DAS-10	32-QAM	2	65.6
DAS-11	32-QAM	3	81.6
DAS-12	32-QAM	3	98.4

* Only for retransmissions of blocks originally transmitted using EGPRS

Table 2 · EGPRS2A downlink modulation coding schemes.

Modulation Scheme	Modulation Type	RLC blocks/ Radio blocks	Data Rate per slot (kb/s)
MSC-1	GMSK	1	8.8
MSC-2	GMSK	1	11.2
MSC-3	GMSK	1	14.8/13.6
MSC-4	GMSK	1	17.6
MSC-5	8PSK	1	22.4
MSC-6	8PSK	1	29.6/27.2
UAS-7	16-QAM	2	44.8
UAS-8	16-QAM	2	51.2
UAS-9	16-QAM	2	59.2
UAS-10	16-QAM	3	67.2
UAS-11	16-QAM	3	76.8

Table 3 · EGPRS2A uplink modulation coding schemes.

Modulation Scheme	Modulation Type	RLC blocks/ Radio blocks	Data Rate per slot (kb/s)
MSC-1	GMSK	1	8.8
MSC-2	GMSK	1	11.2
MSC-3	GMSK	1	14.8/13.6
MSC-4	GMSK	1	17.6
MSC-6*	8PSK	1	29.6/27.2
MSC-7	8PSK	2	44.8
MSC-8	8PSK	2	54.4
MCS-9	8PSK	2	59.2
DAS-5	8PSK	1	22.4
DAS-6	8PSK	1	27.2
DAS-8	16-QAM	2	44.8
DAS-9	16-QAM	2	54.4
DAS-11	32-QAM	3	81.6
DBS-5	QPSK	1	22.4
DBS-6	QPSK	1	29.6
DBS-7	16-QAM	2	44.8
DBS-8	16-QAM	2	59.2
DBS-9	16-QAM	3	67.2
DBS-10	32-QAM	3	88.8
DBS-11	32-QAM	4	108.8
DBS-12	32-QAM	4	118.4

Table 4 · EGPRS2B downlink modulation coding schemes.

Modulation Scheme	Modulation Type	RLC blocks/ Radio blocks	Data Rate per slot (kb/s)
MSC-1	GMSK	1	8.8
MSC-2	GMSK	1	11.2
MSC-3	GMSK	1	14.8/13.6
MSC-4	GMSK	1	17.6
UBS-5	QPSK	1	22.4
UBS-6	QPSK	1	29.6
UBS-7	16-QAM	2	44.8
UBS-8	16-QAM	2	59.2
UBS-9	16-QAM	3	67.2
UBS-10	32-QAM	3	88.8
UBS-11	32-QAM	4	108.8
UBS-12	32-QAM	4	118.4

Table 5 · EGPRS2B uplink modulation coding schemes.

the figure depicts the radio blocks in a 4-slot single carrier allocation, while the right side of the figure depicts the radio blocks in a 2 × 4-slot dual carrier allocation. The two frequencies (MAIOs, in case of frequency hopping) are typically not adjacent.

Higher Order Modulation and Higher Symbol Rate

3GPP Release 7 introduces two terms, EGPRS2A and EGPRS2B, to represent the HOM and HSR, respectively. Because the implementation of EGPRS2B may require BTS hardware upgrades, it is generally less popular than EGPRS2A in the initial development stage. Unlike EGPRS2B, EGPRS2A requires no hardware upgrade. Information regarding the EGPRS2A and EGPRS2B UL and DL are as follows:

- EGPRS2A Downlink—The EGPRS2A DL introduces eight new modulation coding schemes (DAS-5 to DAS-12), all of which involve the use of turbo coding. These schemes are listed in Table 2.
- EGPRS2A Uplink—The EGPRS2A UL introduces five new modulation coding schemes (UAS-7 to UAS-11), all of which involve the use of turbo coding. These schemes are listed in Table 3.

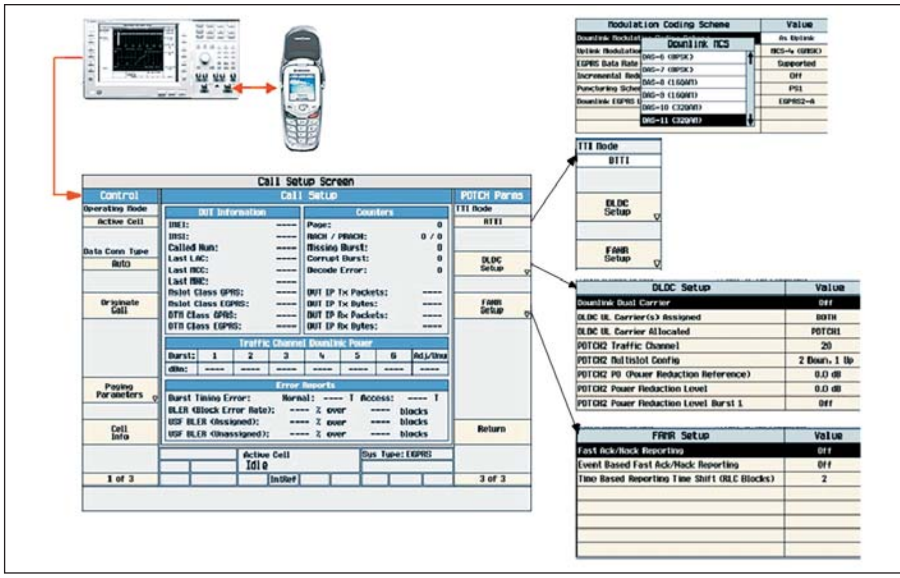

Figure 5 · A design and test tool like Agilent's Evolved EDGE solution in its 8960 wireless communication test set is able to address the new features in E-EDGE.

- EGPRS2B Downlink—The EGPRS2B DL introduces eight new modulation coding schemes (DBS-5 to DBS-12), all of which involve the use of turbo coding and a HSR clock of 325 ksymbol/s. These schemes are listed in Table 4.
- EGPRS2B Uplink—EGPRS2B UL introduces eight new modulation coding schemes (UBS-5 to UBS-12), all of which involve the use of turbo coding and a HSR clock of 325 ksymbol/s. These schemes are listed in Table 5.

Mobile Station Receive Diversity

For a mobile station, the receive diversity capability increases sensitivity and robustness in areas of high interference and dense deployment. As a downlink feature, it improves the receiver performance of the mobile station by means of an additional antenna. In fact, the introduction of Single Antenna Interference Cancellation (SAIC) characterized by the Downlink Advanced Receiver Performance (DARP) requirements has already shown that receiver enhancements in the mobile station can provide significant gains in terms of spectral efficiency. Mobile station receive diversity also offers the possibility of enhanced channel diversity and the potential for improved interference cancellation performance for Gaussian minimum shift keying (GMSK) modulated signals. Moreover, it enables significant gains over SAIC for 8PSK-modulated signals.

Mobile station receive diversity has even been noted to have significant impact on the required mobile station hardware. Increased hardware complexity may also impact mobile terminal power consumption and size.

Implications for Design and Test Tools

While these new E-EDGE features offer significant benefits, they also create unique challenges which must be met with design and test tools. These tools must have the ability to test RTTI, FANR, DLDC, and HOM functionalities—either in active cell operation mode or test mode (see Figure 5). More specifically, they must:

- provide the ability for the developer to choose the TTI mode (BTTI or RTTI) and the USF mode when the RTTI mode is selected,
- offer FANR settings (e.g., enable/disable the FANR state, the event-based FANR state, PAN encoding type, pan payload generator, time-based FANR timing shift, and CES/P field) to allow flexibility in configuring the FANR test,
- allow the customer to enable/disable the DLDC state, configure the traffic channel, frequency hopping state, MAIO, power reduction, modulation, and coding schemes, and support multislot configuration of the Carrier 2; and
- support EGPRS2A UL and DL modulation and coding schemes.

Conclusion

E-EDGE brings new challenges to developers, as well as to the vendors of design and test tools. Luckily, new measurement capabilities are now available (e.g., validation on the protocol side and RF measurements) to address these challenges. Such capabilities in today's design and test tools will greatly accelerate the development of E-EDGE features.

Author Information

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