SAMU project: tests and improvement of UMTS for users in a car

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Abstract. **This paper gives an overview of the French collaborative project SAMU[1], Advanced Services by Mastering UMTS, dedicated to develop enhanced services for users in a car. For that purpose, complementary research domains have been investigated such as radio resource management, IP over UMTS and the use of software agents. While field trials were planned in the project to validate the outputs of the above mentioned research areas over an UMTS experimental network, the general delay encountered by UMTS manufacturer lead the project to investigate alternative experimentations. Hence, an UMTS-TDD software radio platform has been built to show IP based telematics applications over UMTS.**

I. INTRODUCTION

The world of telecommunications currently knows two major evolutions: the explosion of the mobile communications and the extremely fast development of the Internet, as well on the level of the computers connected as to the number of services offered. The quasi-immediate adoption of these technologies by the users confirms the market trend of telecommunications to move towards a general convergence of the worlds of telephony, data processing and diffusion. Consequently, third generation systems, and especially UMTS, will have obviously to ensure continuity with the current services of mobile telephony, but to also support efficient data services. However, because of some troubles in the telecommunication business, the success of 3G appears to be less obvious.

The SAMU project [2], Advanced Services by Mastering UMTS aims at contributing to the rapid adoption of UMTS by the users and thus to the success of 3G mobile systems. For that purposes, it explores the following issues:

- *To anticipate* frequency shortage thanks to the development of intelligent resource management (Work-Package 1)
- *To marry* the Internet and the UMTS worlds by defining means to provide an end-to-end quality of services (WP2)
- *To introduce* intelligent agents to make the system autonomous and help the user finding his way in the complex landscape of (Internet) services (WP3)
- *To validate* the previous results by a field trials of telematic services based on IP over an UMTS radio link (WP4)

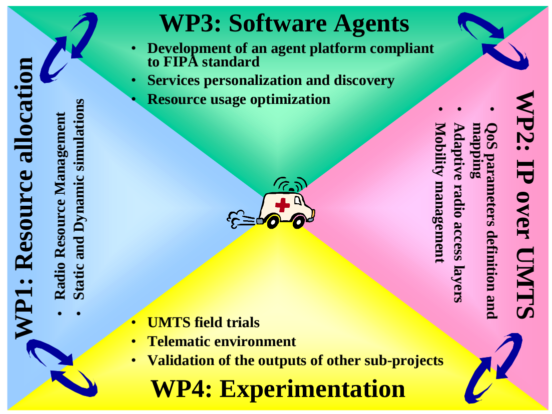

Figure 1: Overall view of SAMU project

SAMU project is a collaborative project involving 5 complementary partners, Motorola Labs, the research entity of Motorola, SFR, a GSM operator, Renault, the car manufacturer, and 2 high-level French universities: Eurecom Institute and University of Versailles.

This paper presents the concrete results of this research project at mid-project. More complete results will be available at the end of the project, i.e. in September 2002. The following sections describe the outputs per work-package: section 2 presents the work related to radio resource management. Section 3 focuses on possible radio layer improvement to cope with IP based traffic. In section 4, the benefit of using software agents is described. Finally section 5 presents the experimental set-up.

II. WP1: INTELLIGENT RESOURCE MANAGEMENT

In this work-package, 2 directions were investigated. The first one, based on Monte-Carlo simulations investigates soft handover to improve the quality of service of downlink traffic. Main results are following: the population in soft handover mode are principally characterized by the primary link properties. Soft handover leads to a more uniform QoS in the cell as perceived by an individual user, but at the cost of less users served by the system. Finally, soft handover as it is currently defined in UMTS standard should be precisely managed: an inaccurate choice of soft handover margin as

[1] The SAMU project is supported by the French Ministry of Industry, Economy and Finances through RNRT [1] (National Network of Research in Telecommunication).

well inappropriate power control schemes might harmfully impact the system capacity.

SAMU project lead to the conclusion that the best choice for soft handoff margin was 3dB. We propose in addition a novel power control method, adapted to soft handover.

The second axis of work in WP1 is more analytical and deals with uplink code allocation method. After analysing the source of interference, it was proposed to cluster users having similar services with the same scrambling code; user differentiation being made thanks to spreading codes. This scheme, named OSSC One Service One Scrambling code improved the system capacity in terms of number of accepted users for services. Analytical performance of OSSC are described in [8] while simulation results are captured in [7].

III. WP2: IP OVER UMTS

A. *Review of QoS mechanisms*

The UMTS [3] architecture is split in different domains, user equipment, access network and core network domains. In addition, UMTS is based on a layered structured in functional stratums. Upon these structures a Quality of Services (QoS) architecture is defined, based on the concept of bearer services and QoS classes. A bearer service includes all aspects to enable the provision of the contracted QoS and could be subdivided into radio access bearer service and core network bearer service, each service having its own set of parameters. The mapping or translation of QoS attributes from one bearer to the other is not obvious. In SAMU, a mapping between the UMTS QoS classes onto the UMTS radio layers mechanisms has been proposed. Basically, the maximum allowed number of retransmission at the RLC layer is used to control the residual packet error rate and the delay over the wireless interface.

On the other hand, the IETF [4] has defined QoS mechanisms for IP based networks, such as Diffserv or Intserv with their own QoS attributes. To provide an end-to-end QoS for IP based traffic over an UMTS network, one of the most difficult issue is to provide QoS attributes translation and mapping between the IP world and the UMTS world. This issue is being addressed in the SAMU project and some result dealing with the mapping of Diffserv classes and UMTS QoS classes are provided below.

In Diffserv, three main Per Hop Behaviours (PHB) have been defined:

- *Expedited Forwarding* (EF) [5] provides a low delay, a low loss and an assured bandwidth similarly to a voice circuit,
- *Assured Forwarding* (AF) [6] provides delivery of IP packets in independently forwarded AF classes. Within each AF class, an IP packet can be assigned different levels of drop precedence. The AF can be used to implement, for example, the so-called *Olympic service*, which consists of three service classes: *bronze, silver,* and *gold*.
- *Best Effort* (BE) provides no guarantee.

UMTS on the other hand specifies four different QoS classes:

- *Conversational class* provides a low delay and low jitter service suitable for speech and other real-time applications such as video-conferencing.
- *Streaming class* provides a service suitable for adaptive real-time applications. These applications require the delay variations to be limited however they do not have any requirements on low transfer delay. This class is a one-way transport class.
- *Interactive class* requires low loss rate with better service than best effort.
- *Background class* requires low loss rate with no delay requirements.

From the definition of these QoS classes, it is clear that conversational class in the UMTS and the expedited forwarding PHB in the DiffServ architecture have the same characteristics. Streaming class has less constraint on the average delay and it can be mapped to an assured forwarding PHB. Interactive class with its different traffic handling priorities may match the assured forwarding paradigm with its different priority classes at the first glance. The only problem is that interactive class has no reserved resources in UMTS while AF has a share of bandwidth in Diffserv. We may map the interactive class to the least priority class (bronze class) of the AF with the minimum allowed bandwidth reservation. The priority levels of the interactive class may then correspond to the drop precedence attribute of the AF class. We also need a mechanism to differentiate the situations where an AF class must be mapped to streaming class from the situations where it must be mapped to interactive class. We may use the gold class of the AF service for the streaming class and the bronze class for the interactive class. Finally, the best effort is mapped to the background class of the UMTS network. The following table depicts a possible mapping between UMTS QoS classes and DiffServ QoS classes.

DIFFSERV	**UMTS**
EF	Conversational Class
AF – Gold Class	Streaming Class
AF – Bronze Class	Interactive Class
Best Effort	Background Class

Table 1: Mapping of Differentiated Services Classes to UMTS QoS Classes

Table 1 follows a static mapping mechanism where the UMTS QoS classes are always mapped to a fixed DiffServ class and vice versa. There are some situations where we want a more flexible and dynamic scheme. In this case, rather than saying that the gold class of an AF PHB for example will be always mapped to the streaming class, we may say that a specific application such as video on demand is always mapped to the streaming class. This makes the mapping procedure application dependent and dynamic.

This mapping proposal does not fully solve the concern of providing to IP based traffic an efficient radio bearer service. The next paragraph highlights another area of investigation of work package 2 dealing with turbo codes and Hybrid ARQ.

B. Hybrid ARQ and Turbo-codes

Data communications were originally developed on wired networks require high quality transmissions. For wired links, reliability is traditionally obtained thanks to repetition. A packet is retransmitted when the previous attempt was unsuccessful. Such mechanism is named ARQ (Automatic Repeat Request). In the case of wireless transmissions, packets should be protected to mitigate the channel noise, the fading due to mobility, and the interference created by the other users. Protection is mainly given by forward error coding (FEC), i.e. transmitting additional bits to the packet. However, to provide the same quality as in wired system, FEC overhead could lead to very inefficient transmissions. As a result, hybrid schemes, combining FEC and ARQ have been defined. In parallel, a novel class of FEC, the Turbo-Codes has appeared [9]. These codes offer very good protection for an acceptable complexity and outperform all classical coding schemes in terms of performance.

It was thus interesting to assess the performance of HARQ in the context of turbo-codes for delivering IP based services for mobile users. Different strategies can be designed for implementing HARQ. The SAMU project only considers schemes where the same packet is always retransmitted (no incremental redundancy) since such schemes could be easier introduced in the UMTS standard. The simulations conducted and reported in [10] lead to the conclusion that Turbo-codes were robust enough and that the complexity induced by conditional retransmission is not worth compared to the gain it produces.

IV. WP3: MOBILE AGENTS

Mobile agents [11] are software programs that can move around a network under their own control, moving from host to host and interacting with other agents or accessing server's resources on each host they visit. Due to the code mobility, mobile agents are very well suited for information retrieval or E-Business applications. Mobile agents based distributed computing have received a great interest during the last few years for their ability to support asynchronous interaction and to reduce networks traffic in client/server interactions.

Mobile agents are a powerful paradigm for distributed computing, and are especially well suited for dealing with mobile or partially connected devices like laptop computers that are connected to the network and the new generation of mobile equipment that will emerge in the next 3 years. The main interests when using mobile agents are the ability for the user to stay disconnected during the whole interaction and the reduction of communication costs.

Our idea in this project is to associate a mobile agent per user. The agent will play the role of proxy and will try to execute a large number of requests by replacing the user. A lot of signaling information will be avoided on the air interface. Two applications were studied: POP3 for emails [12] and Web navigation [13].

In the UMTS architecture [3], the Node-B seems to be the ideal location for the mobile agent. In fact, when the user enters in a high mobility state, the network can easily locate the user and consequently, the agent can follow the user in his mobility.

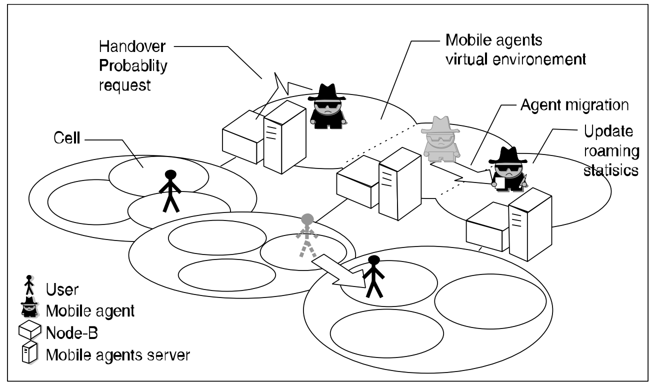

Figure 2. Mobile agents based architecture.

Figure 2 shows our proposed platform to integrate mobile agents in the UTRAN architecture. This figure depicts the ability of an agent to move from Node-B to Node-B. Some resources on the wired part of the UTRAN can be reserved for the agent connections.

A. The pop3 application

POP3 is a protocol that allows connections to a mail server for checking the new arrival mail. Then the POP3 fetches all new mails to the client host. POP3 is a very simple protocol. Indeed, just few commands are needed to make a POP3 session. A POP3 session is composed of an identification procedure (login and password) followed by a request to check for new mails, and finally if necessary a sequence of fetches commands to retrieve mails. The main drawback of the POP3 protocol is the way that it operates. In fact, POP3 requires the user to regularly connect to the server to look for new mails. Except for a high mail arrival rate, it's obvious that the POP3 client is constraint to make useless connections in order to aware the user of new mails in acceptable time (Usually, an interval of 10 minutes is recommended in the majority of client software applications).

The idea that developed in the project consists of giving the whole responsibility of checking e-mail to the appropriate mobile agent. In this way, the agent must check every time interval that is fixed by the user for new arrival mail. When a new mail is detected, the agent fetches the mail and keeps it in a local register. When the time interval fixed by the user expires, the agent sends all received mails to user. To avoid losing a mail during a handover, the agent must execute the same handover than the user, a move to the corresponding new base station. Such a method reduces signaling on the air interface by limiting useless mail checking since every POP3 time intervals, the user checks for new arrival mail by using some kind of signaling to open a connection on the air interface. When no new mail is checked, this connection is useless. The use of agent eliminates completely these useless connections because the user will receive all its emails in a single connection. Moreover, an intelligent agent might decide on its own the most appropriate time to transfer the mail, when for instance the user benefits from good radio condition. In [12] the optimization introduced by mobile agents is analyzed in more details. Indeed, the bandwidth occupation is reduced by a factor of 3. This reduction is computed during the POP3 checking interval.

B. The web navigation

HTTP [14] is the protocol that permits to get web pages from WWW servers. Web pages consist of HTML documents that contain references to other pages, and embedded documents like images, sounds, scripts and HTML files when pages are composed of multiple frames. HTTP is a simple client server protocol with a few sets of commands necessary to fetch HTML documents. The client establishes a connection to the web server where the requested page is located. Once the connection is established, the client sends a *get* command to retrieve the HTML page. Then, the client parses the page during its reception and open connection for each embedded link encountered in the page. The page will be displayed while downloading and embedded documents appearing during their reception.

In [13], a mobile agent acts himself like an HTTP proxy from the browser standpoint and like a client navigator from the server standpoint. Loading a web page requires to fetch the HTML document and to retrieve embedded documents when encountering their references in the page. Giving to the agent the task to pre-parse the page while transmitting it to the client allows sending requests for embedded documents on the fixed part of the network before the client would request them in the classical way and through the radio link. The major problem of this technique is to prevent the client to post requests for documents that the agent has already downloaded. To avoid this problem, a small adaptation on the terminal side is needed. The application should wait for agent to send embedded documents. When the agent finds such a reference in the page, he notifies the program of the incoming file. The program will create a file corresponding to this document in the cache of the browser. So, when the client browser encounters the reference, he will check first in the cache before sending a request to the server.

Users can argue that it is silly to discuss this problem nowadays because the bandwidth is so high that we do not care to waste the bandwidth during a small time interval. This drawback or rather strategy is not penalizing as long as we use resources on actual wired high bandwidth computer networks. However, we think that this strategy becomes really critical when working on mobile equipments, which suffer from lower quantity bandwidth.

Simulation results that presented in [13] show clearly that mobile agents based framework improves web access performance in various situations with a gain up to 20%.

V. WP4: DEMONSTRATION

Because of the delay encounter by UMTS manufacturer, field test of full UMTS was not available during the first phase of the project. However, basic test have been made and showed that UMTS was not ready for packet traffic (the tests were conducted in summer 2000 on an experimental platform tested by SFR). In parallel, an UMTS-TDD software radio platform has been developed and adapted to SAMU project. This platform was used to demonstrate telematics applications based on IP over an UMTS-TDD link. The applications were specifically developed by Renault, the car manufacturer, and correspond to real expectations of users in a car. The following paragraphs describe in more details the software radio platform [15].

The experimental platform used in the SAMU project is an early prototype of an UMTS-TDD platform which is under development in the framework of another RNRT project, the PLATON [16] project. The twofold features characterize the platform: flexibility, achievable by a software driven architecture and duplex communication.

In this prototype version, the platform has been based on single antenna architecture for the mobile station as well as the base station. An extension to multi antennas is currently under progress. The system elements are:

- A RF Front End capable to receive and transmit UMTS radio signals and providing AD/DA conversions.
- A data acquisition card permitting high speed full duplex transfer from the base band subsystem to the RF front end.
- A base band module based on a standard Pentium PC architecture.

The platform provides IP connectivity between a mobile station and a server in the fixed network. For the SAMU experimentations, the platform has been configured to provide up to 400 kbps on the downlink and up to 100 kbps on the uplink channel.

The Figure 3 depicts the UMTS-TDD platform.

Figure 3. UMTS TDD platform used in the SAMU project

The UMTS/TDD standard proposal has been considered for a first implementation because of several reasons. For instance, contrary to the FDD mode the TDD mode only needs a single band for both uplink and downlink. Under certain conditions TDD allows reciprocity between the uplink and downlink channels. This feature turns to be very useful to perform effective downlink transmit signal processing exploiting uplink channel measurements, in particular when employing multiple antennas. The UMTS/TDD proposal also envisages the use of short periodic spreading codes (contrary to the FDD mode) allowing the design and implementation of sophisticated signal processing algorithms (e.g. multi-user detection). Therefore, beyond the SAMU experimentations, this platform could be used for validations of advanced mobile communication signal processing algorithms.

VI. Conclusion

This paper presented the results obtained in the collaborative project SAMU, co-funded by the French government. The areas investigated by this project covered various themes such as resource management, end-to-end IP transport, software agents, and validation through experimentation. These areas of coordinated research have a single goal: to provide the car users with better services.

References

[1] http://www.telecom.gouv.fr/RNRT/

[2] http://samu.crm-paris.com

[3] http://www.3GPP.org

[4] http://www.IETF.org

[5] V. Jacobson and K. Nichols and K. Poduri, “An Expedited Forwarding PHB”, RFC 2598, June 1999.

[6] J. Heinanen and F. Baker and W. Weiss and J. Wroclawski, “Assured Forwarding PHB Group”, RFC 2597, June 1999.

[7] T. Al-Meshhadany and K. Al Agha. “A new code allocation scheme for UMTS system”. In IEEE VTC'01-Fall: Vehicular Technology Conference, Atlantic City, USA, October 2001.

[8] T. Al-Meshhadany and K. Al Agha. OSSC: “A new scheme for code allocation in WCDMA”. In IEEE PIMRC'01: Personal Indoors and Mobile Radio Communications, San Diego, USA, September 2001.

[9] C. Berrou, A. Glavieux, P. Thitimajshima, “Near Shannon Limit error-correcting coding and decoding: Turbo-codes”, in Proc. IEEE International Conference on Communications, 1993.

[10] G. Vivier, “Simulations of HARQ for Turbo-coded services in UMTS-TDD”. EPMCC'01: European Personal Mobile Communication Conference, Vienna, February 2001.

[11] V. A. Pham and A. Karmouch, “Mobile software agents: an overview”, IEEE Communications, vol. 36, July 1998.

[12] L. Perato and K. Al Agha. “Reduction of signaling on cellular systems with mobile agents: the POP3 application.” In IEEE PIMRC'01: Personal Indoors and Mobile Radio Communications, San Diego, USA, September 2001. IEEE Publisher.

[13] L. Perato and K. Al Agha. “Web access for the UMTS air interface by using mobile agents.” In IEEE WCNC'02: Wireless Communications and Networking Conference, Orlando, USA, March 2002. IEEE Publisher.

[14] R. Fielding, U. Irvine, J. Gettys, J. C. Mogul, L. Masinter, P. Leach, and T. Berners-Lee, “Hypertext Transfert Protocol,” RFC 2616, IETF Network Working Group, June 1999.

[15] C. Bonnet, G. Caire, A. Enout, P. A. Humblet, G. Montalbano, A. Nordio, and D. Nussbaum, “A software radio testbed for UMTS TDD”, Proc. of ISTMobile Communications Summit 2000, Galway, Ireland, October 2000.

[16] PLATON: software implementation of the UMTS/TDD standard proposal, including networklayer (IPv.6) and multiple antennas functionalities. Information available at http://www.telecom.gouv.fr/rnrt/projets/res_61_ap00.htm