SATLIFE New Broadband Services over a Regenerative DVB-RCS Satellite Platform

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***Abstract*—SATLIFE, Satellite Access Technologies Leading Improvements in Europe, is a European project belonging to the 6th Framework Program (FP6). SATLIFE includes an ambitious set of R&D activities over the first DVB-RCS OBP satellite platform, AmerHis. The core of this multimedia system is an On Board Processor (OBP), the Alcatel A9343, able to join the DVB-S and the DVB-RCS worlds. AmerHis is actually boarded in the AMAZONAS satellite launched the 4th of August of 2004.**

The revolution of the new technologies and the growth of Internet have motivated the development of new services and applications over satellite. The main objective of SATLIFE (2004-2006) is to evolve the AmerHis system, integrate the multimedia applications in a satellite environment and to extend the concept of 'Broadband for all'. SATLIFE will drive the development of new broadband services and real time applications, based on the AmerHis system.

The consortium coordinated and managed by HISPASAT and co-leaded by Alcatel ESPACIO and Telefónica I+D is completed by Alcatel SPACE, Nera, EMS, Shiron, Univ. Of Surrey, U.P.M., Indra and Thales.

***Index Terms*— Broadband Access, Multimedia Services and Applications, On Board Processor, Regenerative Satellite.**

I. Introduction

Nowadays a revolution in the satellite domain is happening. Thanks to the recent advances in the spatial technology the satellites have moved from being mere repeaters to have the capacity of on board processing and routing capabilities. This on board intelligence has changed completely the type of communications and services that can be offered through a satellite. The new generation of satellites including an On Board Processor opens the possibility to a wide range of broadband and real time services not accessible before.

The main objective in SATLIFE is to create the technological platform that the multimedia market currently needs. SATLIFE is a strategic response to provide broadband access to remote areas where no other option is available (e.g. DSL in rural areas). It is based on the transparent and regenerative DVB-RCS systems and adds enhancements in efficiency, security, multicast, quality of service and integration with terrestrial networks.

This paper describes the system and architecture of SATLIFE highlighting the network aspects as quality of service, multicast and security. Later the services and applications built on top of them are presented, as the logic evolution of the AmerHis system.

II. SATLIFE System

SATLIFE is the evolution of an OBP-based system: AmerHis, an innovative solution in the field of satellite communications. AmerHis contains the A9343, an on board processor that allows bidirectional, multi-beam (Europe, North America and 2 in South America as seen in Fig II-1) and real time communications through the satellite. AmerHis is boarded in the Amazonas satellite from Hispasat and converts the DVB-RCS on the uplink to DVB-S in the downlink.

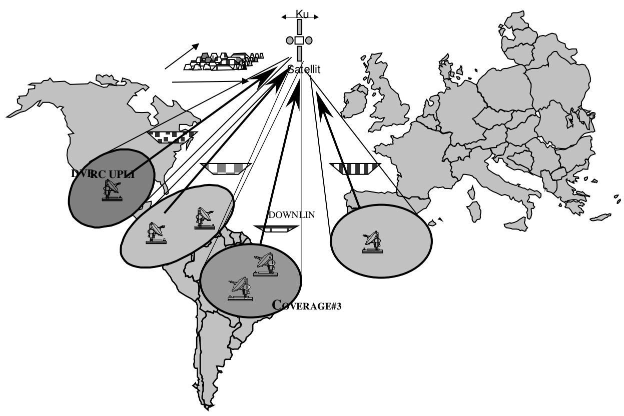

Figure II-1: Multibeam Connectivity in AmerHis/SATLIFE

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III. Actors and Roles

There are different roles in the system defined by a set of management functions. The real entities playing one or several of these roles are called actors. In SATLIFE we can distinguish different roles as seen in the following figure:

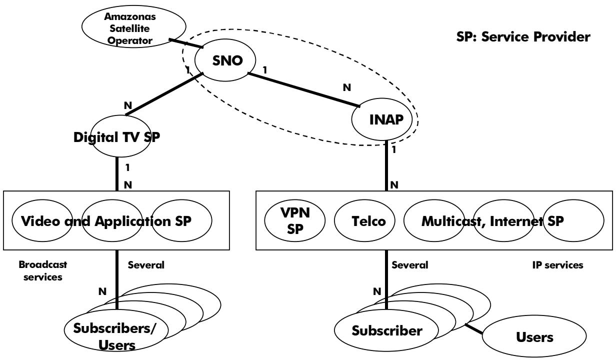

Figure III-1: Actors and Roles in SATLIFE

Amazonas Satellite Operator

It owns and is responsible for maintaining, managing, deploying and operating the AMAZONAS satellite. It exchanges with the satellite network operator the OBP configuration and status data.

SNO (Satellite Network Operator)

It owns and is responsible of maintaining, managing and deploying the SATLIFE system excluding terminals. It is responsible for the global traffic and performance of the network. It manages the partitioning of the resources between INAPs according to their contract.

INAP (Interactive Network Application Provider)

It provides Virtual Satellite Networks (VSNs) to the Service Providers and star and mesh connections to subscribers. One subscriber is linked to one and only one INAP. The INAP allows subscribers to benefit from services offered by Service Providers. It is responsible for the sharing of resources between VSNs. It manages and controls physical resources and RCS terminals.

Service Providers (SP)

They give access to a wide range of services involving terrestrial networks or not. They book capacity (one or several VSNs) to the INAP and offer services to the end user. There are several types of SPs, classified into three groups:

- *Network Service Providers* (NSP): Internet Service Providers, Multicast Service Providers, Telephony companies (Telcos) or VPN Service Providers.
- *Application Service Provider* (ASP): it provides games, Video on Demand, Internet Telephony Service Provider, Multiconference Service Providers.
- *Digital TV Service Provider (DTSP):* for native video broadcasting (or any content as interactive services).

Subscribers

They use the Interactive Services provided by the INAP. It has a contract with an ISP for the provision of services and can host one or several user terminals.

User (or end-user)

It can connect directly or via a Local Area Network its own host to a return channel satellite terminal (RCST). Several users can share the same RCST.

IV. System Architecture

A. Reference Architecture

The SATLIFE system includes the following elements:

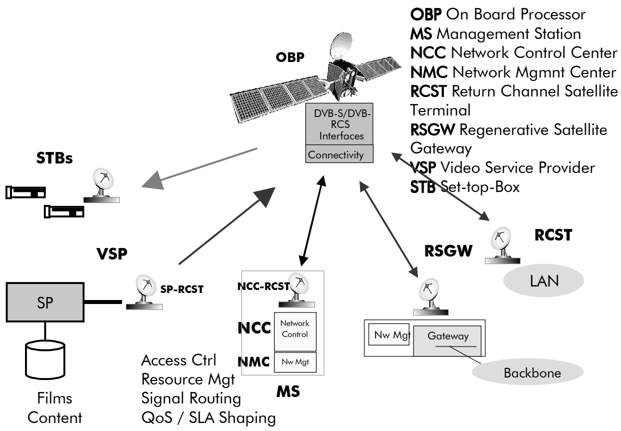

Figure IV-1: Reference Architecture in SATLIFE

OBP (On-Board Processor)

The OBP combines DVB-RCS and DVB-S standards into a single multi-spot satellite system allowing cross-connectivity between different uplink and downlinks thanks to the signal processing on board.

Providing the packet-level switching and multiplexing, it is designed to physically support the IP Multicast on-board.

The OBP payload supports being configured from the management station or through the standard TM/TC channel (see Figure VI-1).

MS (Management Station)

The MS manages all the elements of the system. It also controls the sessions, resources and connections of the ground terminals. It is composed by:

- *NMC* (Network Management Center), in charge of the management of all the system elements.
- *NCC* (Network Control Center), which controls the Interactive Network, provides session control, routing and resource access to the subscriber RCSTs and manages the OBP configuration.
- *NCC_RCST*, the satellite terminal of the MS, supporting modulation and demodulation functions to access to the satellite.

RCST (Return Channel Satellite Terminal)

The RCST (or simply terminal) is the interface between the System and external users. These terminals are able to work in transparent or in OBP-based systems, allowing different kinds of connectivity:

- Single satellite-hop mesh (unicast and multicast) connections with other SATLIFE subscribers or double-hop connections through the gateway. It is possible to interconnect NERA, EMS and SHIRON user terminals.
- Single satellite-hop connections with ISDN/PSTN through the RSGW
- Single satellite-hop connections with terrestrial IP networks (Internet, Intranet).

The bandwidth supported by the terminal ranges from 500 Kbps up to 4 Mbps in the uplink (8Mbps in the downlink. A TDMA scheme allows rates down to a granularity of 4 Kbps.

RSGW (Regenerative Satellite Gateway)

The RSGW (or simply gateway) provides interconnection with terrestrial networks (ISDN/POTS, Internet, Intranet). At the same time, it manages all its subscribers, guaranteeing their Service Level Agreement (SLA).

The RSGW will as well establish point to multipoint connections to provide a dynamic Star Multicast Service.

VSP (Video Service Provider)

It broadcasts video contents directly to end-users having a commercial set-top-box. It consists of two elements:

- *Content Service Provider*: it contains not only the video but also applications to be broadcast. It uses new codecs as H.264 and MPEG2.
- *Terminal (Service Provider RCST)*: it is in charge of transmitting all the data to the air. It must minimize delay as the main traffic is video on real time.

B. Network Architecture

In order to provide secure and efficient end-user services, IP connectivity is used on top of a layer-2 adaptation layer based on DVB Standards.

Routing functions are distributed between the NCC, the gateway and the terminals. The subscriber RCSTs work as routers in front of the final user terminals and provide IP connectivity, QoS, security and multicast facilities.

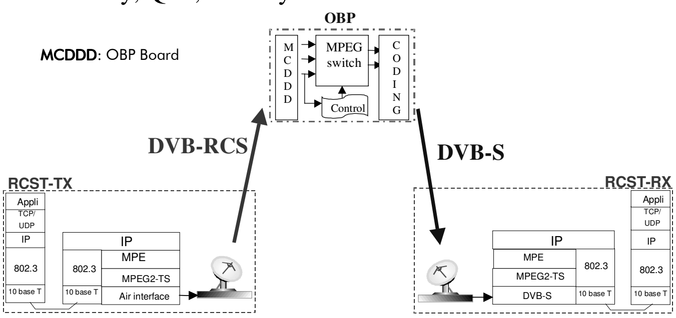

Figure IV-2: Network Architecture in SATLIFE

IP Addressing and Routing

The Interactive Network is partitioned in Virtual Satellite Networks (VSNs), managed by the Service Providers (SPs). Each VSN may use the full private IP address range, plus any public IP ranges. It can work in two modes:

- Routing Mode: terminals behave as routers. Connectivity is performed at level 3 (IP).
- Bridge Mode: terminals behave as bridges. Connectivity is performed at level 2 (Ethernet).

In both cases the whole addressing information is kept into the management station internal database, which will make sure that two terminals belonging to different VSNs cannot establish a connection between them.

Moreover, the VLAN architecture of the RCSTs will allow that one gateway can give service to several VSNs with independent addressing scheme.

QoS

The Network QoS depends on the traffic profile of the whole System and the traffic profile of the RCST.

Quality of service is achieved in each RCST by means of traffic prioritization, allowing that in each traffic channel, packets are classified into two different buffers according to the priority level. Layer-4 and/or layer-3 parameters are used to estimate layer-2 QoS parameter. The following table shows an example:

Layer-3 parameters IP packet level	Layer-2 QoS connection parameters
Source IP address range Destination IP address range DSCP range Protocol Source TCP/UDP port Destination TCP/UDP port	Activity timer Priority (LP/HP) Tx Sustained Data Rate Tx Peak Data Rate Rx Sustained Data Rate Rx Peak Data Rate Direction (unidir/bidir)

In the case of Layer-2 connectivity, i.e. terminals acting as bridges instead of routers, there is a mapping between Ethernet priorities and QoS connection parameters.

TCP/HTTP acceleration is mandatory in geo-stationary satellite environments due to long delays. For that reason incorporation of I-PEP (Interchangeable Performance Enhancing Proxies) protocol in a standardized way for the different terminals is also an objective for the Project's QoS architecture.

Security

System security in SATLIFE intends to cover the following aspects and the final implementation is still under analysis:

- RADIUS user authentication or RCST authentication.
- IPSec for RCST-RCST traffic connections.
- Separate keys for encrypting unicast and multicast traffic.

Some extension of the DVB-RCS security standard is needed to satisfy the former requirements. Key Exchange protocols need to be extended in order to support multiple keys per RCST, to identify which unicast or multicast channel uses a given key. Efficient key transmission, different security profiles, at-logon or on-demand keys sending and periodic rekeying are other aspects to include in the DVB-RCS amendments for SATLIFE security specification.

In Addition, Layer-3 security in transport and tunnel modes, creating security associations from the hosts or the RCSTs, will be supported by the System. Although implying more IP packet overhead, layer-3 solutions evolve easily in time and allow specifying different security levels depending on the service.

The major security demands correspond to Multiconference and Transactional HTTP services. It will be a task for the service providers to evaluate whether the application provides the security needed or it is preferred the Layer-2 solution mentioned above in this section.

Multicast

Taking advantage of the on-board processor (data replication on board), SATLIFE offers a mature multicast solution, characterized by the following features:

- Mesh and Star multicast
- IGMP adaptation for satellite environment
- Adaptation of security protocols to multicast
- Interoperability with other multicast systems
- QoS support (in the NCC, RSGW and RCSTs)

Upon contract service level, multicast transmission is enabled for one subscriber. Any RCST behaves as an IGMP router, and proxies membership reports coming from the LAN interface. Session profiles can be configured in RCSTs at management level.

Multicast Service is used as platform for other System services such as multiconference or streaming. Point-to-Multipoint connections are requested to the NCC from subscribers using the same link layer protocol as unicast. A multicast PID (MPEG2-TS Packet Identifier) range is defined at VSN level. Terminals know by logon the PID to receive the MMT (Multicast Map Table), where the association between multicast IP addresses with multicast PIDs is stated. When a host in the RCST LAN tries to join to a multicast group, its RCST starts to decode the adequate multicast session PID.

The RSGW plays an important role in the Star Multicast Service, acting as the interface with the terrestrial sources. Therefore, it will support GRE tunneling, MSDP (Multicast Source Discovery Protocol) and MBGP (multicast BGP).

V. SATLIFE SERVICES

Several end-user services and applications have been identified as target applications inside SATLIFE:

Video Broadcast and Video On Demand

Several video compression techniques will be studied for broadcasting in SATLIFE apart from MPEG2, having the common objective of reaching the DVD quality. They will reduce the bandwidth used (up to 2 Mbps) and demonstrate that the system supports standards such as MPEG4, H.264 or WM9. A specific terminal for the Video SP, the SP-RCST is included in the system.

The VoD (Video on Demand) service suggests important requirements (time control, unicast channels, conditional access) hard to commit in the Satellite environment. SATLIFE will explore the transmission protocols (RTP, RTCP, RTSP), combined with QoS, necessary to provide VoD and using a normal RCST (for video reception and as return channel).

LAN Interconnection

This service consists of providing to each VSN with unicast and multicast one satellite-hop connectivity using the full private IP address range (plus the desired public ranges). Isolation from the rest of VSNs of the System is assured. Not only on-demand but also permanent connectivity is provided. It is the ideal platform for Corporate services.

Internet/Intranet Access

VSNs including a gateway may connect to terrestrial packet networks, such as Internet or private Intranets. This is very useful when none of the RCSTs of the VSN has Internet/Intranet access, or for individual subscribers willing to access to the Internet. Target applications for this service range from less constrained ones (Web browsing) to applications needing guaranteed rate/delay (streaming media).

The Intranet Access service involves a RSGW connected to the terrestrial network of a Telco (e.g. leased line) and provides interconnection of subscriber subnets from remote locations (branch offices) to the Corporate Intranet (Head Office).

ISDN Access

Telephony calls with ISDN/PSTN users is also possible by means of the gateway. Subscribers registered to the Audio/Video Service can register in the RSGW gatekeeper and establish audio/video conferences with H.320 or PSTN standard terminals.

SATLIFE will support H.323/SIP VoIP clients or standard H.323/SIP phones. The gateway will be in charge of alias translation, call signaling, supplementary services and billing functions. At the same time, QoS provided by the System will ensure guaranteed rate/delay for the audio/video calls, by using the High Priority (HP) queue of the corresponding RCST channel. For the incoming flows, the RSGW will tag the appropriate type-of-service value in the generated IP packets.

V2oIP

Voice and Video over IP (V2oIP) flows are generated from standard host applications, but may be mapped to High Prio flows with QoS support provided by the NMC. Taking into account the benefits of one-hop connections between SATLIFE users, V2oIP results into a high-featured communications service.

Multicast

IP Multicast Service takes advantage of the on-board replication of a single multicast uplink in several downlink TDMs. Two alternatives are provided at subscription level by the System:

Star Multicast Service transports, upon request of the SATLIFE user, IP multicast flows coming from multicast sources in the terrestrial networks.

Mesh Multicast Service provides multicast connection establishment between SATLIFE subscribers and does not involve the RSGW.

Multiconference

The multiconference system over SATLIFE will have the following characteristics:

- Use of multicast connections
- Session and conference control
- Security and QoS
- Subscriber-adapted audio/video traffic profiles

MCU could be employed in certain network connection scenarios, when the number of users makes it impossible by average hosts to support the processing needs, but de-centralized multiconferences will be normal case.

Nomadic Access

Nomadic Access is a fixed mobile solution with automatic scanner polarizer and beam positioner system for an affordable two-way satellite antenna. It provides a broadband access tracking satellites from a mobile vehicle.

To fulfill the former features, it is requested that the terminals support automatic acquisition, satellite independent connectivity and interoperability with other terminals.

VI. System Management

All the Network Elements of the System (NCC, RCSTs, NCC-RCST, SP-RCST, RSGW) will be managed from the Network Management Center (NMC).

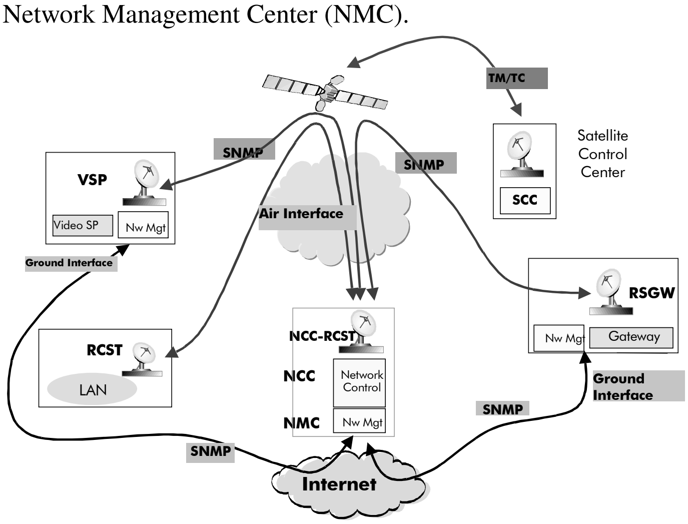

Figure VI-1: System Management in SATLIFE

The Management Station (MS) is responsible for the operation and billing of the system.

The NMC will operate all the terminals of the System, using SNMP protocol for configuring terminal parameters and provisioning the services. It will store information for every user of the System, necessary for the NCC in session, connection and resource control functions.

The Service Profiles will be normally mapped to certain applications, and the subscribers will be able to upgrade the terminal capabilities in a fast and flexible way.

The Interactive Network Access Provider (INAP) operates the NMC to provide Virtual Satellite Networks (VSNs) to SPs and connections to subscribers. It will configure all the satellite routes and VSNs with certain capacity values.

The gateway is managed by the operating Service Provider (Internet, Telephony or Telco), except for the RCST itself, that will be controlled as normal terminal by the operator (INAP).

Billing functions are also centralized by the NMC, which integrates a server collecting the necessary files and counters from NCC and the different gateways.

VII. Conclusions

SATLIFE develops solutions such as Video on Demand (VoD) or multiconference improving the quality of service, the multicast and the security. This makes the satellite network to be an active player of the Next Generation Networks (NGN). SATLIFE represents a step forward in offering multimedia applications over satellite.

The advantages of on-board processing are here shown as multicast and real time services (not available in the current transparent systems as Voice over IP) and interactive applications offered to end-users.

It evolves the AmerHis model towards the commercial deployment and enables the system as an alternative and complement to the terrestrial networks.

Acknowledgment

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