Modeling and Performance Evaluation of Dynamic Abis for E-GPRS

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***Abstract* -- The Enhanced General Packet Radio Service (E-GPRS) has been standardized to improve the data transport efficiency and data rates in GSM/GPRS air interface. GPRS relies on a static mapping of resources between the Abis and the air interface (made by provisioning). This current approach does not provide enough resources on the Abis interface to transport traffic from the air interface when the coding scheme has a data rate superior to 16kbits/s. E-GPRS will then require more resources on the Abis. This paper investigates the performance of two dynamic allocation policies for the Abis interface for E-GPRS systems. The first strategy is called micro circuit strategy. The second strategy is referred as buffered strategy. Performance evaluations are performed by computer simulation.**

Keywords -- E-GPRS, Abis Interface, Dynamic Resources Allocation, Performances.

I. INTRODUCTION

General Packet Radio Service (GPRS) is a wireless radio packet access that introduces new packet support nodes on the Network Sub System (NSS) while minimizing the modifications of Base Station Subsystems (BSS) devices. New protocol stacks are also introduced to transport packets and support terminal mobility [1]. The system architecture scheme is depicted in figure 1.

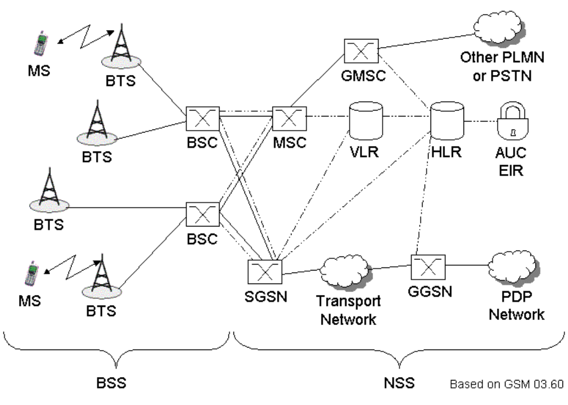

Figure 1. GSM/GPRS network architecture

Enhanced GPRS (E-GPRS) [5] is an evolution of GPRS that improves data transfer rate by using a 8-PSK modulation instead of the GMSK modulation. It requires a modification of the Base Transceiver Stations (BTS) to support 8-PSK modulation and an adaptation of some interfaces to support new data rates.

A. Abis architecture

The Abis Interface is located between the Base Transceiver Station (BTS) and the Base Station Controller (BSC). Its transport technology is based on a 2048kbits/s E1 PCM Frame [3]. The GSM system uses a coding scheme which requires a 13kbits/s channel for the voice transport and a 9.6kbits/s channel for the data transport. To improve the efficiency of the Abis interface, each channel of the PCM Frame has been originally divided into 4 sub-channels of 16kbits/s. Then, the Abis PCM frame can support up to 124 16 kbits/s channels. In practice, the PCM frame is shared between several BTS. The Abis interface architecture scheme is provided in figure 2.

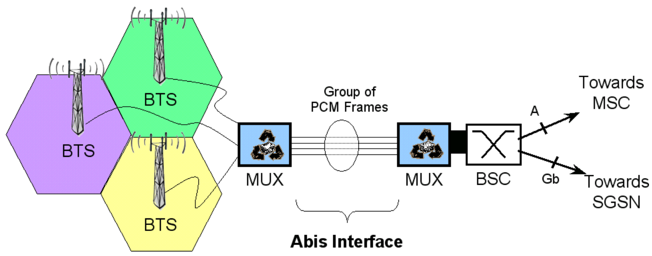

Figure 2. Abis Interface Architecture

The Abis channels are not only used to carry voice communications and user data. They convey signaling traffic between BSC and BTS.

B. Abis channel allocation policy

In GSM, the allocation policy consists in the mapping of one 16 kbits/s channel on the Abis interface to one slot of the Air interface. In GPRS, a user can have several slots in the same TDMA frame. As a result, the BSC must allocate the same number of Abis channels to transport the user RLC/MAC blocks. Despite these multi channel allocations, it is only possible to transport information with CS1 and CS2. These coding schemes do not exceed 16 kbits/s per channel.

GPRS, and especially E-GPRS, are designed to support data rates that exceed 16kbits/s. Therefore, the resource allocation policy of the Abis interface must be adapted to support new coding schemes.

One approach is to allocate on demand several channels on the Abis interface for each slot of the air interface: this approach is called micro-circuit strategy. It changes noticeably the method of resources allocation on the Abis interface because it is not still possible to keep a permanent association between an Air slot and an Abis channel. Then, it could be interesting to share, for voice and data channel, the same Abis resources between several BTS. The second approach is to allocate independently data resources on the Abis and on the air interface. This approach requires the introduction of buffers in the BTS.

This paper aims at comparing the performances of two dynamic allocation strategies. It is organized as follows. Part II introduces the simulator used for the study. Part III details the traffic models used for the simulations, gives the results and the interpretation about the two strategies in case of high and operational downlink loads. In this part, we also investigate the BTS buffer size for the buffered strategy.

II. SIMULATION MODEL

A. Overview

We have developed two BSS simulators. They simulate voice and data traffic on the Air and Abis interface for the uplink and downlink. In this investigation, only the user traffic is considered (not the signaling traffic). Voice is modeled in classical way (Poisson traffic). The data transmission is processed differently in the two simulators. In the first simulator, a micro-circuit approach is used. The BSC allocates on demand the required number of Abis channels to transport data to/from radio slots (first strategy). Once an IP packet is sent, the micros circuits (Abis channels) are released. The second simulator considers the case where the BTS has buffer capacities. The transmission is processed in two steps: from the BSC to the BTS and from the BTS to the MS. The BTS can store RLC/MAC blocks in a buffer until the different resources become available for transmission (on the air interface or in the Abis interface).

B. Data transmission

A data generator creates WEB traffic according to a given traffic model [2]. The HTTP packets are transported [4] in LLC-PDU with a maximum size of 8000 bits. LLC-PDUs are segmented in RLC/MAC blocks. The size of useful information in the RLC/MAC blocks depends on the coding-scheme used by the mobile station on the air interface. For example, a mobile phone which uses a MCS-4 coding scheme (data rate per slot: 20 kbits/s) produces blocks of 400 bits containing 360 of bits useful data and 40 bits of header.

The LLC-PDU layer implements a time limit before the transmission is abandoned. If the LLC-PDU is not segmented before this time limit, it is discarded.

Each data block is transmitted on the Air and Abis interfaces, according to the direction of transmission. The receiver acknowledges data blocks and re-assembles them in LLC-PDU. When a buffering system is implemented in the BTS, the BTS transmit them without any extra segmentation or re-assembling.

An error model can be implemented on the Air or the Abis interface to simulate loss of blocks.

A mobile can leave the cell before sending or receiving all his data. In these two cases, the data are lost.

C. Ressource Allocation Algorithm

The resources allocation policy depends on the traffic type - voice or data - and on the presence of buffers on the BTS. The simulator, on the Air or Abis interface, distinguishes three types of resources: voice, data, or mixed resources. Voice and data resources are respectively reserved for voice or data traffic. The mixed resources are used for data traffic but can be preempted by voice traffic when needed.

For data traffic, two allocation policies have been implemented for each strategy. In the first allocation strategy, each BTS has dedicated resources on the Abis interface. The number of resources is proportional to the number of data resources on the Air interface. The second allocation strategy is more dynamic. Abis resources are shared between the BTS. Like in dedicated resources policy, the BSC allocates Abis resources to the BTS proportionately to the Air slots used on the Air interface. The difference is that the unused Abis resources are given to the BTS which need them.

For data transmission in the “micro-circuit” strategy, the Air and Abis resources allocation depends on the mobile capacity and the coding scheme. For each slot on the Air interface, one ore more Abis channels must be used simultaneously. A mobile station with (3+1) capacity and a coding scheme of 20kbits/s can use three downlink slots on the Air interface and six 16kbit/s channels on the Abis interface (respectively one slot and two channels on the uplink).

In the “buffered” strategy, the resource allocations on the Air and the Abis interfaces are independent. If the BSC has data to transmit, the BSC allocates resources in the Abis interface to transmit the data to the BTS. When the BTS has data to transmit to a mobile, it reserves some resources for transmission.

III. MICRO CIRCUIT ALLOCATION STRATEGIE COMPARED WITH BTS BUFFERING MECHANISM

The aim of this part is to evaluate the performance of the different approaches of dynamic allocation strategy. We compare the performance of the “micro-circuit” strategy where Abis resources are not shared with other BTS with the “micro-circuit” and “buffered” strategies with dynamic resource sharing. The evaluation is done for high and operational load. The traffic models used are described in [2] and the parameters used in the simulation are detailed in table 1.

A. Simulation parameters

For all the simulations, we consider a group of 10 BTS with 17 voice traffic channels (TCH), 2 packet data traffic channels (PDCH) and 2 mixed resources (PDCH which can be pre-empted by a TCH in case of TCH shortage). The Abis interface is configured with 170 TCH, 20 PDCH and 20 mixed resources.

The cells traffic parameters are provided in table 1. All the GPRS mobiles have a downlink multislot capability of 4 slots. The error model implemented follows a uniform law. It marks 0.1% of RLC/MAC bloc “in error”. The buffer size implemented in the BTS for the “buffered strategy” is set to 4096 bits.

TABLE I. CELL PARAMETERS SETTINGS

Parameters		Value		
Voice User	User arrival rate	5/min		
	Average call duration	2 min		
Mobile Traffic Capability (bits/s/slot)		13 000 (MCS2)	20 000 (MCS4)	47000 (MCS7)
Data user	User distribution	50%	30%	20%
	Session duration (s)	300	300	300
Data traffic parameters	Inter Session Time (s)	60	60	60
	Number of packet call per session	5	5	5
	Inter packet call time (s)	5	5	5
	Number of packet in a packet call	25	25	25
	Inter packet time (s)	0.1	0.0625	0.0246
	Packet size (pareto cut-off parameters)	α=1.1 k=81.5 m=66666	α=1.1 k=81.5 m=66666	α=1.1 k=81.5 m=66666
	Packet time validity (s)	30	30	30
	Mean Data Rate per Mobile (kbits/s)	4,92	5,16	5,44

For the study of the load performances, we consider the variation of the mean number of mobile phones in each cell.

B. High load downlink performances

The transmission performances in the case of high load are depicted in the figures 3 and 4: the figure 3 depicts the LLC-PDU transmission rate and the figure 4 depicts the transmission time.

If we compare allocation policies, we can notice that the BTS resources sharing has always better performance than the policy were each BTS has its own pool of resources on the Abis. However, the gain of performance is not really significant in the case of high loads (more than 10 PDP contexts active in the cell). In this case, all the BTS have data to transmit at the same time. Then, they cannot obtain more data resources for transmission than in the case were the resources are dedicated. For high loads, the transmission rate becomes too low for being used in an operational system. To offer an acceptable quality of service to the subscribers, the operator needs to increase the number of data traffic resources in the Air and Abis interfaces.

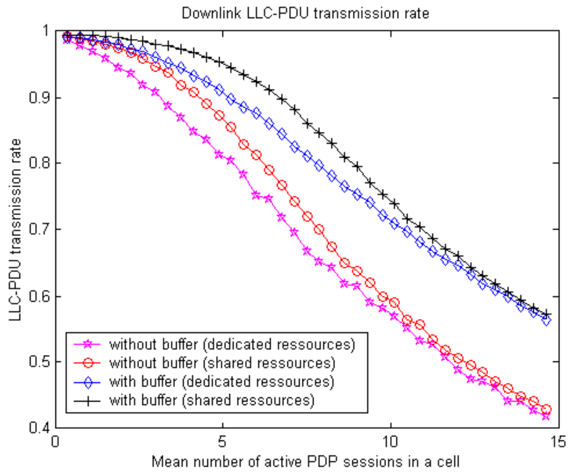

Figure 3. High Payload Downlink PDU transmission rate (170 20 20)

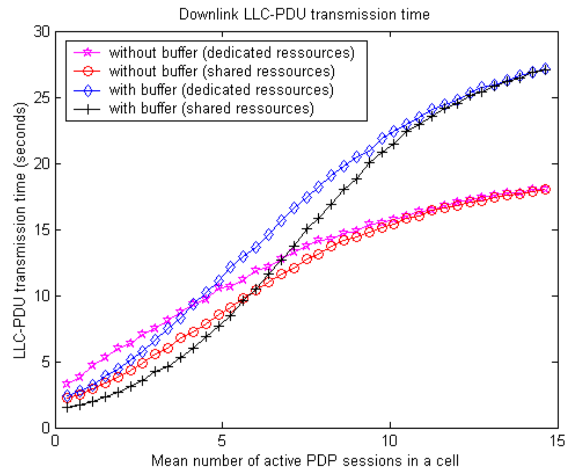

Figure 4. High Payload Downlink PDU transmission time (170 20 20)

For high loads, the buffered strategy offers better performance in terms of transmission rate. Nevertheless, this transmission rate improvement involves a sensible increase of the transmission time. For less than 5 active PDP sessions, the difference of transmission rate between the “micro circuit” and the “buffered” strategies is not significant. The performances depend on the Air and Abis interfaces configuration, the characteristics of the data traffic, and the mobiles profile. For example, for less than 2 PDP active sessions, with the same parameters, if we consider 100% of MCS4 mobile, the micro-circuit strategy is more interesting in terms of transmission rate.

The improvement of transmission performances can be obtained by increasing dedicated data resources or by increasing the number of mixed resources. This last proposition is more interesting for an operator because it does not need to increase the capacity of its Abis interfaces.

The figures 5 and 6 presents the results obtained with an Abis configuration of 140 TCH, 20 PDCH and 50 mixed resources. The results are very close to those of an Abis interface with 170 TCH, 40 PDCH and 20 mixed resources.

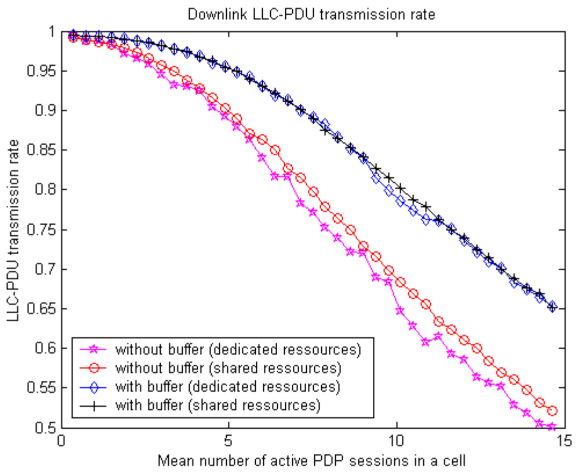

Figure 5. High Payload Downlink PDU transmission rate (140 50 20)

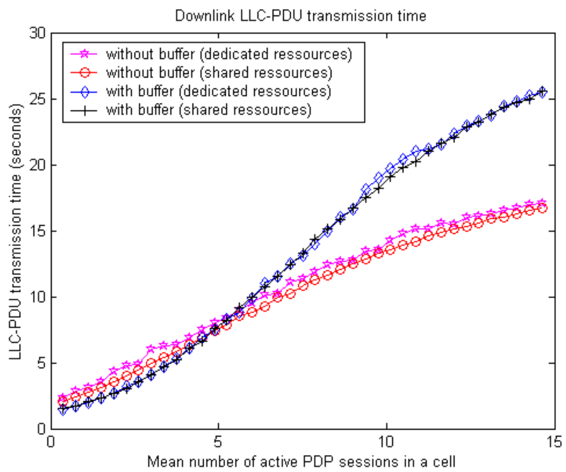

Figure 6. High Payload Downlink PDU transmission time (140 50 20)

The increase of data traffic capacity reduces the difference between the “dedicated” and the “shared” allocation policy. The performances of the “buffered” and “dedicated” strategies are improved compared to the figure 3 and 4. We should note at this point that the differences between the two strategies are still the same: buffered strategies have better performance in terms of transmission rate but not in terms of transmission time.

C. *Low load downlink performances*

For low downlink load conditions, we have considered less than 4 mobiles with active PDP sessions in each cell. This traffic configuration is more accurate to the real traffic conditions. The simulation curves in this article only consider the shared Abis resources policy for the two Abis configurations of section B. The figure 7 depicts the LLC-PDU transmission rate and the figure 8 depicts the transmission time.

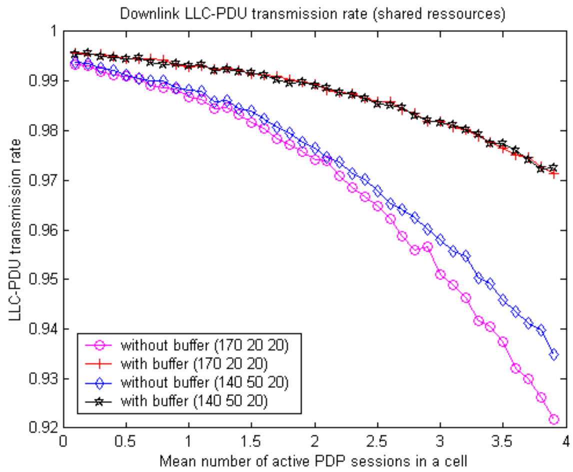

Figure 7. Operational load Downlink PDU transmisssion rate

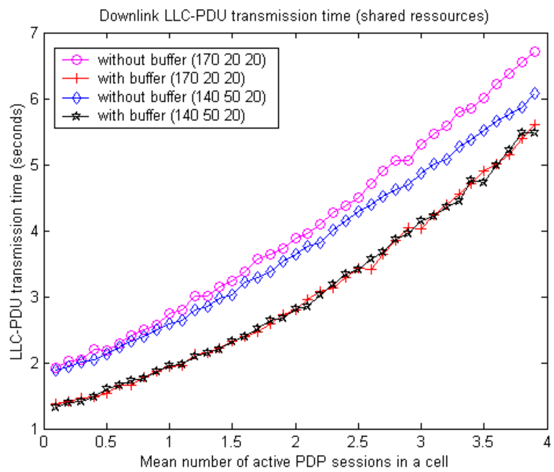

Figure 8. Operational load Downlink PDU transmission time

For this traffic configuration, we can notice that the buffered strategy presents better performances than the micro-circuit strategy. The buffered strategy seems to be more efficient when the traffic increases. The transmission delay is still better than in the micro-circuit strategy.

The increase of data resources produces a little improvement of the “micro-circuit” performances but has no effect for the “buffered strategy”. This result is due to the fact that in case of “buffered strategy”, for low loads, the Abis interface is not a bottleneck. The shared resources policy is sufficient to provide enough data resources.

Considering these results, it seems more interesting to adopt a buffered strategy with shared resources on the Abis interface. In this case, it is not necessary to increase the number of data resources.

If it is not possible to add a buffer on the BTS, it is necessary to increase the number of data resources on the

Abis and to share them between several BTS to improve the performances (trunking effect).

D. *Investigation about the buffer size*

In this part, we have considered the "buffered strategy" with a shared Abis resource policy. The mean number of active PDP contexts per cell is set to 10. The figure 9 and 10 present the mean buffer size and the transmission rate for three different buffer capacities: 2048 bits, 4096 bits and 6144 bits.

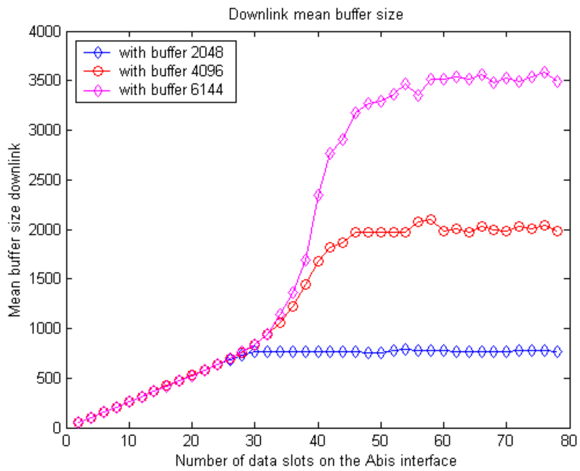

Figure 9. Downlink buffer size in the BTS

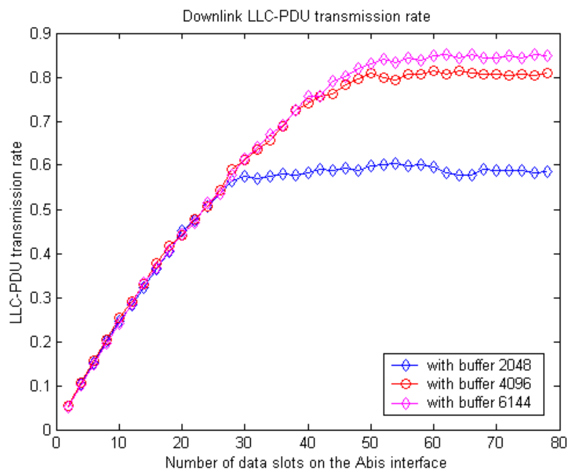

Figure 10. Downlink PDU transmission rate

In these figures, we investigate the effects of the BTS maximum buffer size on the LLC-PDU transmission rate and on the BTS mean buffer size. For a number of Abis data channels between 0 and 30 the buffer size is stable (no buffer overflow) and the transmission rate is low (due to the small amount of Abis channel configured and to the timeout of LLC PDUs). Between 30 and 40, the buffer starts increasing rapidly because the system is loaded. For a number of Abis data channels superior to 40, the air interface becomes a bottleneck. The BTS fills their buffers up to their maximum capacity and the number of Abis data channels configured has no effect on the mean buffer size.

As we can see on the figures 9 and 10, it is not useful to increase heavily the buffer sizes. The performances of the 4096 bits and the 6144 bits buffer are very close. In fact, it is not efficient to use a high capacity buffer if the Air interface cannot convey their content.

We can also notice that it is inefficient to increase heavily the number of data resources on the Abis interface. In our case, for more than 45 data resources on the Abis interface, the Air interface limitations limit the load. This limit closely depends on the traffic characteristics. If the mobile uses low transmission data rate per slot, the traffic load reaches its limit more rapidly.

Considering these results, the choice of the buffer size and the number of data resources on the Abis depend closely on the traffic characteristics and the Air interface configuration. If we consider the figure 9, it is inefficient to take more than 45 data resources on the Abis interface and 4096 bits for the buffer. In practice, if an operator will determine the configuration of the Abis interface, he can considerate the curves of the buffer size depending to the number of resources on the Abis interface considering a BSS configuration (number of BTS and their Air interface) and the traffic characteristics. A good configuration is when the Abis traffic load is not higher than the Air traffic load, in other words, when the size of the buffer does not increase too much.

IV. CONCLUSION

The "buffered" strategy is always better than the "micro circuit" strategy. The shared resource strategy does not really improve the transmission performances of the buffered strategy, but have a positive effect on the "micro-circuit" strategy. As a result, to improve the transmissions performance, the better way is to add buffers on the BTS. If it is not possible, the "micro-circuit" strategy with shared Abis resources is the better strategy. An evaluation method of the most efficient number of data resource and the size of the buffer is also provided.

An evaluation of the impact of these modifications on the uplink transmission will be carried out in future works.

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