EVOLUTION PHASES INTEGRATING SATELLITE AND TERRESTRIAL NETWORKS IN THE CONFIGURATION OF S-UMTS

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Abstract – S-UMTS assumes the role of a new generation global system for mobile communications. The standardization of its newly introduced technologies and features is on the run. This paper proposes a possible structure of S-UMTS and discusses steps towards the final architecture. A smooth migration process is suggested resulting in a system with all requested new features which is compatible and involves almost all, previous generation, terrestrial and satellite systems. The first step foresees the interworking of today operable systems achievable by introducing Interworking Units (IWUs) which connect regarded systems and provide some of the needed features. The next step involves introduction of new elements, which should work together with the previous generation systems. By adding elements, in the further steps, the new S-UMTS system becomes independent of the "old" generation systems. However, a complete usage of the previous systems will be sustained. The users will have the possibility to get new services, but also to remain in their "old" systems. In both cases a connection with every single part of any of the "old" or "new" generation networks is possible.

I. INTRODUCTION

S-UMTS (Universal Mobile Telecommunications System with Satellite component) represents a real Third Generation Global System for Mobile Communications. It will add new features and introduce relevant technological innovations evolving from second generation terrestrial and first generation satellite mobile communication systems. Standardization process in Europe is led by ETSI (European Telecommunication Standard Institute) which recently started to coordinate its work with other standardization institutions world wide. Different approaches, mixed with market requests and reality dictates, led to many changes in concepts and strategies of S-UMTS development. The very first ideas introduced completely new systems, but neglected the reality, i.e. the previous investments in second generation systems and their wide usage. It became obvious that during and after implementation of a new system the exploitation of already operated systems was a necessity. These facts turned the investigations and standardization process in the direction of a smooth migration process. In this light, S-UMTS was seen as a system which would be implemented stepwise. In the first phases, as well as in the end, the usage of today operable systems would be sustained, while the new elements, protocols and procedures are gradually introduced.

The idea is that at the beginning only few of the wished new generation features will be available. To achieve this, work must be done to provide interworking possibilities for the second generation terrestrial, as well as the first generation satellite mobile communication systems. The term *interworking* stands for more systems existing together, interacting, providing their services seamlessly to all users and on all places covered by mentioned systems without the change in any of the system parts, protocols or procedures (1). Interworking will be achieved by using IWUs, relay systems, which perform it's relaying function at the Network Layer. These units will provide additional functionality to the systems. They will necessarily adopt protocols and procedures or provide the possibility to get additional data needed for the connections, but existing in the data base of other by IWUs connected, systems.

The following phases foresee an introduction of new system elements, protocols and procedures. These parts will have a full compatibility with the previous system generation. Complete usage of the "old" equipment will be possible. Nevertheless, the new equipment, also on the user side, will be introduced. By these innovations further services will be offered. These migration steps are marked as integration and interworking. *Integration* is defined as incorporation of a part or the whole S-UMTS functionality into contemporary and evolving systems and networks resulting in the capability to provide S-UMTS services (2). The difference, compared with interworking, is that systems are changed by involving new parts or protocols. Finally, all necessary parts for the complete function of the new generation systems are integrated with each other and with the previous generation systems.

Due to the stepwise strategy the users right to use their "old" terminals as long as they want has been taken into account. On the other hand, it is more reasonable for investors, which could apportion their investments in more steps and also further use already installed systems.

This paper presents in the second part the concept as well as requirements and expectations on S-UMTS. It follows the description of the proposed steps and evolution phases for interworking and then, integration of various satellite and terrestrial networks in the configuration of S-UMTS. The last section concludes the paper.

II. CHARACTERISTICS OF A THIRD GENERATION MOBILE SYSTEMS

S-UMTS is an ambitious integration task. Basic innovations and revolutionary techniques are requested. The fascinating multitude of existing first and second generation telecommunication systems and heterogeneous computer communications networks has to be evolved towards a universal, global, distributed system, which appears to the user as one unique omnipresent infrastructure for personalized mobile multimedia services. Features of third generation systems regard the kind of services offered and the approach to provide services across network boundaries. The basic requirement for S-UMTS is the capability of supporting multimedia services with data-rates of up to 2Mbit/s. This implies that S-UMTS will be a broadband system in contrast to most of the narrowband second generation systems. To assure a long technical lifetime for S-UMTS, one related requirement is that S-UMTS must have a very modular structure. It can be optimized for new and specific services only by this means. The multimedia services to be supported by S-UMTS will differ from second generation services particularly with respect to the *variable bit rate* (VBR) used. Hence, packet switching techniques used in second generation enhancements like GPRS, are foreseen with S-UMTS to make efficient use of the resources. A flexible bandwidth allocation scheme will be necessary. Especially within the network, switching and transport capabilities must be sufficiently available to support high data-rates. The separation of call control from connection and bearer control is a way to add or remove bearers during a connection. This is also important to guarantee different classes of quality of services in the system. Classes of service are another important service related requirement for third generation systems.

From the user point of view important fact is that he will be able to use the same mobile station exploiting various access systems including terrestrial as well as satellite based. In third generation systems the user will be able to select a set of services and will find one terminal that will integrate all the required functionality. That implies that user could be served by different access networks or even obtain a service mix from more then one provider. S-UMTS user will using his mobile terminal be reachable everywhere on the globe. This important feature is known as global roaming. It should be stressed that satellite networks plays a non-replaceable role by providing a global roaming functionality.

Further, an objective of S-UMTS is to assure seamless provision of global services. That means that support of new handover functionality between S-UMTS and the different first and second generation systems should be provided. Increased complexity of handovers compared with GSM is to be expected due to the support of multimedia services, separation of call and connection control and introduction of pico-cellular environment.

III. S-UMTS EVOLUTION PHASES

When defining the S-UMTS a clear understanding of the integration and interworking of the existing first and second generation telecommunication systems and computer communications networks is an absolute priority. Among all these networks, mobile satellite systems hold a special position, primary because some of the requests of the S-UMTS are not possible without them (e.g. global availability) and secondly since they are viewed as a complementary component to the terrestrial mobile systems.

The development of the real S-UMTS is foreseen through several phases which are necessary because of the need to overtake, as much as possible, the legacy of the today operable systems, especially the very much used GSM-like systems.

Interworking phases

In the first phase of the S-UMTS, the usage of the extended reference model similar as the one developed in the INSURED project (Fig. 1) is proposed (4). This model presents interworking of the second generation terrestrial GSM systems and the first generation mobile satellite systems. The GSM and satellite systems remain completely unchanged and the interworking is made possible by the usage of the following IWUs:

- on the network side: IWU1 between GSM Gateway-MSCs (G-MSC) and Satellite-Gateways (S-Gat) for switched connections i.e. IWU2 between GPRS SNs-Gateway (GGSN) and the Satellite-Gateways (S-GP) for packet transmission.
- on the access side: IWU3 as a part of the Dual Mode Terminal (DMT)

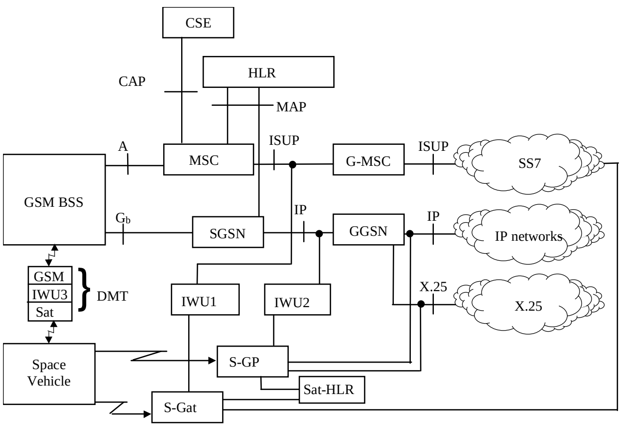

Figure 1: Interworking of the terrestrial system II generation and the satellite system I generation

These IWUs should provide: roaming in both systems, handovers between the systems, S-UMTS services multiplicity (of IC cards, USIMs, user profiles ...), user profile negotiation etc. From the side of the treated networks IWUs are seen as normal elements of this system i.e. G-MSCs and GGSN. All elements connected with IWUs exchange with them only the usual protocol messages. That implies that IWUs integrates all features foreseen for G-MSCs i.e. GGSNs, as well as S-Gats i.e. S-GPs. This and some other functionality implemented only in IWUs make them able to provide before mentioned additional features. A possible realization of IWUs and their protocols and procedures has been successfully implemented and verified by trials in the ACTS project INSURED (5).

All following steps deal with the introduction of the new S-UMTS elements. In the next two interworking phases, only the connection of UMTS Radio Access Network (URAN) and S-UMTS Core Network (CN), with previous generation systems has been considered. Their inside structure wasn't specified. Such approach has been chosen because in the mentioned phases the complete freedom is given in building of URAN and S-UMTS CN since S-UMTS network is totally independent. Limitations are only due to the UMTS requested characteristics, but not to the previous generation systems. The inside structure of the S-UMTS system blocks has been taken into account in integration phases. The idea was to introduce new elements not only to fulfil the UMTS requests, but also to start a stepwise replacement of the previous generation elements.

In the second phase URAN will be introduced. URAN will provide real UMTS access but no UMTS core network will be available (Fig. 2). The ability to provide multimedia features including different logical bearer for different media components, dynamic bearer release and re-negotiation etc., is limited due to the fact that URAN uses GSM i.e. satellite core networks.

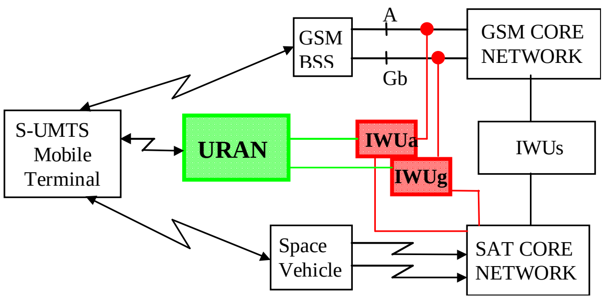

Figure 2. Introduction of the URAN

Nevertheless, further investigations of the problem of e.g. multiple bearers provision resulted in the idea to provide single bearer multimedia where different multimedia components are multiplexed to one bearer instead of providing a multiple bearers for different multimedia components. This is achievable also by using GSM and first generation satellite core networks. Such scenario could be at least used for initial deployment of URAN when only coverage of isolated islands (e.g. city centers, industrial plants, business areas, etc.) could be provided. URAN is connected with core networks via IWUs. These IWUs should adopt the A and Gb interfaces (BSS to the MSCs i.e. SGSNs) to the URAN Iu interface. Also the IWUs from the first phase should be kept.

The step to the third phase would be the introduction of the S-UMTS core network (CN). It, together with URAN, should provide a number of bearers that differ in flexibility and offer various capabilities. These bearers should be independent of the radio interface technology, radio environments and fixed wire transmission systems (note that all IWUs which are introduced in the previous phases must be used because all networks are still independent). In the Figure 3 the connections of the S-UMTS CN with other systems derived from the previous steps have been presented in the GSM example.

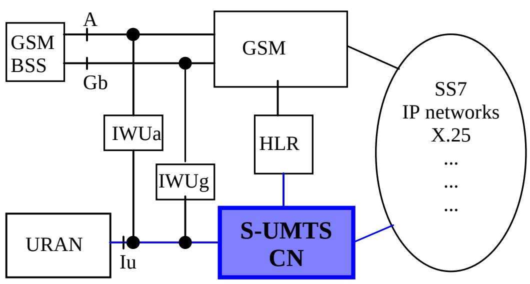

Figure 3: Connections of the S-UMTS CN

Integration phases

Since the discussed matter so far is concerned more with the interworking (even interworking of the S-UMTS with previous generation systems) than with the integration, the first real integration step is proposed in the phase 4 when the S-UMTS MSC becomes a part of the S-UMTS CN (Fig. 4). This scenario assumes that ATM will play an important role what could be expected because of it's benefits like variable bandwidth, support for different QoS requirements, statistical multiplexing etc. The most advanced access systems, as URAN and second generation mobile satellite systems, should be connected via Iu interface directly to the ATM-switch, which is the part of the S-UMTS MSC. Other features, requested for S-UMTS systems, will be also provided using the modules of the S-UMTS MSC that perform separated bearer control from session and call control, sophisticated QoS management, UMTS mobility management integrating voice and packet mobility, support for second generation base stations etc. The latest functionality enables the start of updating the previous generation networks and partial and sequential replacement of their elements. Second generation terrestrial systems base

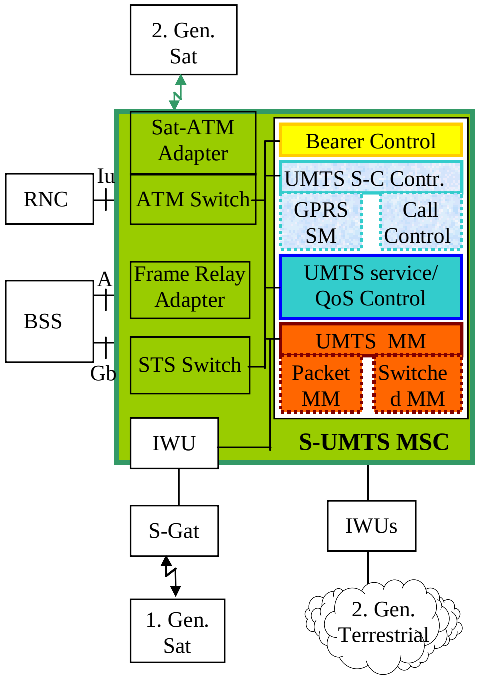

Figure 4: Introduction of the S-UMTS MSC

stations, as GPRS and GSM BSCs, could be connected to the S-UMTS MSC via usual Gb i.e. A interfaces. The necessary functions for this case will be integrated in the common modules of the S-UMTS MSC. This means that e.g. GSM and GPRS mobility management modules will only be a part of the UMTS MM module. Connection with the first generation mobile satellite systems as well as second generation terrestrial systems, which structure remains the same, will be provided over IWUs, which could even be a part of the S-UMTS MSC. The implementation of mentioned IWUs for mobile satellite systems should follow only in a very limited number of S-UMTS MSCs according to the known needs of satellite systems. Note that the modular structure of S-UMTS MSC enables that its complicity could be determined according to its user needs and investments.

In the last phase, all of the "new generation" elements would be integrated in one **ATM area** (Fig. 5). The overall communication in this area is based on ATM: between users and S-UMTS base stations (RNC), base stations and gateways, SVs and S-gateways, etc. The DMT will still be necessary for unlimited access to both satellite and terrestrial networks. The ATM switching will be provided by SV on board or alternatively in the S-Gateways. The control and switching will be separated as ETSI foresees. All data bases will be unified, meaning that ATM switches in every network would be able to route the ATM cells to all the parts of the common network. For example, by handover (HO) from terrestrial to satellite system the user would simply express a wish to HO and his RNC will immediately contact the appropriate satellite part. First and second generation networks will be connected to the ATM area via Gateways and by using Permanent Virtual Circuits (PVC) or Switched Virtual Circuits (SVC). PVCs are used as simple replacement of the facilities provided by conventional trunks and SVCs could be used if the ATM network is configured to support dynamic switching.

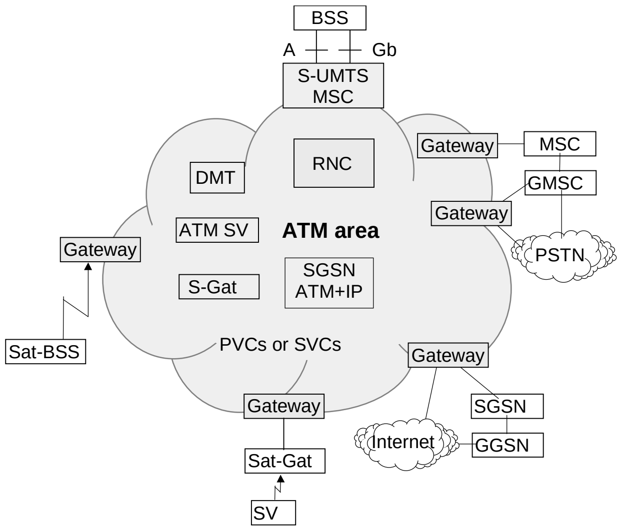

Figure 5: Introduction of the ATM area in the late phase of the S-UMTS

IV. CONCLUSIONS

This paper proposes a smooth way towards the future S-UMTS. Four distinct evolution steps which should provide a natural crossover from today operable networks to S-UMTS are determined. Each step introduces some more of the requested S-UMTS features. The early phases provide only the interworking between various “old” generation terrestrial and mobile satellite systems. It is to be achieved by using IWUs which connect various networks without changing anything inside them. In the following phases then, new elements with S-UMTS functionality are introduced. The first one is proposed to be URAN where the involved elements would have only S-UMTS characteristics. Since URAN must use GSM or satellite CNs (because of lacking of the S-UMTS CN), there will be a damage of the system performances. In the next step this is corrected by introducing S-UMTS CN.

Integration phases introduced elements able to provide S-UMTS services, but also to operate with previous generation networks. S-UMTS MSC is the most important element and his important innovation is the usage of the ATM switching. It was assumed that the last phases will be strongly based on ATM techniques. This led to the common ATM area which integrates all of the new elements but provides further possibility to interwork with unchanged previous generation networks.

It should be stressed that all phases considered also the satellite systems because of their important and non-substitution role especially for global coverage which is one of the most valuable S-UMTS ideas.

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