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Abstract
This paper presents a smart collection of existing technologies to provide low-cost satellite delivery of triple-play services to the home with a TV-centric terminal. The satellite connections provides the best and quickest solution to reduce the digital divide in less-favored areas, which has been considered as a major issue in the diffusion of broadband access. The platform employs DVB-S(2) and DVB-RCS technologies in the forward and the return link, respectively. The flexible framing structure of DVB-S2 and the adoption of the Adaptive Coding & Modulation (ACM) functionality allow an efficient exploitation of the satellite resource. The paper provides a description of the TV-Centric services, the required QoS and the relevant system architecture.

1. Introduction

A critical element which constitutes an obstacle to harmonious continent-wide development is the "social divide". The lack of skills and ability to use a computer or other interactive devices create a significant barrier to broadband access to older people. TV-Centric technologies to provide interactive triple-play services satisfy the demands of the broadest possible span of European consumer communities.

Accessing and using new media, such as interactive TV, Internet, mobile video and new combinations of those, whether via a computer, a mobile phone, or a TV Set Top Box (STB), will grow considerably, especially in major metropolises and most developed areas. Unfortunately, rural areas in well-developed countries and large areas with limited terrestrial network infrastructure in developing countries are still excluded from traditional access choices.

Satellite-based telecom systems provide the best and quickest solution to reducing or eliminating the digital divide in less-favored areas to allow the diffusion of broadband access, owing to their wide geographical coverage and the speed and ease of deployment of terminal equipment. For satellite systems to fulfil this role, however, they must be efficient and cost effective, and capable of full inter-working with state-of-the-art terrestrial broadband networks.

This paper presents a TV-Centric two-way broadband satellite architecture developed in the framework of the UNIC (UNIversal satellite home Connection) project (Boccolini et al. 2007, Seager et al. 2007)), sponsored within the 6th EU Research Programme Framework. The UNIC architecture provides TV-Centric triple play services to actual end-users in the home employing DVB-S(2) and DVB-RCS technologies in the forward and the return link, respectively, together with a newly low-cost defined architecture for the distribution of connectivity to end-users.

The flexible framing structure of DVB-S2 and the adoption of the ACM functionality allow optimizing the transmission parameters for each individual user on a frame-by-frame basis, dependant on path conditions and required QoS, under closed-loop control via the satellite return channel. The result is an efficient exploitation of the satellite resources and even greater gain of DVB-S2 over DVB-S for point-to point applications.

The main application scenario of the UNIC system is a remote village not served by terrestrial broadband infrastructures (i.e. ADSL, WiMax). This platform is therefore designed to provide (i) broadband connectivity to the homes, via a bi-directional Collective Satellite Gateway (CSG) located in a building or a village city hall (e.g. serving a group of houses, a village, a large multi-storey building), and (ii) conventional TV/HDTV services via Direct-to-Home (DTH) reception. The user STB, allowing seamless access to the various services independently from their origin/transport

infrastructure, is an hybrid DVB and IP box connected to the CSG through a wired (Ethernet LAN) or wireless (WiFi/WiMax LAN) local broadband network (for interactive IP-based services) and to the DTH receiving antenna through the home cable network (for TV/HDTV services).

The UNIC system provides a set of primary services such as Internet, interactive TV, IPTV, HDTV, VOIP and videoconference services together with another set of innovative services such as surveillance, monitoring, tourism information, distance learning and home-based care services that will reshape the way consumers use DTV.

The system two-way platform fully support the IP and TCP/IP protocols, resulting in an optimisation of the required satellite bandwidth. A reduction in the amount of bandwidth needed lowers network costs and allows for greater profitability of new services.

The first step of the project was to imagine a contour of services towards users of existing satellite TV services who have no access to alternative services (PC access, web access, email, video conferencing, music download). Afterwards, we identified which services were more suitable and viable when carried over new satellite technology. The result of this study is a list of potential services listed in the Section II.

Once the services were defined, the technology adaptation needed to be prototyped to enable their delivery. This required a thorough evaluation of the key parameters impacting the quality of each service - bandwidth, packet loss, delay and jitter - alongside a study of the likely usage across a population to estimate the burstiness of the underlying video traffic. In section IV we will describe the overall architecture of the system.

2. TV-Centric Services

In this section we will first list a set of primary services constituting the *must* of UNIC, that are commonly gathered under the term of *Triple Play* services. These are mainly entertainment services using the TV set as a universal gateway for consumers at home. They all present some differences compared to the usual Triple Play services offered today. Another set of services is further defined to exploit the possibilities of UNIC to provide new original features to consumer or to extend them to business users.

The list of defined services is not exhaustive neither it is supposed to be supported entirely by the UNIC project. This list is solely intended to provide a general overview of the possibilities of UNIC in the context of TV evolution.

2.1 Real Triple Play

Beyond Internet services: Web2TV, Email2TV, Chat2TV, Music Download/Playback, Online Gaming, Home on Demand Gaming, Extreme Online Role-Playing Game (XORGS) Audience, Cyber-Gaming. Internet TV-centric services are mostly intended for people who do not own computers in order to make the World Wide Web available to everyone.

Beyond TV services: SD/HD TV, Personal TV, Interactive TV, Interactive TV return Channel, Personal Video Recording (PVR), Time Shifting (TS), Video on Demand (VoD), Electronic Program Guide (EPG), Mosaic. Several of these are already delivered by terrestrial and satellite Digital TV providers using the current PSTN return channel for interactive services. Exploiting the satellite return channel combined with the DVB-S2 technology will allow UNIC to be an attractive alternative.

Beyond phone services: Phone2TV, Video Conferencing. The TV-Centric structure will ensure that any person with a TV set can potentially communicate with voice and/or video with one or more other distant persons. These services already exist on terrestrial broadband but require a computer, a webcam and adequate video conferencing software. Having a TV-Centric video conferencing service available to any person owning a TV would have a great impact on the business context, considering that it provides a turnkey solution for video conferencing.

2.2 More Services

Surveillance and monitoring services: Home/Office Surveillance/Automation, Weather Monitoring, Crop Monitoring & Management. These services are designed mainly for industrial applications in developed area and to meet local governments' needs in rural areas in developing world.

Tourism services: Interactive Travel Channel, Virtual Cultural Visit (VCV), Real Estate Timeshare Information, Nightlife Events Information, Weather Forecast. It will be possible to access to tourism information in remote areas lacking Internet connection.

Other services: Bringing Courses Into Home, TV All Together, Live Announcement, Assisted Living, TV Health Centre. UNIC can give a large contribution to the continuing trend of distance learning and home-based care services reshaping the way consumers use Digital TV.

2.3 Services requirements

The performance requirements of all services from the user perspective were obtained similarly to ITU G.1010 (2001) to take into account all aspects of a service as it can be experienced by the user. These requirements are *network-agnostic* and focus on user-perceivable effects.

We exploited the QoS criteria commonly used for IP data communication services to define the QoS requirements for the particular services.

QoS criteria for IP data communication services are based on the definition of parameters that allow specification and assessment of the performance of speed, accuracy, dependability and availability of the IP data communication services. In the process of IP packet transfer, the following event can take place: *successful transmission, loss and error*.

We investigated the basic services establishing a set of recommended values for each transfer parameters. The QoS requirements must be fulfilled to achieve sufficient service quality. We used these basic applications as building blocks for the more advanced services outlined in this section. For instance, the Video Conference service requirement is the combination of Conversational voice and Videophone application requirements.

3. System architecture

The following picture recalls the UNIC architecture:

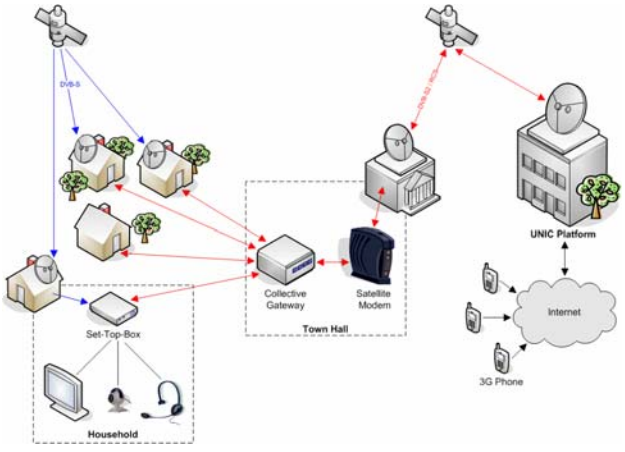

Figure 1: UNIC Architecture

In the picture above, all interactive services (red arrows) transit through the Collective Gateway (CG). The CG is shared among users of the same local network, so is the Satellite Modem and the DVB-S2/DVB-RCS [5-7] connection over satellite. Hence the end-user does not need a personal satellite antenna for these interactive services as they all transit over terrestrial connection (Ethernet or WiFi) from the Set-Top-Boxes to the CG. This architecture resembles the one of standard terrestrial Triple Play service providers where the CG, Satellite Terminal and antenna can be compared to the DSLAM (Digital Subscriber Line Access Multiplexer) except in the case of UNIC the DSLAM is connected to the Internet Backbone via Satellite and through the UNIC Platform.

One of the advantages of the UNIC architecture over terrestrial Triple Play is that the television service is provided Direct To Home (DTH) using the power of broadcast via satellite with the possibility to provide multiple real full HD channels. For this service the end-user will require a receive only satellite antenna (60-80cm) on his/her own roof.

The UNIC System Platform is composed of four segments:

- User /Home Service Segment
- Collective Service Segment
- Transport Media Segment
- Ground Service Segment

A. User/Home Service Segment

The UNIC User is intended as a non technical single in-home user. The UNIC User accesses the normal broadcasted programmes and UNIC interactive services mainly from the television equipment connected to the UNIC STB. The UNIC User can also provide his own multimedia content via mobile phone or PC to a central collection point.

The UNIC STB is defined as the front-end device that allows UNIC users to interact with the contents and the services, providing appropriate user interfaces, navigation tools and local storage.

The UNIC STB is a small box connected to the CG on one side and to a television set on the other side. There could be several STBs in the home, bringing triple play services to multiple rooms. The STB is responsible for dealing with users requests through the remote control (additional user inputs to be considered like webcam, microphone, etc.). Requests are handled locally or transmitted to the CG if a connection to the outside world is required. The STB is also responsible for video and audio output as well as application interfaces rendering to television.

Motorola has developed the DVB STB subsystem. The STB is the platform for the TV centric user interactions and graphical interfaces for the UNIC services provided by the STB Portal. The STB consists of the following parts:

- STB Hardware: including CPU, storage, audio & video codecs, external inter-faces, etc.

- STB HAL (Hardware Abstraction Layer) including Linux Operating System, HW interface library, drivers, etc.
- STB Application Platform including Application services, web Browser and application program interfaces (APIs) for both C++ and Java Script.
- TOIX UI Framework used for the development of the STB Portal.

The STB Portal (see Figure 2) was developed by Eutelsat using TOIX and the JavaScript APIs. The STB Portal is an STB application providing the graphical interface and utilising the functionality in the STB subsystem.

Figure 2. The UNIC portal Homepage

B. Collective Service Segment

The Collective Service Segment (CSS) contains all those components/functions providing services to a community of users (i.e., the residents of a multi-storey building or the inhabitants of a small country village) connected to a bi-directional satellite terminal. Since the satellite media is particularly suitable for multi-casting applications, local storage is a key function of the CSS to allow high quality multimedia services and optimum use of the satellite frequency resources. In case of unicasting, the satellite segment provides ACM functionalities (using the DVB-S2 standard) in order to maximize the satellite capacity throughput .

The Collective Gateway (CG) is the core of the CSS. The CG is the local unit of the platform providing a number of functions available to all the users connected to it. Components of the CG can be described as follows:

The *Captive Portal* (CP) is the subsystem that permits users to access to the built-in TV-Centric Services.

The *Local VoIP Gateway* provides VoIP services to the users. It is interconnected to the centralized VoIP Gateway in the Service Operation Centre (SOC) and provides access to the telephone network using this peer system.

As per the VoIP subsystem also for web content browsing a two level architecture has been chosen. This means that when a user requests a web content the request is automatically redirected to the *Local Web Server*. If the page is already cached by this system (e.g. already requested previously and not yet expired) it is returned to the requestor with no occupation of the satellite link. If the page is not stored yet in the local cache the request is routed to the centralized web proxy-cache and then, if needed to the Internet.

The *Local QoS Manager* is in charge of deciding the QoS policies to be applied for each client and for the whole CG. It is interconnected with the QoS-to-ACM Controller which is responsible for remapping QoS requirements in ACM messages to be sent to the peer system (QoS-to-ACM Actuator) in the Service Operation Centre. QoS information at application level are processed by the Local QoS Manager that can decide to generate ACM messages. The messages are prepared and delivered by the QoS-to-ACM Controller.

The *Multicast Content Delivery Client* (with Local Storage) subsystem receives contents distributed in multicast, stores them on a local storage area and makes them available to the STBs and the client devices.

C. Transport Media Segment

The Transport Media Segment (TMS) provides a communication network that supports multimedia services over GEO bent pipe satellites. It includes ground subsystems (hub, teleport for satellite), communication infrastructure and local terminals. The TMS is designed to complement the direct satellite broadcast (one-way) audio and video transmission channel with a bidirectional IP based access system.

The satellite transport network comprises one Gateway and a large number of Satellite Terminals (ST) connected with the CSS or the HGW. It supports star links between the Gateway and the ST, but also ST to ST connectivity through the Gateway.

The *Gateway* is the central component of the network. It offers a connection to the UNIC platform – and wherefrom external networks – through its IP router. The Gateway handles the traffic between the platform/external networks and the STs and manages all access services. It provides a powerful radio resource management, which allows efficient utilization of the satellite capacity with circuit and packet types of traffic.

The TMS is described here in a layer based

approach. The access layers are divided into the following two links: the forward link, which provides connectivity from the gateway to the STs, based on the DVB-S(2) standards, and the return link, which provides an MF-TDMA access scheme offering cost-effective sharing for the return bandwidth between the STs, based on the DVB-RCS standard.

The access layers are sub-divided into the physical layer (modulation, bursts), the layer 2 transport layer (ATM or Multiprotocol/Generic Stream Encapsulation) and the Medium Access Control (MAC) sub layer. The latter handles the mapping and scheduling of higher layer flows onto layer 2 transport means and it is an important part of the end-to-end QoS enforcement.

At the transport layer, the segment also supports a specific acceleration scheme in order to mitigate the "high delay x bandwidth" adverse effect of the satellite transmission channel on TCP connections.

D. Ground Service Segment

The Ground Service Segment (GSS) contains the:

- Service Operation Center
- Multicast Content Delivery platform
- Integrated Value added Service platform.

The GSS allows:

1) Independence from the actual service providers making the UNIC platform ready to interoperate with different "Existing Service Providers", such as mobile operators, IPTV broadcaster, etc.

2) Central provisioning and access of basic services, making it easy to account and log services and to monitor actual performances.

3) Integrated QoS Management specifically designed to optimize the perceived QoS in the collective scenario, and possibly work in conjunction with the QoS management module at level of TMS.

4) Easy integration of Value-Added Services, such as Push VoD and User-Generated Content or other service platform from external actors.

The *Service Operation Centre* (SOC) provides an independent access to all the available transport media as well as gateway to provide basic services such as SMS/MMS, Email, Internet Access, VoIP Gateway.

The *Multicast Content Delivery platform* is the core of the content distribution system. It is a hardware/software system designed to handle robust and secure multicast content distribution with no return channel. It is based on a Multicast Delivery Framework (MDF), that is a general framework for easy, robust, optimized and secure multicast file delivery and has two main components: MDF Server and MDF Client. The MDF Server has the main role of file pushing through the one-way multicast channel. In order to allow an MDF client to receive the right and expected file other synchronization information are sent, called Electronic Service Guide (ESG). MDF is optimized with full bandwidth control and group management to send the same content to more than one user, but not all the user.

The *Integrated Value Added Service platform* allows the following processes to be applied to the multimedia content: acquisition, storage, metadata provision, transcoding and Digital Right Management.

5. Conclusions

The above paper gives a description of the interactive bidirectional satellite architecture being developed in the UNIC project. Lab and home trials phase is running throughout the first months of 2008, following a stepped scenarios approach. First the delivery of basic IPTV services over satellite is to be validated. Then, additional services (push and forward solutions, content delivery) will be added. Finally, more interactive service will be tried for demonstration. At the end of the project, July 2008, it is expected that the proof of concept platform will show the potential of the TV-centric satellite approach, using efficient standards, and leveraging on terrestrial IP solutions, to bring to TV users in remote areas an effective access into the digital world.

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