Performance Evaluation of GPRS MCAST[1] Multicast over GPRS Solution

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***Abstract*—The scope of this paper is to present the results of network performance evaluation of the MCAST [3] Multicast over GPRS technique that could be exploited over existing cellular networks. The performance analysis investigates the applicability of Multicasting in GPRS mobile networks based on comparison between Unicasting and Multicasting methods of delivering content based on commercial network configuration and market demands. Special focus is provided to radio resource utilization gain, taking into account the resource limitations that a GPRS network may face in heavy traffic conditions. The analysis is based on a simulation tool taking into account realistic background voice and data traffic scenarios.**

***Index Terms*— Evaluation, GPRS, Multicasting, Unicasting.**

I. INTRODUCTION

Mobile communications, following the extremely successful period of growth mainly based on voice and SMS services, have the recent years entered an era of fundamental changes in both terms of enabling technologies (such as GPRS and 3G) as well as the offered service products in the area of data services. This environment has raised new challenges in network design and technology migration activities combined with the challenges in the field of service product design and development.

From the technology evolution viewpoint, GPRS network infrastructure introduced a few years ago, is currently available in almost all European Mobile Network Operators (MNOs) while the majority of them have introduced 3G, covering for the time being only specific densely populated areas. In parallel, a set of new services exploiting the capabilities of these technologies have been launched commercially, however, resulting in a much slower growth pattern compared to the voice service history. Taking into account that the user experience plays a dominating role in the success of such types of services (e.g., content delivery, etc.) it appears that it is not enough to have the enabling technologies in place but the network performance should meet the user requirements. Based on [1], the mobile content delivery services and especially the mobile video services will present dramatic rise over the coming years. The demand for mobile data services will increase when more advanced terminals enter the market. Therefore, MNOs should find efficient ways for delivering multimedia content (via streaming or download) to their customers without performing great investments in network equipment and additional software. The Multicasting technique allows Mobile Operators to deliver rich media content to mass markets over cellular networks and enables the profitable use of the network resources.

The mobile Multicasting services, which are based on new technology trends, address a new market and are considered innovative [2]. Multicasting will allow for resource efficiency in environments with high customer demand for content. This is the case in densely populated urban areas where there is a trade off in multicasting resource efficiency as the smaller the cell size the lower the number of customers that will receive from the same multicast channel is.

The aim of this paper is to evaluate the applicability of the MCAST Multicasting technique (in terms of user experience improvement and network decongestion) in currently deployed GPRS networks based on realistic scenarios and on the experience gained from the EU funded project MCAST [3]. The field trials conducted under the MCAST project provided the necessary input for performing an in depth analysis of the Multicasting technique over cellular networks.

The paper is structured as follows:

Section 2 presents the MCAST Multicasting technology (applicable to GPRS networks) highlighting its advantages compared to unicasting.

In section 3, the simulation results are presented in a way to clarify and demonstrate the applicability of MCAST Multicasting in a realistic GPRS mobile network.

[1] The material presented in the paper represent the views of the authors and not the project consortium as a whole.

Finally, in section 4 conclusions are drawn concerning the evaluation of the Multicasting techniques from the mobile operator's perspective.

II. Technology Description - Mobile Multicasting

Multicasting technology enables cellular operators to use shared channel resources for broadcasting content (video, images, text, etc.) and any other kind of data over 2.5G and 3G networks. From an operator's point of view, Multicasting aims to increase the resource efficiency in content delivery and enable services that require massive content distribution. The potential elimination of resources limitations would allow for lower pricing and higher operators' revenues per channel, making thus mobile communications networks an economically attractive mean for content distribution.

A. Current Technology Constraints

Currently, rich media content can be delivered over cellular networks using unicasting (point-to-point) technology. This method has the disadvantage of low scaling capability, which leads to high delivery cost and limited cell capacity. In a Unicasting scenario each mobile terminal that accesses a content server for on-demand content delivery is being served independent of the others. Thus, when a number of users access simultaneously rich media content an excessive amount of network resources is required leading to potential congestion especially in densely populated areas. Apparently, even in the case that users are located in the same cell and download exactly the same content separated radio resources will be allocated. In the case that the user demand for content increases, the network capacity should be expanded in a scale dis-proportional to the expected revenues.

Concerning standardization activities, the 3rd Generation Partnership Project (3GPP) is in the process of standardizing protocols for Multicast operation in UMTS [8], [9], [10], and is advancing a standard for Multicast and Broadcast services for the GSM/WCDMA based cellular network technologies. The standard is referred to as MBMS (Multimedia Broadcast Multicast Service) and it is expected to be available with release-6 3GPP networks.

B. Challenge, Solution and Opportunity

Multicasting technology is based on a one-to-many communication concept. Employing Multicasting enables the delivery of identical content (e.g. TV signal) simultaneously to an unlimited number of subscribers (mobile terminals) residing in the same coverage area. This allows services to scale to almost any number of users while having a manageable and limited impact on available capacity per cell.

The main disadvantage of Multicasting is that content delivery needs to be synchronized for a group of users limiting thus the ability to provide on-demand type of services. On the other hand, Multicasting exploits the idea of "Push" content to subscribers upon subscription to certain content types. From the end user point of view, this approach might represent a convenient and cost efficient way of accessing rich media content.

Considering its technological characteristics, Multicasting is particularly suitable for rich media content (e.g. video, audio, gaming) delivery. Major market research institutions forecast the market potential of video services to nearly double that of audio services e.g. [5] and a take up in 2005/06 e.g. [6], [7]. Based on this, our research focuses primarily on the delivery of video clips to mobile handsets.

Alternative Multicasting technologies like DVB-h [4] represent a competitive option to cellular Multicasting. However, such types of technologies require the deployment of a parallel radio network and the exploitation of additional spectrum. As the introduction of cellular multicasting is a natural functional evolution of mobile communication networks it appears that this option is more viable for mobile operators.

III. Simulation results – Analysis

For the evaluation of GPRS Multicasting, a series of simulations were performed based on realistic scenarios from the commercial network of Vodafone Greece.

The GPRS Network Simulator developed by Vodafone has been exploited in MCAST project. The GPRS Network Simulator is an ideal tool for planning and testing the performance of a commercial GPRS network under different traffic conditions. As such, it forms the basis of extensive trials for testing, simulating and evaluating the performance of the Multicasting technique under real network conditions.

It should be noted that the simulation input parameters correspond as close as possible to actual network conditions (network equipment, capacity, resource allocation techniques), as well as the actual traffic (voice and data) conditions. Concerning the input traffic, the peak hour traffic (worse case scenario) was applied.

The main cell parameters as well as the offered traffic profile that was simulated are summarized in the following table:

TABLE 1:
CELL'S PARAMETERS AND TRAFFIC SIMULATED

Parameter	*Value*
Cell capacity	24 time slots
Traffic channels	22 time slots
Control and Signalling Channels	2 time slots
Carrier to Interference ratio (C/I)	12 dB
Peak Hour Voice Traffic (Circuit Switched)	14 Erlangs
Packet Switched traffic (not related to Multicasting)	• 50 MMSs/hour • 20 Browsing sessions/hour • 10 Streaming sessions/hour
CS traffic priority over PS traffic	Both scenarios tested
Timeslots dedicated for PS traffic	No
Half Rate activated	No

During the simulations, the Unicasting delivery method (Point to Point) was analysed in order to investigate its efficiency for content delivery. More precisely, the Point to Point delivery was simulated with content sizes 100, 200 and 300Kbytes respectively. The content size was selected to be in line with GPRS capabilities. Based on the simulation results, two categories of graphs were produced:

- The content delivery delay with Unicast transmission, and
- the percentage of Blocked Voice Calls,

versus the number of Unicast sessions per hour.

These results are further compared with the Multicasting scenario simulation measurements. One Multicasting session is considered to take place.

A. Content delivery delay

A delay threshold of 260sec (4min) was assumed to be representing the maximum time that a subscriber can tolerate when downloading a video clip, or the terminal resources can be occupied by the GPRS session.

As it can be seen from Fig. 1, the delivery of content of size 200 and 300 Kbytes might become delay critical in the case that the rate of packet sessions is high (>150 sessions/hour) and given that voice traffic is prioritized over packet traffic. Fig. 2 indicates that point to point content delivery delay is not critical in the case that packet traffic is prioritized over voice traffic which is not the common case in GPRS networks.

From the same Figures it is obvious that when Multicasting is applied then content delivery delay is acceptable and independent of the number of sessions (representing the number of users receiving the content in this case).

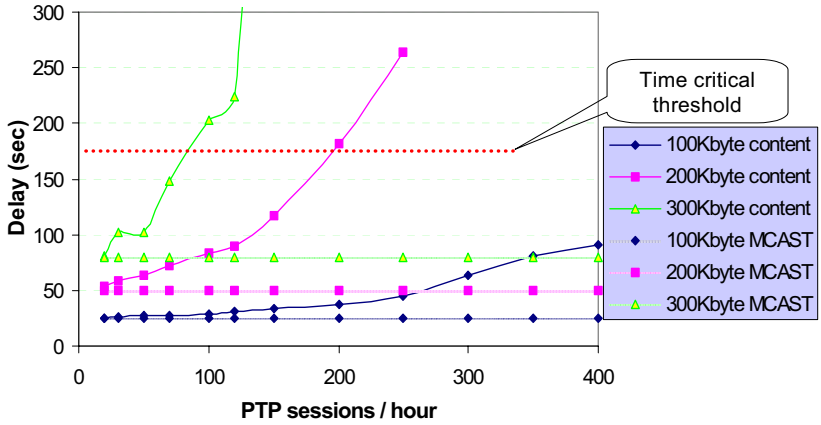

Fig. 1: PTP content delivery delay for CS traffic priority over PS

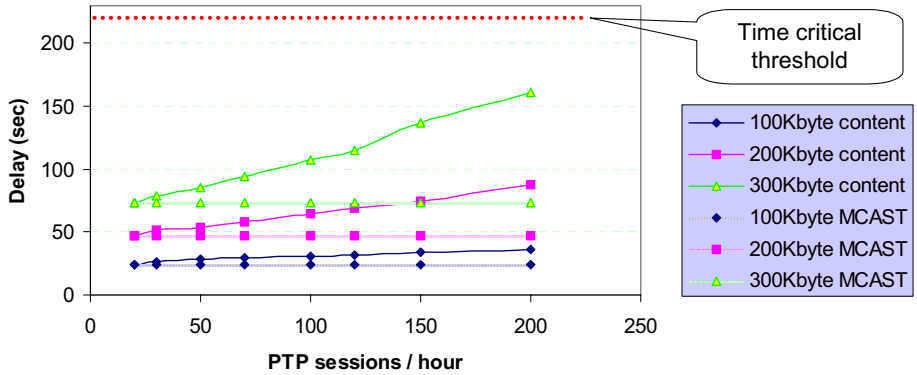

Fig. 2: PTP content delivery efficiency for PS traffic priority over CS

Therefore, based on the simulation results, it is evident that although Multicast is more efficient from the delivery delay viewpoint, Point to Point content delivery method is also acceptable unless an extremely high access rate of large content delivery is experienced.

B. *Percentage of Blocked Calls*

The next important parameter to consider in our simulation model is the percentage of blocked voice calls (CS) which represent the impact of content delivery in voice traffic (and associated revenues). A call blocking level of 2% is considered as the acceptable threshold of congestion from an operator's perspective. In case this value is exceeded (within a cell), a remedy action in the form of network capacity expansion must take place.

As it can be seen from Fig. 3 and 4 when the Multicasting technique is applied, the percentage of Blocked calls is 0.4% and 1.6% for CS traffic and PS traffic priority respectively. In both cases, the percentage of Blocked calls is irrespective of the number of the users being served by multicast channel.

For Point to Point content delivery, the call blocking threshold is not exceeded when CS traffic is prioritized over PS traffic (Fig. 3). In the opposite case (Fig. 4) the call-blocking threshold is exceeded when the rate of sessions increases.

C. *Analysis-Evaluation*

Based on the above presented simulation results the following conclusions derive with regard to the applicability of GPRS Multicasting for content delivery:

- The Point to Point delivery technique can be applied in most cases, thus eliminating the extra investment required for developing the Multicasting infrastructure.
- GPRS Multicasting is applicable:
  - For time critical content delivery, especially when employing Unicasting the delay exceeds 4 minutes.
  - For a large number of users residing on the same cell.
  - For content size exceeding 300Kbytes.

An example of profitable and efficient use of Multicasting could be for covering special events/venues with large density of users (e.g. stadiums, concerts).

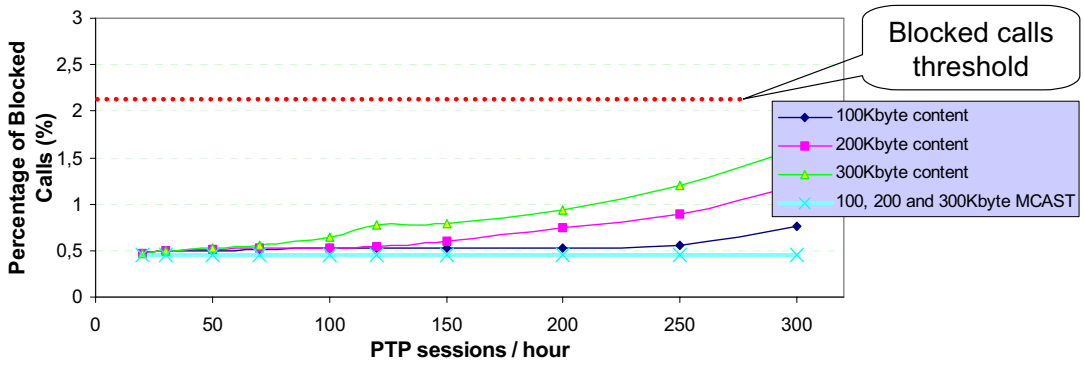

Fig. 3: Percentage of Blocked calls vs. PTP sessions (CS traffic priority)

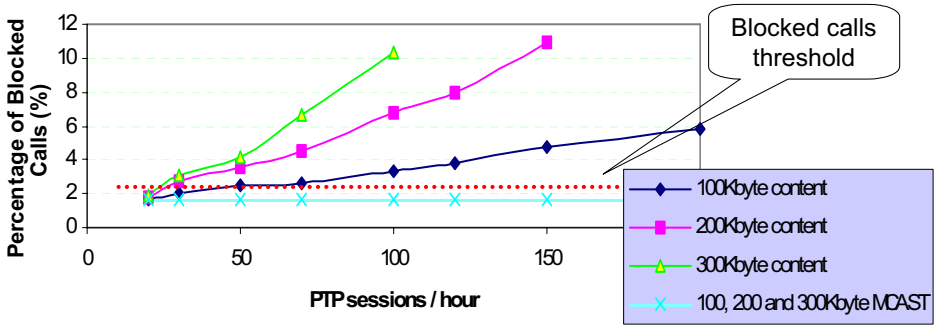

Fig. 4: Percentage of Blocked calls vs. PTP sessions (PS traffic priority)

IV. CONCLUSIONS

The GPRS Multicasting technique presents an attractive way and a potential for mass delivery of personalised multimedia content. Additionally, Multicasting applications over GPRS can provide the means for exploiting the network infrastructure already deployed through a content "push" rather than a content "on-demand" model.

However, its applicability is constrained by the limited PS traffic served currently by the GPRS network, which allows for affordable performance of Point to Point content delivery. The simulation model presented in this paper indicates that GPRS multicasting could only be valid for delivering time critical content in special occasions and venues with great density of subscribers. However, such hot-spots are already covered by 3G and therefore, 3G-multicasting appears to be a more promising option.

Next steps of our work will be the evaluation of the UMTS Multicasting technique taking into account real network scenarios and the expected demand growth for personalized content delivery.

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