SIP based services and Virtual Home UMTS environment in the IST research project "FUTURE"

Filomena Del Sorbo, Giuseppe Lombardi, Dario Pompili
Computer Science Department, University of Rome "La Sapienza"
Via Buonarroti, 00184 Rome
The authors are listed in strict alphabetic order

Abstract- **The integration of a terrestrial UMTS network with a satellite platform represents one of the most attractive proposals to develop a functional Virtual Home UMTS environment for a generic mobile user provided with an "ad-hoc" dual mode terminal, which will be able to exploit the two integrated systems (hereafter referred to as "segments") for a set of innovative multimedia services. At this purpose, the IST research project "FUTURE" (Functional UMTS Real Emulator) aims at studying and implementing an integrated Satellite and Terrestrial UMTS (S-UMTS, T-UMTS) demonstrator in order to develop new multimedia services provided "anywhere for everyone", targeting, at the same time, to an efficient exploitation of the satellite transmission capabilities. This paper deals with the implementation and the demonstration of new services, based on the adoption of the SIP (Session Initiation Protocol), in the overall FUTURE scenario.**

I. INTRODUCTION

In the age of multimedia communications, new market scenarios are open to the development of innovative services upon the future telecommunication networks. The unexpected success of the second generation cellular systems has stressed the desire of the final user for ubiquitous services to be provided "everywhere and anytime", regardless of the user's status and position. Furthermore, the availability of advanced transmission systems, i.e. the arising UMTS standard, implies the necessity of the development of new services, which should be able to exploit the capabilities of such systems.

In this framework, the European IST Research project "FUTURE", through a consortium composed by important European universities and telecommunication companies, aims at the development of an integrated satellite and terrestrial UMTS network, that will be able to offer to the final user a huge set of innovative services with a wide coverage area. In other words, the basic goal of the FUTURE consortium is the design of a "Virtual Home Environment" for the final user through the adoption of new services which should be attractive for him, being able, at the same time, to fit in the most convenient way the multicast/broadcast capabilities intrinsic in the satellite segment. At this purpose, the properties of a high-layer signaling protocol such as the SIP (Session Initiation protocol) have been investigated and new SIP-based services have been developed.

All these issues have been deeply analyzed at simulation level, allowing to demonstrate the efficiency and the feasibility of the innovations proposed. At the same time, the FUTURE consortium aims at developing a suitable demonstrator, which will be used to carry out and prove all the achievements of the project. The architecture of the demonstrator comprises two Dual-Mode user terminals (i.e. being able to be connected both to the terrestrial and to the satellite network), an access section and a real core network. The radio access network's Physical Layer is emulated by a proper device, named ROBMOD, which is able to emulate all the physical characteristics of an integrated terrestrial-satellite UMTS (i.e. delay, fadings, multipath, losses); ROBMOD also allows to emulate both a GEO and a LEO satellite constellation, in order to show the different performance of the two possible constellations. The core network is composed by a set of standard UMTS nodes (SGSN, GGSN, etc.). The architecture of the FUTURE demonstrator is depicted in the following figure no.1

On the left there are two Dual mode Mobile Terminals (MT) linked to the two UMTS segments and to a GPRS segment by means of a terminal inter-working unit (T-IWU); it is worth mentioning, on the right, the SIP based Internet Multimedia (IM) subsystem, which comprises a User Mobility Server (UMS), a Call State Control Function (CSCF) and a Feature Server, which will be detailed in the followings.

The goal of this paper is to introduce some new IP multimedia location based services that are targeted for the overall integrated terrestrial-satellite network; in this way, it will be possible to show how the "Virtual Home Environment" concept has been developed in the FUTURE

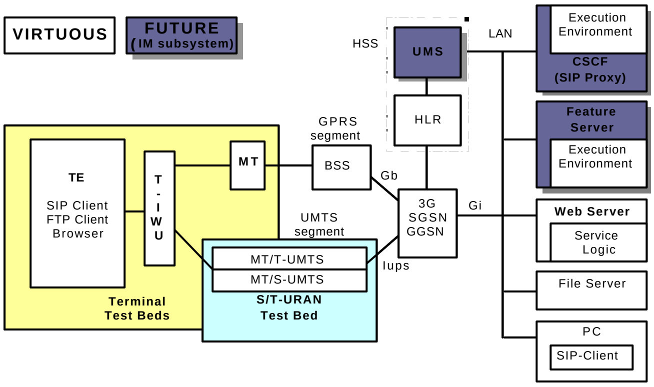

Fig.1. FUTURE demonstrator architecture

project scenario. Extensive simulation results will be added to prove the feasibility of the new services proposed.

II. SIP AND THE DEVELOPMENT OF NEW SERVICES

The SIP (Session Initiation Protocol) is a proper tool used to establish, modify and terminate all types of sessions. These sessions include Internet multimedia conferences, Internet telephone calls and multimedia distribution. SIP is a text-based, HTTP-like protocol, with two types of messages, requests and responses.

SIP is able to invite parties to unicast or multicast sessions and it is not necessary that the initiator is a member of the impending session. Two types of SIP entities have been designed and simulated ad hoc for the FUTURE project: SIP User Agents (UA, placed in the terminals) and the SIP network server, i.e. the Call State Control Function (CSCF). Also the User Mobility Server (UMS) has been designed and implemented: the UMS, together with the Home Location Register (HLR), composes the Home Subscriber Server (HSS), and contains information about the system where a mobile station is currently registered. It stores the User Service Profile and User Mobility information. It is involved in the registration phase and it is interrogated to retrieve location to reach a user. The CSCF acts as a SIP Proxy and as a SIP Serving Function. As a proxy, it acts as a gateway between the IM subsystem and the access network (S-UMTS, T-UMTS, GPRS). It interrogates UMS to retrieve the user's address and forwards SIP request/response from UE to Serving CSCF (S-CSCF) and vice versa.

Network servers are used for call routing and call states maintaining. SIP is able to manage the user mobility functionality, i.e. a user may receive and terminate calls on any terminal and in any location.

It is worth highlighting that the SIP is completely independent from the lower-layer transport protocols and furthermore it can be extended with additional capabilities.

One of the objectives of the FUTURE project is the implementation of applications combining the advantages of real-time multimedia communication services and the non real-time Web based information services.

The promising capabilities of the SIP-based Multimedia Subsystem have been tested particularly concerning the flexibility added to the multimedia sessions. This flexibility includes the modification of sessions (determination of media parameters) and the management of participants. In this way, multimedia services taking advantage of these features have been/will be tested in order to validate the IP Multimedia Subsystem functionality. In particular, the broadcasting, multicasting and location-determination capabilities of the satellite segment have been evaluated through services that are based on these features.

All these features have been taken into account in the implementation of a particular class of SIP based services in the overall S-UMTS, T-UMTS system, that are the so-called "Location Based Services" (LBS), which have been developed, tested, simulated and will be finally implemented in the demonstrator.

The location based services are based on the idea to enable a user to receive information that is specific to his/her actual geographical location. This allows ideating a huge variety of services targeted to the user's actual position. Just to have here an idea of the LBS potentialities, it is possible to imagine advertisement targeted to the user's actual position (such as shops located near the user's position, etc.) but also, for instance, tourist services based on tourist information sent via multicast from a remote host towards a group of interested users, especially near tourist-interesting areas.

This information service requires prior subscription of the user. During subscription the user has the possibility to control the type of information provided. He/She is able also to choose between traffic and advertisement information

After subscription, the user shall receive information according to his/her actual geographical location and to the selected type of information service.

Whenever the served user wishes to terminate the information service, he/she is able to cease his/her subscription.

As already mentioned, some of the most interesting location based services that the FUTURE projects aims to implement are going to be marketing services, tourism information services such as city mapping, archeological information, lodging and dining information etc.

In the next paragraph all the technical aspects implied in a generic location service design will be stressed, such as the location of users in a certain area and the procedures to admit users to the service, and the simulation results will be shown to demonstrate the feasibility of the service and the validity of the design choices.

These issues have been faced and solved at simulation level, allowing the start, in the nearby future, of the implementation and trials campaign phase.

III. LOCATION BASED SERVICE DESIGN

The development of the Location Based Service starts with the integration in the FUTURE architecture of procedures used to detect the user's geographical position.

Basing on the UMTS procedures developed to estimate the geographical position, it was decided to simulate a procedure based on the integration of GPS detection system with a simple transmission delay (TD) detection method, based on the relevant transmission delay over the uplink connection: this positioning is called Assisted Future GPS Method (AF-GPS). There are two fundamental reasons which sustain this choice: the FUTURE architecture constraints, due to the presence of only one emulated T-UMTS radio station, spoil the design of a pure TD oriented position method. On the other hand, a pure GPS method results insufficient to give the requested measurement precision for operative LBS services.

The integration of the GPS method and TD method can be obtained in this context basing on the following hypotheses:

- errors relative GPS coordinates are statistically equal: it is a reasonable assumption considering the GPS error characteristics;
- the transmission delay is not affected by the degradation of multi-path noise.

In this context the GPS position information can be corrected using a simple second-degree equation. In particular, the following assumptions have been made:

- X and Y, which are the coordinates produced by GPS, are both characterized by the same equal error α respect to the real geographical coordinates; so, the real coordinates will be $x=X+\alpha$, $y=Y+\alpha$;
- the distance between the mobile and the radio station, namely d, is equal to [light speed]* [transmission delay]; the transmission delay is the difference between the time-of-arrival of the position measurement packet and the sending-time of this packet (information included in the packet format);
- Q, W are the geographical coordinates of the radio station.

With these assumptions, the second-degree equation that has to be solved (using α variable) is:

$(x-Q)^2+(y-W)^2 = d^2$.

The α solution, which has to be chosen, is the one that respects the GPS error constraints; if both the two α solutions respect GPS error constraints, the one with the smallest abs (α) will be selected.

The second step, needed to develop the LBS in FUTURE, aims at studying the LBS area design. The location area design is a really significant issue in the LBS context because a location service produces useful information only if the requester receives this kind of information when his/her position respects particular constraints. In other words, the utility of the information provided by the location service changes depending from the user position. Starting from these considerations it is evident that the LBS area has to represent the above-mentioned concept of position-depending value for the LBS information. In other words, basing on the 3GPP issues about the efficient use of radio bearers and the idea of maximizing the LBS information utility for the final user, it has been decided to define the location area as the only place where the user can access to a particular location based service. In the location area characterization it is also necessary to take into account a realistic scenario with different users located in the LBS area that are sharing the same transport capacity. If different users ask for different contents, the relevant downloading priority is mapped on the assignation criteria of the transport bandwidth in function of the relative users position inside the LBS area.

The relevant procedure is named Position-dependent-bandwidth-allocation (PDBA).

In order to develop such procedure, it is fundamental to implement a realistic user-mobile-movement emulator (UMU).

The user-mobile-movement emulator describes the movement evolution of a mobile user, which is located in the simulation area scenario.

It is possible to distinguish two types of movement evolutions:

- a movement that describes the behavior of a user which is entering the LBS area (Entering trajectory ET);
- a movement that describes the behavior of a user, which is not entering the LBS area (not-entering trajectory NET).

The ET simulated model is a set of procedures based on a 2-D ergodic processes family. These processes present a mean statistical value that defines a movement vector directed towards the center of the LBS area.

The NET simulated model is a different set of procedures based on a 2-D ergodic processes family. These processes present a mean statistical value that defines a movement vector not directed towards the center of the LBS area, but over the borderline of the LBS area.

In addition to the UMU, the simulation architecture comprises the AF-GPS protocol, which is the communication mean between the GPS and the SIP Proxy; this protocol is located over IP and it works reading the mobile coordinates stored in the IP packet payload (it is necessary to remember that the GPS is integrated in the mobile terminal). In the simulation, to respect the 3GPP directive about the necessity of minimizing the bandwidth consumed to send the localization information, it is explored the idea of using the adaptive rate (ADR) protocol. In more details, the GPS sends position information packets with a certain frequency; the SIP Proxy, using the ADR protocol, has the possibility to make requests on this frequency value. In fact, to manage the position information it is inevitable to consume bandwidth, but with the ADR protocol it is possible to decrease or increase the frequency of location information packets arrival depending on the particular situation, avoiding this way bandwidth wastes. At the same time it necessary to minimize the number of false borderline crosses, which constitutes the most expensive kind of error.

Taking into account these considerations, four service admission (SA) procedures, which represent an evolution of the cell-delineation GSM algorithm, have been designed and analyzed. The idea is that a user has to receive the service only if he/she is in the chosen area and that, at the same time, it is necessary to avoid the admission to the service of users having a false entering trajectory. These SA procedures are based on this condition: a user has to cross the LBS area borderline for two consecutives times to be invited to the set of the LBS users.

The four procedures are all based on the fact that the sampling rate of position information assumes two different values depending from the user position (inside or outside the LBS area).

In the first procedure the position information sampling rate is the same inside and outside the LBS area, in the second the position information sampling rate inside the LBS area is twice the one outside, in the third the sampling rate inside is treble the one outside and so on.

Another fundamental issue explored in the simulation is the position dependent bandwidth allocation. It has been already stressed that the information utility changes with the user position; as a consequence, in the simulation model it has been considered a circular LBS area and it has been decided that the downlink capacity of the multicast channel grows with the approaching to the center of the LBS area if the mobile user is alone. Otherwise, if there are two users in the LBS area, the downlink capacity is divided in two sub-channels: the bandwidth division obeys to the criteria that the user closer to the LBS area center conquers the highest portion of bandwidth, but in any case, reserves a part of bandwidth also to the low-priority user.

The software used for the simulation is OPNET.

Figure 2 shows the simulation scenario where it is possible to identify:

- mobile users, represented by the Portables terminal named User E and User D;
- the Proxy server, where collapses all the FUTURE LBS Logics.
- the HSS, which is the SIP entity storing the user profile;
- fixed users, represented by fixed terminals.

As already said, OPNET simulation tools have simulated a generic LBS. The admission of a user to the service depends on:

- **mobile user terminal capabilities:** the mobile terminal has to respect the service quality constraints;
- **mobile user position**: the user has to respect LBS SA procedures and the allocated bandwidth has to be sufficient for the quality of service constraints;
- **User A decision**: it has been established that the user A manages the service and may decide to invite or not a mobile user in the set of service users. In fact, when the SIP Proxy realizes the presence of an user which respects the two above mentioned conditions, it informs all the users present in the service set, but leaves to the user A the faculty to invite or not the new users.

Figure 3 shows the variation of bandwidth allocation for the four procedures organized by different colors: the absolute shifting among the four curves is limited; this means that the

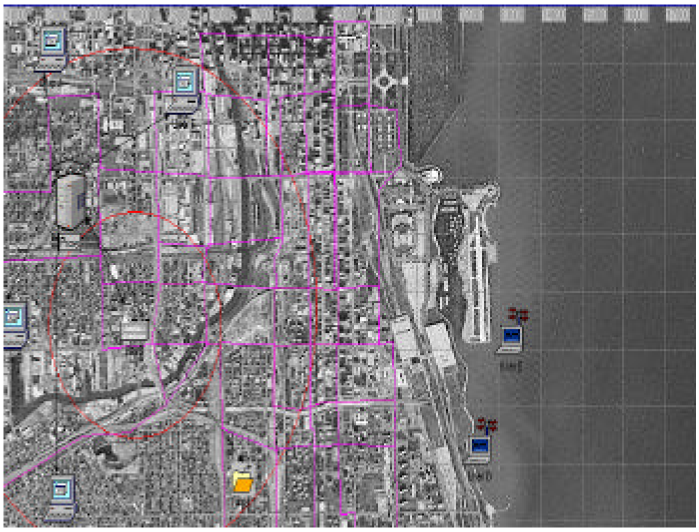

Fig.2. OPNET simulation scénario

only considerable difference among them is the time spent to recognize an entering trajectory.

This fundamental result may be deduced also from figure 4: it shows the bandwidth allocation in the time for one mobile terminal, using the first and the second procedure. The curves peaks correspond to the user invitation; the first procedure (blue curve) may be considered as the reference model for the other three proposed procedures; it results clearly that the second procedure (red curve) spends more time to invite the user, but it does not make the worse mistake, i.e. it does not invite the user when it is not entering the LBS area.

So the proposed SA procedures allow to spent less bandwidth for the presence information transmission, avoiding the worse kind of errors; the only price to pay for it is an increase of the time spent to invite an user. Considering this last issue, the second may be considered the best procedure because the other two produce a too high SA delay.

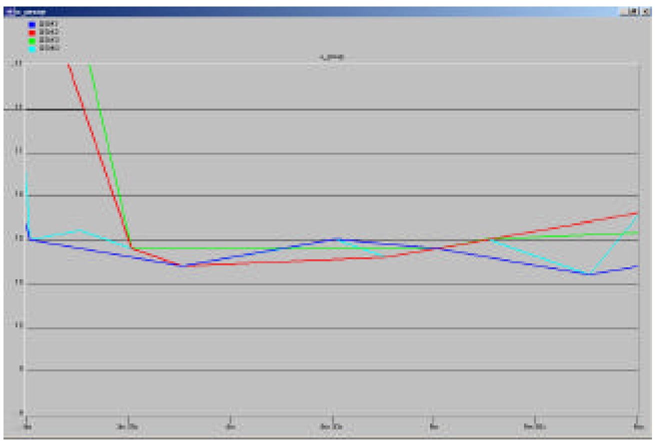

Fig.3. comparing bandwidth allocation for the four procedures

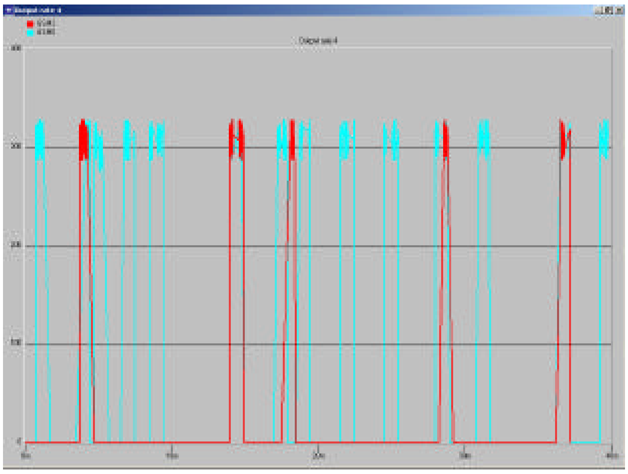

Fig.4. comparing of first two procedures
positive results

IV. CONCLUSIONS

The adoption of new services is expected to play a fundamental role for the successful development of the future mobile communication systems. In the framework of the FUTURE project, an integrated Satellite-Terrestrial UMTS scenario has been designed to develop an actual Virtual Home UMTS environment to carry out these above-mentioned services. In particular, some attractive Location Based Services (i.e. advertisement, marketing and so on) have been designed ad hoc for FUTURE, requiring the adoption of specific tools (the location determination and the bandwidth allocation above all), which have been analyzed and simulated in view of their implementation on the demonstrator. The simulations developed have given a tool for deciding in which way it is possible to implement a set of location based services in the FUTURE network scenario, allowing also to decide the most appropriate procedures to be selected for their efficient management, with the provisions of results showing the feasibility of this task.

REFERENCES

[1] 3GPP, "3G TS 22.105 V5.0.0: Systems and Service capabilities"

[2] Handley, Schulzrinne, Schooler, Rosenberg, IETF-RFC 2543bis-03ps

[3] Schultz, Albani, Huber, Dimopoulou, Giralda, “The IST Project FUTURE - Extended Service Capabilities in a multisegment environment”, Proc. of the IST Mobile Summit 2001, Barcelona.