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EGPRS2 Deployment as a Resource-saving Feature for Voice

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***Abstract*— EGPRS2 is part of the GERAN evolution standardized in 3GPP GERAN Release 7 and it allows higher throughput rates per timeslot due to the adoption of higher order modulation, higher symbol rate, turbo codes and spectrally wide pulse shape. Another possibility for EGPRS2 adoption by operators is to keep the existing EGPRS throughput rates using less network resources. EGPRS2 with higher spectrum efficiency and higher number of multiplexed users per timeslot can lead to lower PDTCH utilization. EGPRS2 deployment can lead to resource savings, which in turn can be used to increase the voice quality/capacity or can be used to refarm spectrum to WCDMA/HSPA/LTE networks. This paper shows how EGPRS2 adoption can provide voice gains in a regular scenario where PDTCH resources can be saved. EGPRS with 4 PDTCH is compared with EGPRS2 using 3 PTDCH.**

Keywords*— *GERAN Evolution; EGPRS; EGPRS2; spectrum efficiency; resources saving.

I. Introduction

GERAN networks have the highest number of users in the world. This fact can be explained due to the lower cost of voice when comparing with other radio technologies like CDMA or UTRAN. Low cost terminals and ubiquitous infrastructure enables massive deployments covering millions of users per each market. GERAN has the highest number of handsets and network manufacturers, the highest number of operators, and the highest number of countries than any other cellular technology. The success of cell phone as one of the main products in the economy history is directly related to the affordable GSM voice costs.

GSM is based on TDMA access technology where network was initially designed to supply voice services and low rate data services. 3GPP GERAN Release 7 data evolution targets to further improve the physical layer. CDMA (UMTS) and OFDMA (LTE) networks are more efficient for data services, while the voice services in GERAN networks have low cost for the users and sound return of investment for the operators. In 3GPP GERAN Release 9 GSM voice evolution is under standardization to multiplex two or more users in the same physical radio resource[1] and deploying this will increase the GSM voice advantages.

In the emergent markets many persons and many places are starting up with the first mobile service and the wireless voice is the first necessity for mobile communications. For these markets the lower GSM cost of handset and network have a huge advantage. Wireless data services using mobile phones are the second necessity since computer and digital subscriber lines may not exist. The creation of specific mobile data services according to the language and local necessities can have an impact also on the necessary development steps. Therefore major part of the population in emerging markets have a mobile service before a fixed internet service, and this will have an impact to the data services culture. A great tendency in the market is the interworking between GSM/HSPA and GSM/LTE, where the voice is provided by GSM and data services by HSPA and LTE in the hot spots and later on in the rural areas when the penetration rate of high end devices increases.

The EDGE Evolved is the last data services evolution in the most popular mobile network standard which starts with GSM deployment allowing data connections of 9.6 kbps around the year of 1992. In order to allow higher data rates it was specified the HSCSD (high speed circuit switch data) in release 96 which allow multislot connections and 14.4 kbps per timeslot. Since HSCSD needed dedicated circuit it was not economically popular and it was rapidly replaced by GPRS and EDGE. GPRS (General Packet Radio System) was the first service in GSM data services evolution which allowed packet switched connection and new network elements were introduced in the core to make the packet service available, namely SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support Node). GPRS achieved peak data rates around 171kbps per carrier using GMSK modulation which has 2 bits per symbol. EDGE (Enhanced Data rates for Global Evolution) was specified in release 99 to allow higher data rates with low impact in the GPRS layer 1 specification and kept the same packet core network elements (SGSN and GGSN). EDGE increased the data rates for peak values of 473kbps per carrier by the adoption of 8-PSK modulation which uses 3 bits per symbol [2]. Figure 1 shows this evolution.

The GERAN Evolution, also called EDGE II or Evolved EDGE, is specified in the release 7 of 3GPP and its goals are to increase spectrum efficiency and capacity, improve coverage and data rates, reduce latency and enhance service continuity with other RATs while minimizing impacts to the infrastructure [3]. This new release involves a set of enhanced techniques which can be used independently or together depending of handset and network limitations. These techniques are based in the features adopted in HSPA and LTE networks [2].

These set of features includes new modulation schemes like QPSK, 16QAM and 64QAM combined of HSR (Higher

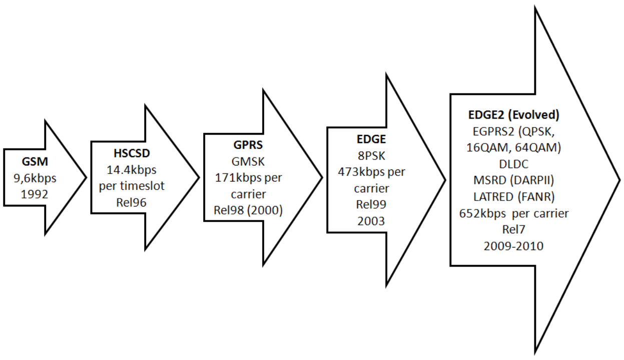

Fig. 1. GSM data services evolution pathway

Symbol Rate) which increased from 270KHz to 325KHz. This feature also called EGPRS2 provides 652 kbps per carrier. Another feature is DLDC (Downlink Dual Carrier) which allows the mobile to double the downlink bandwidth achieving peak data rates above 1Mbps per carrier. LATRED (Latency Reduction) is a feature which reduces the round-trip-time by the adoption of fast ACK/NACK (FANR) and the reduction of Transmission Time Interval (TTI). The Mobile station receive diversity (MSRD) also known as DARP2 (Downlink Advanced Receiver Performance phase 2) means that the handsets will have dual antennas to receive the downlink which will allow a more efficient interference cancellation [4].

Note that the highest MCS schemes do require good signal to noise/interference reception conditions, i.e. the availability of the resulting highest data rates is restricted to appropriate cell areas [5]. The initial reason for EGPRS2 deployment is to increase the data services performance in average conditions in order to follow the evolution in other radio technologies such as HSPA and LTE. UTRAN and LTE are based on CDMA and OFDMA physical layer respectively and with advanced radio resource scheduling can allocate all the radio resources to a single UE thus enabling significantly higher peak rates compared to GSM. However, the average data rates in moderately loaded heterogeneous networks are considerably closer. Thus, EGPRS2 deployment can be used to save network resources, enable improved capacity and provide service continuity between the radio access technologies.

One major benefit from EGPRS2 is to allow the same EGPRS data throughput performance with less resources or spectrum allocation, since EGPRS2 has higher spectrum efficiency than EGPRS. The saved spectrum can be refarmed for different radio technologies (e.g. LTE, UTRAN) or used to increase the voice performance of existing GERAN network. In this paper, a mixed scenario with EGPRS data and voice simulation is created and compared to a similar scenario where EGPRS is replaced with EGPRS2. The blocked call rate (BCR) is the key performance indicator (KPI) of voice call capacity in the network and the users data throughput is the KPI for data. The objective is to decrease the BCR without decreasing the user data throughput. The focus of this paper is in the optimization of the air interface, in order to show how the EGPRS2 can be used in end-to-end communication and what are the elements involved [6]. A dynamic system level simulator is used to compare EGPRS and EGPRS2, showing the resources saved by EGPRS2 and the voice capacity gains [7].

The paper is organized as follows: Section II presents the EGPRS2 basic concepts for GERAN evolution, the simulation scenarios are explained in Section III, and the simulation results are shown in Section IV. Conclusions are provided in Section V.

II. EGPRS2 Basic Concepts

EGPRS2 extends the number of bits per symbol to increase data throughput [4] using higher order modulations. The coding schemes [8] are presented in Figure 2 for downlink and Figure 3 for uplink and they are divided in two levels A and B. The main difference between level A and B, is that A uses 8-PSK and 32-QAM in downlink and B uses QPSK and 32-QAM in both directions. Another difference is that level B uses 20% higher symbol rate and spectrally wide transmit pulse shaping filter for uplink and downlink, whereas level A uses the legacy symbol rate and spectrally narrower Linearized GMSK pulse shaping filter for both downlink and uplink. The need for higher bit rates makes favorable the use of faster symbol rate and spectrally wide transmit filter. Currently, the legacy symbol duration is 3.69μs while 3.077μs symbol duration was standardized for EGPRS2 Level B. [4]. Furthermore, EGPRS2 level A and B are divided into different families A, B and C. Each family has a different basic unit of payload: 37 (and 34), 28 and 22 octets respectively.

The new modulations 16QAM and 32QAM increase the bit per symbol to 4 and 5 respectively. Since those modulations are more vulnerable to interference, a link adaptation (LA) algorithm is needed to choose the most suitable coding scheme for current radio link conditions to be used during the data transmission, e.g. to get the highest possible data throughput rates. The LA acts per each block transmission and also in case of retransmission. The MCS can be switched during subsequent retransmissions as indicated by two-ended arrows in Figure 2 and Figure 3. The payload of some schemes can be padded and retransmitted using an MCS from different family (for example UBS-11 can be retransmitted using UBS-10). This is shown by one-ended arrows with the number of added padding bits. To further increase the coding robustness and thus to ensure successful transmission, the blocks using lowest MCSs can be split into two or three blocks (e.g. one DAS-7 block into three MCS-2 blocks).

III. Simulation Assumptions

The simulations are using a dynamic simulator which uses a standard macro cell scenario with an ideal hexagonal grid layout with 75 sectors and it simulated the air interface and the Abis interface is considerd ideal. Considering that

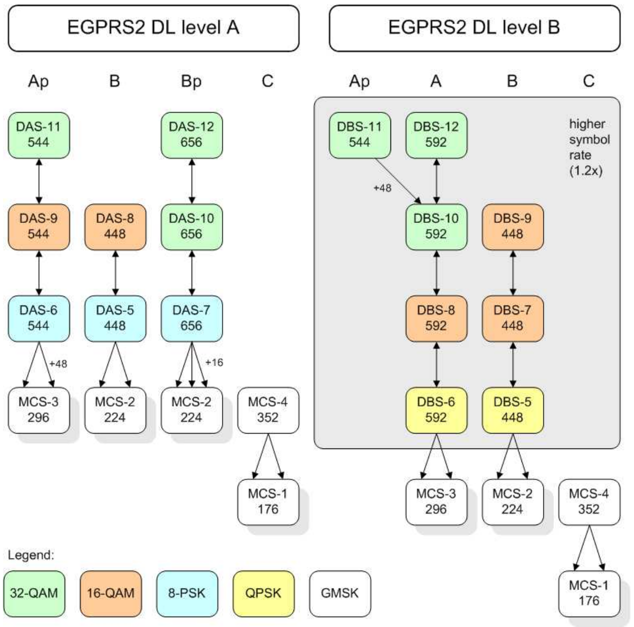

Fig. 2. EGPRS2 DL modulation and coding schemes organized in families

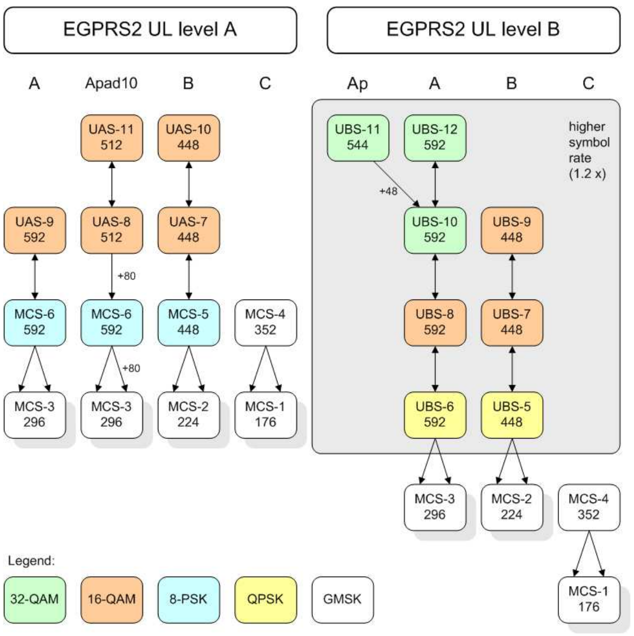

Fig. 3. EGPRS2 UL modulation and coding schemes organized in families

the objective is to keep the same data throughput, reduce the resources for data and improve the voice capacity, it is important to create scenarios, in which changes are minimal between EGPRS and EGPRS2 to isolate the gain only from this change and not from other scenario differences. Therefore the scenarios used to compare the EGPRS and EGPRS2B are very similar. The only difference is the PS territory size that is decreased from 4 TS to 3 TS in scenario 2, that runs EGPRS2. Also, the dynamic PDTCH territory updating was disabled in the simulations. Moreover, the uplink was simulated because it is important to guarantee the similar behavior also in the uplink. When one direction is simulated, the other link direction does not transmit. This approach was used to keep the simulation assumptions simple and to allow easier analysis of the simulation results. Common parameters are shown in Table I

TABLE I
COMMON PARAMETERS FOR ALL SIMULATIONS SCENARIOS

Parameter	Simulation scenario
Frequency Band	900 MHz
Cell Radius	500 m
Number of TRX	2 (1BCCH + 1TCH)
BCCH Frequency Reuse	4/12
TCH Frequency Reuse	1/1
Frequency Hopping	Synthesized
Fast Fading Type	Typical Urban
MS Speed	3 Km/h
BCCH or TCH Under Interest	Both
Network Sync Mode	Asynchronous
Service in PS	FTP
Timeslot used per user	4
Size of file transfered	1 MB
Proportion of initial PS connections	8%
Proportion of initial CS connections	92%
CS Channel Mode	Full Rate
PS Territory Pool	4 (EGPRS) and 3 (EGPRS2B)
Number of TCH Frequencies	9
Bandwidth	4.4 MHz
Guard Band	0.2 MHz
Link adaptation	Yes
Power Control for CS	Yes

IV. SIMULATION RESULTS

The dynamic system level simulation [7] results show that EGPRS2 feature can be used to increase the voice quality or voice capacity. EGPRS2 with higher spectrum efficiency allows to decrease the number of required packet timeslot resources without decreasing the data throughput compared to legacy EGPRS. The saved timeslot can be used to improve voice capacity.

Figure 4 shows that the EGPRS2 DL throughput with 3 PDTCH is still higher than legacy EGPRS DL throughput with 4 PDTCH and the gain is 7% in the point that was used to analyze the results. Also, if maintain the same value of throughput, it could get 14.8% of increase of the offered data load. Figure 5 shows the voice gains due the saved PDTCH. The voice gain was analyzed at 1.5% of voice blocking: the gain can be used to increase the voice capacity by 5% or to reduce the blocked call rate by 32%. Figure 5 shows blocking up to 2% since higher blocking is not allowed in the majority of networks.

The voice gain due to saved timeslot by EGPRS2 increases when the PDTCH resource proportion is higher. In this simulated case the reference EGPRS scenario had 4 PDTCH for a total of 15 timeslots. In scenarios with lower proportion of packet resources the voice gains are not significant. For example, a scenario with a third TRX for voice was simulated but the gains were low due to low PDTCH proportion, which was 4 PDTCH and the total number of timeslots was 23. The EGPRS2 throughput gain shown in Figure 4 can be used to save more resources for voice, but the gain is dependent on PDTCH proportion.

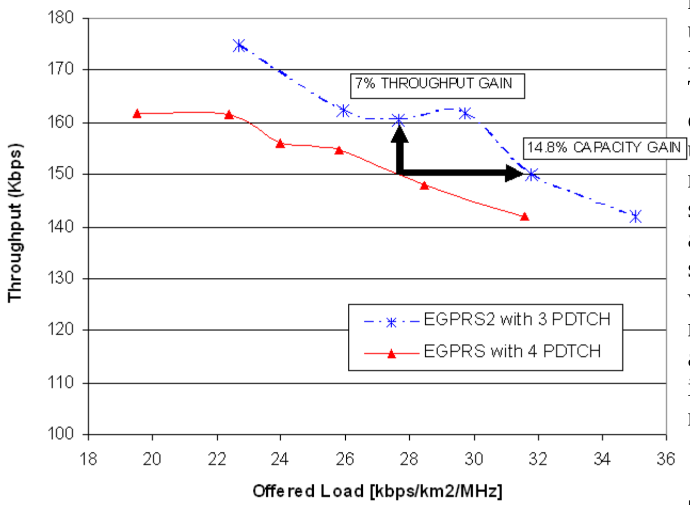

Fig. 4. EGPRS2 DL throughput with 3 PDTCH vs EGPRS DL throughput with 4 PDTCH

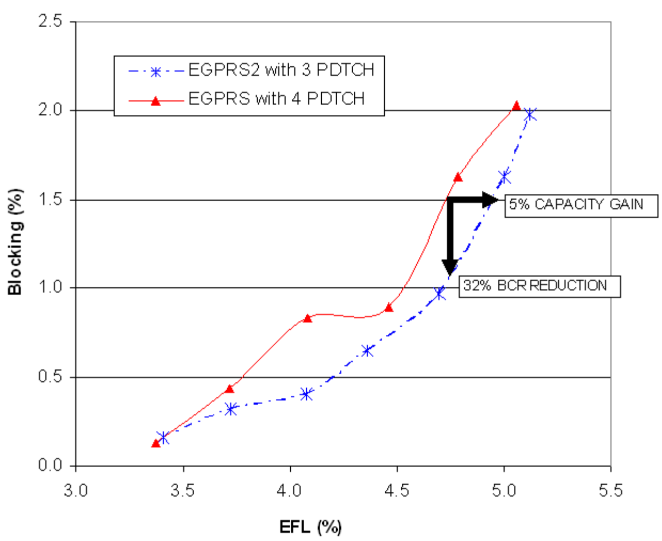

Fig. 5. EGPRS2 Gain in Capacity and Reduction of Blocked Call Rate

Network configuration, network planning and deployment scenario can impact the gains obtained from EGPRS2. Those gains are dependent on some key parameters of a scenario like the frequency plan, number of TRX per sector, spectrum available, number of BTSs and Half Rate penetration rate. Therefore, the gains presented here are closely related to the configuration of the scenario. Also, it is necessary to have a good signal quality to obtain higher spectrum efficiency from EGPRS2.

V. Conclusion and Future Work

The objective was to provide voice gains without decreasing the throughput of the data users. Using the simulation results from the dynamic simulator, this was accomplished using a smaller data territory. Moreover, the change from EGPRS to EGPRS2 showed that, without adding a new TRX, the GSM voice capacity and the data throughput can be improved. The minimum throughput of the data user was still achieved with less timeslots, so those saved resources by EGPRS2 deployment were used for voice services. Consequently, the voice blocking rate got lower and gains in the order of 5% were observed in the downlink scenario. So, replacing EGPRS with EGPRS2-B is a possible way to decrease the blocked call rate when the existing network configuration does not fulfill the requirements from a regulatory law or demand from the current users without increasing the number of TRX or the bandwidth of the network.

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