



SAMBA

WP 3 – Requirements and Architecture

Deliverable 3.2.1

System Architecture Specification

Reference:	SAMBA/PUSP/wp3/3.2
Category:	Report
Author(s):	Denis Gabos, PUSP; Rodrigo Filev Maia, PUSP;
Verification:	Oscar Mayora, CN, Andreas Zoeschg, DIGILAB
Date:	16/12/2007
Status:	Final
Availability:	Public

Document History

Version History

Version	Status	Date	Author(s)
1	Without Mobility support	December 10th	Denis Gabos (PUSP), Rodrigo Filev Maia (PUSP)
2	With mobility support	December 17 th	Denis Gabos (PUSP), Rodrigo Filev Maia (PUSP)
3	With Final Review	January 10 th	Oscar Mayora (CN), Andreas Zoeschg (DIGILAB)

Contents

1	Introduction	5
1.1	Finality of this document	5
1.2	Scope	5
1.3	Definitions, Acronyms and Abbreviations	5
1.4	References	6
2	SAMBA FRAMEWORK	8
2.1	Functionalities	8
2.2	Domains	8
3	SAMBA ARCHITECTURE	10
3.1	Introduction	10
3.2	Content Domain	10
3.3	Platform Domain	11
3.3.1	CMS	12
3.3.2	Transcoders and Compilers	13
3.3.3	DVB HEAD-END	14
3.3.4	DVB-T Transmission	16
3.3.5	Return Channel Server	16
3.4	User Domain	17
3.4.1	Introduction	17
3.4.2	Architecture with PLC Return Channel	17
3.4.3	The Set-Top-Box	17
3.5	SAMBA Complete Protocol Stack	18
3.6	SAMBA and IMS	18
3.6.1	Return Channel Server and IMS	20
4	MOBILITY SUPPORT IN SAMBA – RETURN CHANNEL	22
4.1	Introduction	22
4.2	GSM/GPRS	22
4.2.1	Basic Technology Background	22
4.2.2	GSM/GPRS Network Architecture	23
4.2.3	Protocol Stack Analysis – GSM/GPRS Return Channel	23
4.3	WIMAX	25
4.3.1	Basic Technology Background	25
4.3.2	WIMAX Access Network Architecture	26
4.3.3	Mobile Device Protocol Stack	27
4.4	Considerations about Mobility Support	28

Figure Index

Figure 1: SAMBA Framework	9
Figure 2: SAMBA Architecture Overview	11
Figure 3: Service Creation Sub-system and Content Management Sub-system	14
Figure 4: MPEG2 Transport Stream	15
Figure 5: CMS and Play Out Centre Communication	16
Figure 6: Set-Top-Box Protocol Stack	18
Figure 7: SAMBA Architecture Complete Protocol Stack	18
Figure 8: IMS features in the SAMBA Architecture	21
Figure 9: GPRS Protocol Stack	23
Figure 10: GSM/GPRS as Return Channel in SAMBA	24
Figure 11: Mobile Device with GSM/GPRS Support	24
Figure 12: Protocol Stack for Return Channel with GSM/GPRS	25
Figure 13: WIMAX as Return Channel in SAMBA	27
Figure 14: Protocol Stack – Mobile Device with WIMAX RC	27

1 Introduction

1.1 Finality of this document

The objective of this document is clearly identify and describe the sub-systems and the appropriate specific modules that compound the parts of the SAMBA Architecture.

The document take into consideration the user requirements identified in the work of the Work Package 2 and translated into functional and technical requirements by the Deliverable 3.1.1.

This document will be the basis for the test beds, the trials and the future developments. The architecture is responsible to granter to the project a long hall life supporting new developments, new technologies, new services, new business process and so on, as far as possible.

This architecture specification is supposed to go beyond the test beds and SAMBA Project itself. For this reason, this document considers at one of its sections, the support for mobility and QoS Control and Management.

Some limitations was considered in the WP2 but others will be considered only in the deployment of the test beds in the WP4.

1.2 Scope

This document comprises mainly the following parts: in the Content Domain: Community Content and Internet and External Content; in the Platform Domain: the CMS, the Transcoders, the Compilers, the Return Channel Servers, The Play Out Center, the DVB-T and DVB-H Transmission; in the User Domain the document will deal with the DVB-T Set-Top-Box Architecture and the PLC Return Channel.

In order to support the mobility in the return channel a specific section will discuss the technologies GSM/GPRS and WIMAX.

1.3 Definitions, Acronyms and Abbreviations

BER: Bit Error Rate

CCE: Content Creation Environment

CMS: Content Management System

CPE: Customer Premises Equipment is the actual PLC terminal, which connects the user device.

DVB: Digital Video Broadcasting, is a suite of internationally accepted open standards for digital television.

DVB-H: Digital Video Broadcasting - Handheld is a technical specification for bringing broadcast services to handheld receivers.

DVB-HTML: Digital Video Broadcast HyperText Markup Language is a standard for allowing digital televisions to access Internet content. It is an optional part of the larger MHP1.1 standard of DVB.

GPRS: General Packet Radio Service is a Mobile Data Service available to users of Global System for Mobile Communications (GSM)

HE: Head End is the PLC equipment that coordinates, as master, PLC terminals (CPE) connected on that.

HTML: HyperText Markup Language is the predominant markup language for the creation of web pages. It provides a means to describe the structure of text-based information in a document.

iDTV: Interactive Digital TeleVision

MAC: Media Access Control

MHP: Multimedia Home Platform (DVB-MHP) is an open middleware system standard designed by the DVB project for interactive digital television.

OFDM: Orthogonal Frequency Domain Modulation is the method that allows several channel transmission in the same media.

PLC: Power line communication describes a system for using electric power lines to carry radio signals for communication purposes.

QoS: Quality of Service

RC: Return Channel

STB: The term Set-Top-Box describes a device that connects to a television and some external source of signal, and turn the signal in content then displayed on the screen.

XML: The eXtensible Markup Language (XML) is a W3C-recommended general-purpose markup language.

1.4 References

[3GPP TS 23.060] General Packet Radio Service (GPRS): Service description -Stage 2 -(Release 7). June, 2006;

[BLACK96] D. Black et. al. An Architecture for Differentiated Services, IETF, RFC 2475, 1996.

[ETSI07] ETSI; TS 123 228 – IP Multimedia Subsystem. v. 7.7.0 release 7, 2007.

[GEER] Geer, D. Building Converged Networks with IMS technology. In Computer

[ITU04a] ITU. Series Y: global information infrastructure, internet protocol aspects and next generation networks. Next Generation Networks – Frameworks and functional architecture models. General overview of NGN. Geneva, ITU, 2004. 18p.

[ITU04b] ITU. Series Y: global information infrastructure, internet protocol aspects and next generation networks. Next Generation Networks – Frameworks and functional architecture models. General principles and general reference model for Next Generation Networks. Geneva, ITU, 2004. 34p.

[MAGEDANZ06] Magedanz, Th.; Gouveia, F.C. IMS – the IP Multimedia System as NGN Service Delivery Platform. Elektrotechnik & Informationstechnik, n. 123, 2006. p. 271-276.

[SAMBA D.2.1.1] Report of the Users' Needs including Requirement specifications Document (May 2007);

[SAMBA D.3.1.1] Definition of Functional and Technical requirements (August, 2007);

[WARD06] Ward, et. al. Domain Management of IMS. In. Bell Labs Technical Journal. n. 10, v. 4, 2006. p. 233-254.

2 SAMBA FRAMEWORK

2.1 Functionalities

The main general objective of SAMBA project is to enable a local community to produce and access local content, and also to access Internet content, using iDTV.

Using Digital TV as the delivery method and PLC as the preferential return channel technology, the project is including the low-income population as its core users. But the System Architecture will explore also the potentials of utilization of iDTV within mobile virtual communities and its possible impact for the creation of future services and business models related to iDTV in the mobile market.

The SAMBA Platform will permit the local community interact with the system and between themselves by the use of several services: creating and publishing content, navigating, selecting, viewing and downloading pictures and graphics, sending and receiving messages and multimedia content to name a few.

The use of the IMS concepts and modules approach to define the SAMBA Architecture will enable, in the near future, the mobility support in a heterogeneous and convergent environment, that will open a very broad area of new applications that require the use of facilities like, for example, heterogeneous handover.

2.2 Domains

The SAMBA Framework (Figure 1) can be understood easier using the concept of domains:

The **Content Domain** is the origin of several sources of content in the SAMBA environments in its deployments: the contents can be produced by the local community to offer services or only as entertainment, but the local community can also look for information in the Internet. As it can be seen in the Deliverable D.2.1.1 - "Report of the Users' Needs including Requirement specifications Document", these people that provide information for the SAMBA System are called Secondary Users.

The **SAMBA Platform** comprises the core systems that implement the SAMBA functionalities. It has servers and sub-systems to receive, to process and to format content. It contains the sub-systems to prepare information to be sent to the digital TV systems and even to store, retrieve and send applications that will run in the STB.

The Digital TV Play Out Center is also part of the SAMBA Platform. It comprises the DVB-IP Gateway that build the MPEG streams from IP content; the Carousel Server that compound the table of contents available to the users and the MUX system the build the final Transport Streams that will be transmitted to the air.

Another important system of the SAMBA Platform is the Return Channel Servers that will deal with the several technologies used to provide means to the users interact with the SAMBA applications and services. The SAMBA Architecture will be generic enough to support several technologies as return channel.

The **User Domain** is where will be found the Primary User (Deliverable D2.1.1 Definition also). They will consume the SAMBA services in a general and complete sense. In the User Domain is found the Digital TV Set-Top-Box with the PLC Return Channel. The General

SAMBA Architecture described in this document will be made some considerations about mobility support with the technologies GSM/GPRS, and WIMAX.

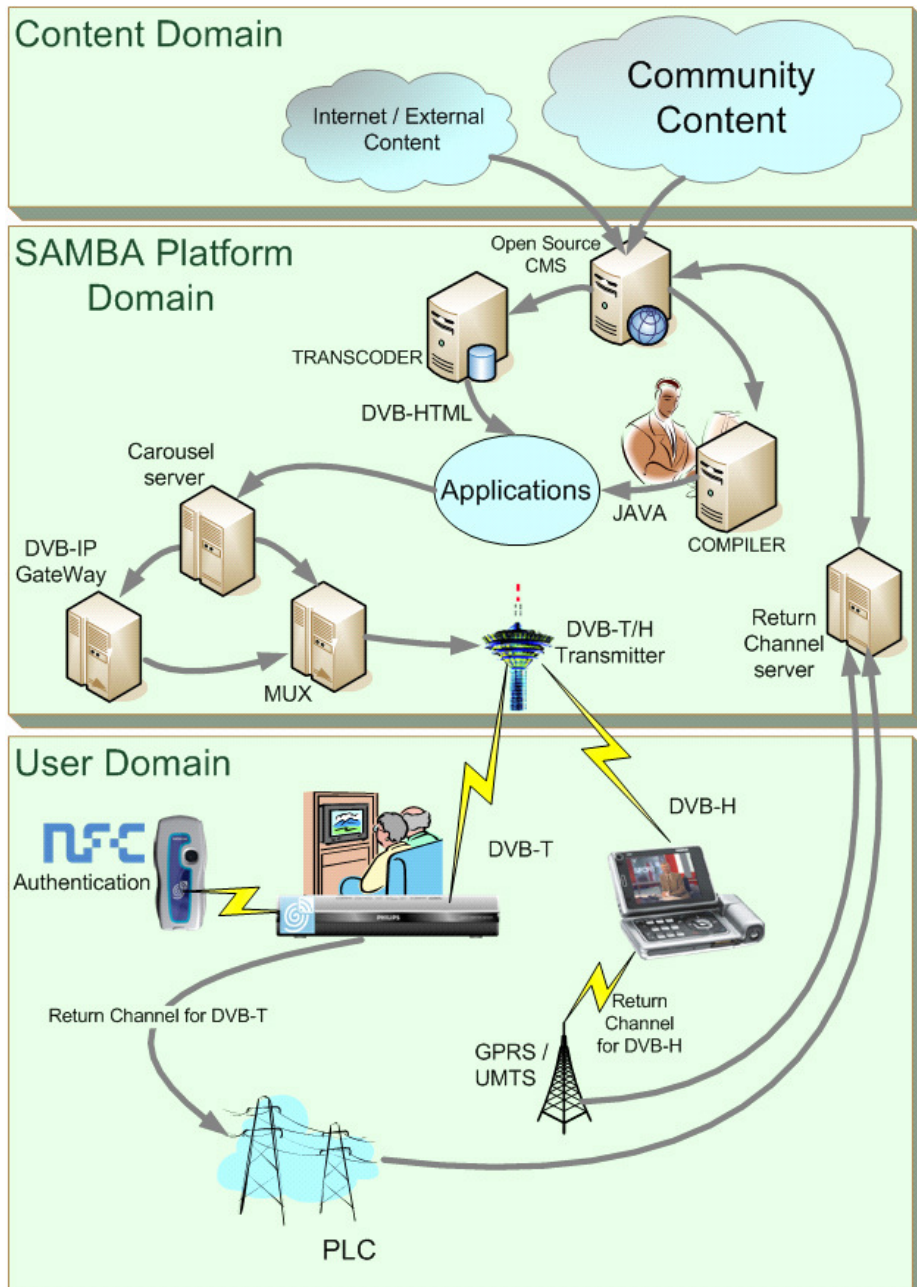


Figure 1: SAMBA Framework

3 SAMBA ARCHITECTURE

3.1 Introduction

The SAMBA proposed architecture is composed by heterogeneous networks which differ in several aspects, ranging from the delivery content system until how it handles the user interactions. This heterogeneity makes possible to support user interactions with digital TV contents, including interactivity and mobility.

Such heterogeneity can be supported by several architecture models and some specifications are under development around the world, such: IMS and OMA. All these architecture proposals are based on specifications of ITU-T Next Generation Networks and Intelligent Networks concepts. [ITU04a], [ITU04b]

The SAMBA System Architecture will be based on several IMS concepts and models. However, the complete IMS specification has more components and tools than SAMBA Architecture Requirements, and so, the specification of this project considers a distributed approach which may differ from a complete and full IMS compliant architecture.

The SAMBA architecture is split into two parts: the Platform Domain and User Domain. The User Domain comprises the infrastructure such as application servers, networks, QoS control, traffic management and user devices (Set-Top-Box, mobile devices). In the Platform Domain is included the service infrastructure and the equipments which will integrate the network technologies and the services, such as Carousel (for Digital TV), Multiplexer and DVB-IP Gateway.

The Figure 2 shows the components of SAMBA architecture:

The next items describe the several sub-systems of the SAMBA architecture defining its functionalities and showing the set and stack of protocols that it uses to interact with the other sub-systems.

3.2 Content Domain

The core idea of Content Domain equipments is permit content creation by local community and exchange or imports other contents from other locations via Internet. For that, all equipments that compose this architectural division must handle IP protocols. Users who create or use third-party contents in order to build SAMBA contents are called Secondary Users and may send and use any kind of multimedia content, since digital TV set-top-box be capable to use such content.

The Content Domain is composed by the Content Provider systems in which the multimedia content is created. However, the CP neither builds a MPEG Transport Stream nor provides interactive mechanisms. Taking into consideration only the CP protocol stack, the communication between the CP and CMS (Content Management System) will use the HTTP protocol in order to send contents.

As CP may generate content or import some content from Internet the proposed protocol stack is appropriate for both situations. The HTTP has also an advantage because it is capable to transport any kind of Internet multimedia content, including audio, video and it also may transport content generated by user interactivity.

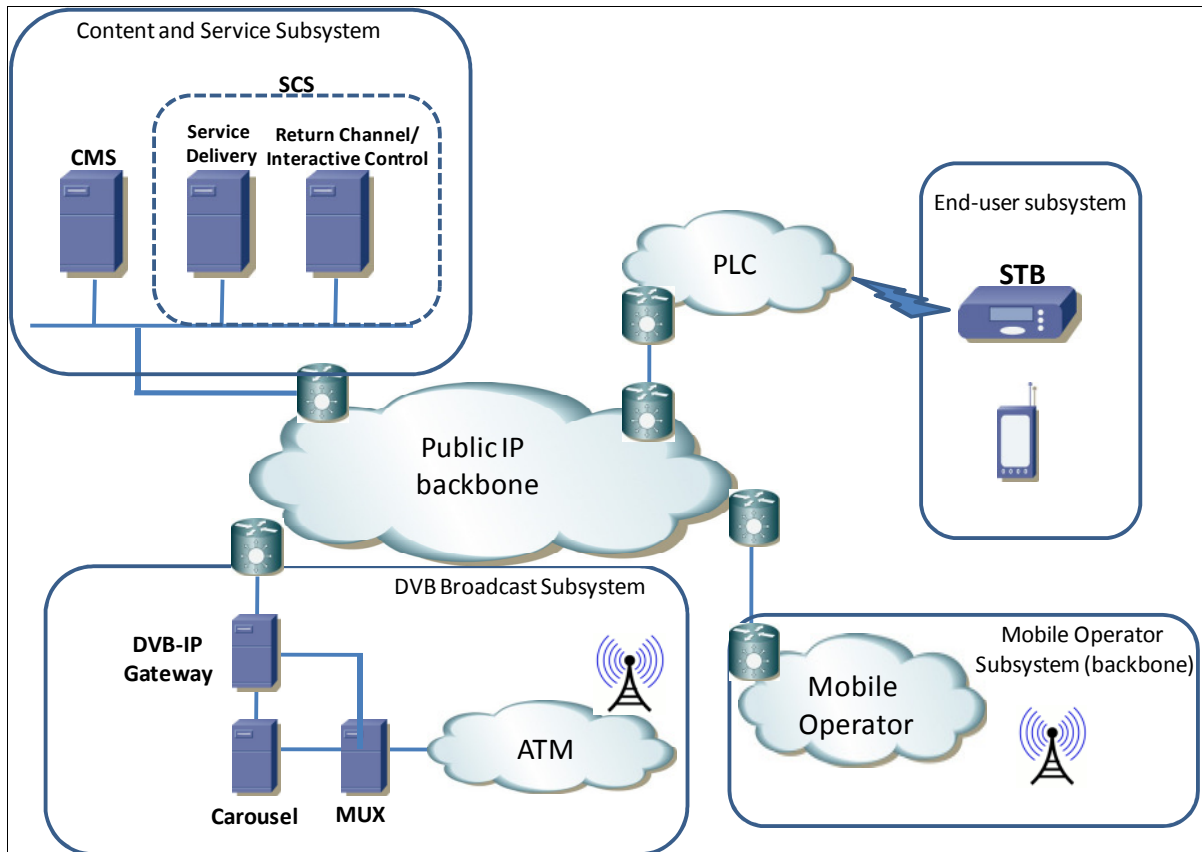


Figure 2: SAMBA Architecture Overview

The layers of CP protocol stack are:

- IP, TCP Layers: The presence of these two levels of protocols, of the TCP/IP architecture, means that the communication between the CP and the CMS (or external content system) can be made through any kind of IP network or backbone. It is important to point out that the QoS issues have to be considered;
- Delivery Protocols: Protocols responsible for ensuring transmission of media and data contents to the CMS. HTTP (HyperText Transfer Protocol) is one of the main choice, and is the protocol that will be implemented in the SAMBA trials. However, this architecture may deliver content by other transmission protocols such as Real Time Protocol (RTP).

This equipment follows the same patterns than similar equipments in the Internet. This equipment may be any Internet Server, which contains content compatible with SAMBA requirements.

3.3 Platform Domain

Some of the modules which compose the SAMBA platform is compared (or is based on) to components from IMS architecture and their functionalities are compared and detailed. The SAMBA sub-systems are a subset of IMS CSCF (Call State Control Functions); however the most relevant difference is that all those functionalities will be distributed by a set of agents, each one responsible for some tasks in the heterogeneous network.

There are some agents that will be responsible for managerial and control tasks related to the multi-agent system itself and they will be also part of the SAMBA architecture (and it is not present in IMS specification).

As the SAMBA architecture is composed by several network technologies, it is reasonable to assume that each network is controlled by a different entity, which composes its own administrative domain. For that, it is considered that each administrative domain has its own management systems and similar systems from different administrative domains may exchange data about common services. There are mechanisms provided by IMS which indicates (or define) how to exchange some control data. However, other mechanisms will be defined by this proposal.

The following items will present the sub-systems functionalities regarding SAMBA end-user point-of-view, considering the primary and secondary users. The item 3.6 SAMBA and IMS will present the control functionalities that can be incorporated in the SAMBA Architecture using the IMS concepts and architecture.

3.3.1 CMS

This subsystem is responsible to handle the content which will be provided by the end-user. The multimedia content will be stored in the CMS and will be delivered in the time of the transmission (in the case of Digital TV) or be accessed (in the case of Community Internet Content).

The CMS must have several copies of the one particular media, each one appropriate for one type of user device (handset, TV receiver; computer, mobile phone). CMS must send all information about the content (such as duration, type of device) to the Service Creation Subsystem in order to make possible the delivery of content to the right kind of device.

3.3.1.1 Service Creation Subsystem

The Service Creation Subsystem (SCS) is the CMS subset which handles the multimedia content in order to build the Electronic Program Guide (EPG) and other useful information about the content. This equipment creates and sends the EPG and information about other multimedia content to Playout Centre in order to provide additional information to the final user.

However, there are other important data about traffic and multimedia content characteristics which must be provided by SCS in order to support QoS Control systems and other network tools. As it is a project assumption, the SAMBA System Architecture (as a whole) must support end-to-end QoS, which is understood as mechanisms and tools which guarantee that the QoS provided by the operator respect what was specified in the user QoS contract. And this QoS must also be measured in the end user device.

The SCS will handle and store the QoS characteristics of contents that it will provide; so the content developer will provide data about how much of each network resource one must be spent to transmit a specific content. This specification must follow the QoS contract established between the content providers, network operators and the end user.

Although some of SCS functionalities provide important data for service delivery, they do not have control functionalities as defined in [BUSTAMANTE06], [ETSI07]. The SCS only provide above information about the content and establish which kind of QoS contract the content may be applied.

3.3.1.2 CMS layers

The protocols used in the communication between CMS and both Content Provider and Transmission system elements and their functionality in the system is described below (Figure 3):

- **Access Network: PLC Layer:** According to the TCP/IP reference model, the PLC Layer has the facilities of the Data Link Layer. This means that it takes a raw transmission facility and transforms it into a line that appears free of undetected transmission errors to the IP layer [BLACK96].
- **IP, TCP Layers:** The presence of these two levels of protocols, of the TCP/IP architecture, means that the communication between the CCS and the SCS can be made through any kind of IP network or backbone. It is important to point out that the QoS issues have to be considered;
- **HTTP and FTP Layers (Delivery Protocols):** Responsible for ensuring transmission of media and data contents;
- **CMS Application:** The service provider has to provide a means for the correct exhibition of its content. For instance, in a soccer game presentation, the user can select among some different camera angles. Each camera stream is encoded before its content is sent. The service provider has to offer a means for the user to change the camera angle, using a framework capable of accessing the API (Application Program Interface) of the Terminal and provide more interaction on the service e.g. MHP, GINGA, etc;
- **The CP Support modules will help secondary users in interaction with the CMS;**
- **The Return Channel module will interact with the Return Channel Servers to receive commands and operations from the primary users.**

The CMS does not build the TS (MPEG Transport Stream) itself because it is not capable to provide programmable content such as compiled applications. For that, the CMS merge content received by CP and data applications from other equipments (called Stream Combiners) and builds an intermediate file called Interactive Content (IC) composed by the content, data applications and their relationships. The IC is sent to the MUX when it is required to transmission.

3.3.2 Transcoders and Compilers

Both Transcoders and Compilers must coding data applications in such way that data application may be coded in TS and be executed in the set-top-box. Although these components are quite important in the SAMBA architecture, they do not impact in the protocol stack definition.

The protocol Stack of transcoder and compilers is composed by (Figure 3):

- **PLC Layer:** According to the TCP/IP reference model, the PLC Layer has the facilities of the Data Link Layer. This means that it takes a raw transmission facility and transforms it into a line that appears free of undetected transmission errors to the IP layer [BLACK96].
- **IP, TCP Layers:** The presence of these two levels of protocols, of the TCP/IP architecture, means that the communication between the CCS and the SCS can be made through any kind of IP network or backbone. It is important to point out that the QoS issues have to be considered;

- HTTP and FTP Layers (Delivery Protocols): Responsible for ensuring transmission of media and data contents;
- Application Layer: responsible for code application into bytecodes in order to be executed by STB virtual machine.

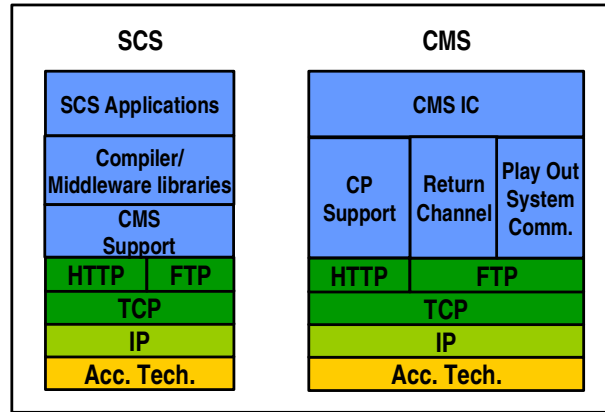


Figure 3: Service Creation Sub-system and Content Management Sub-system

3.3.3 DVB HEAD-END

The DVB HEAD-END functions in this Project are composed of two parts in order to emphasize the aspect of IP/DVB conversion. The DVB-IP Gateway will convert the IP traffic, including transport stream, EPG (Electronic Program Guide) and other data, into a DVB streaming in order to be sent to the MUX. This equipment may receive data from several Carrousel Servers and must organize all data in an appropriate manner in order to be transmitted by MUX.

3.3.3.1 Carrousel Server

In the Digital TV DVB Systems, the Data Carrousel is based on the DSM-CC (Digital Storage Media – Command and Control) standard ISO 13818-6. The Carrousel Server is used to send data files and content pages to the users.

In the SAMBA Architecture the Carrousel Server functionality can be integrated in the DVB-IP Gateway and interact with the CMS to receive the contents to be played out.

3.3.3.2 MUX and DVB-IP Gateway

The DVB-IP Gateway is an end system which has the role of adapting the IP services to the DVB world. Its main functionality is to configure the MUX in order to allow MUX encapsulating data. Therefore, the DVB-IP Gateway needs to exchange information with the SCS and other equipment, such as the QoS management tool box.

The Multiplexer (MUX) is equipment composed by audio and video coders/decoders which task is to code all content provided by SAMBA into MPEG streaming (MPEG2 or MPEG4) and send it to the DVB-T/H transmitters. MUX will build the Packetized Elementary Streams (PES) and based on this MUX generates the transport streaming because of the interaction of several DVB-IP gateways.

Both equipments do not provide any interaction with the end user or the other SAMBA systems. The only data sent by the MUX to the other systems are managerial data, such QoS information and about its operation status.

The layer of this sub-systems are explaining in the following items:

- **PLC Layer:** According to the TCP/IP reference model, the PLC Layer has the facilities of the Data Link Layer. This means that it takes a raw transmission facility and transforms it into a line that appears free of undetected transmission errors to the IP layer [BLACK96].
- **IP, TCP Layers:** The presence of these two levels of protocols, of the TCP/IP architecture, means that the communication between the CCS and the SCS can be made through any kind of IP network or backbone. It is important to point out that the QoS issues have to be considered;
- **HTTP and FTP Layers (Delivery Protocols):** Responsible for ensuring transmission of media and data contents;
- **Transport Stream and DVB Layer:** The DVB layer consists of all the protocols that support the DVB technology and communication in the broadcast way. It is composed of the Transport Stream (the clear blue part) and the pure IP traffic that will be delivered through DVB-H protocols (the white part of the layer)
 - **Transport Stream (TS):** Is a container layer that represents the MPEG2 (Motion Picture Experts Group version 2) systems. Figure 4 shows this container;
 - **MPEG2 TS:** The MPEG2 Transport Stream combines packets from several elementary streams of audio, video, data and so forth
 - **A & V:** Formed by the audio and video elementary streams;
 - **MPEG2 Sections:** Encapsulates the elementary stream of data
 - **DSM-CC:** The DSM-CC (Digital Storage Media Configuration and Control) is a set of tools for the development of stream control. Besides can be used to send application data;
 - **SI/PSI:** The System Information or Program System Information packets carry the information on the content of the Stream. It can be used to build the EPG (Electronic Program Guide) for instance;
 - **MPE:** The Multiple Protocol Encapsulation (MPE) is used to package IP datagrams into the TS;
 - **IP EC / DEC – IP Encapsulator/Decapsulator.** The payloads of DVB-H are IP-datagrams or other network layer datagrams encapsulated within MPE-sections.

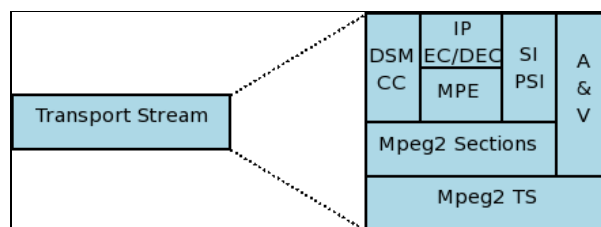


Figure 4: MPEG2 Transport Stream

- **DVB Format Standards:** Used to compress audio and video data e.g. MPEG2, MPEG4, MP3 (MPEG-1 Audio Layer 3), AAC (Advanced Audio Coding), etc;

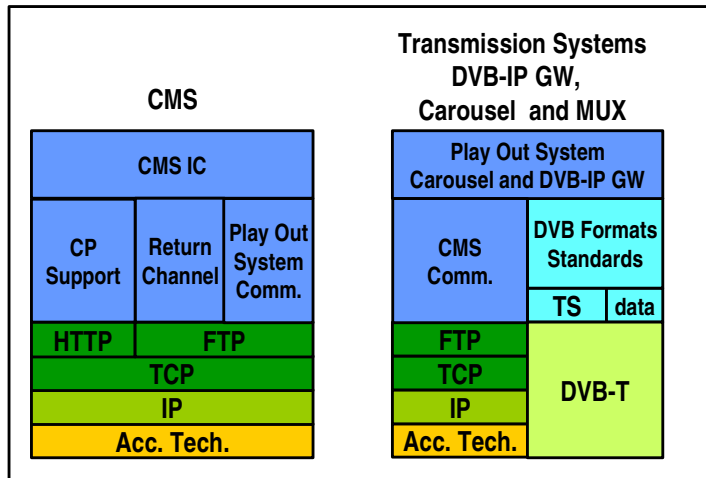


Figure 5: CMS and Play Out Centre Communication

3.3.4 DVB-T Transmission

At the Terminal head-end, it can be assumed that a single Antenna will receive single TS from a single SCS and transmit the information to the users.

The MUX is able to generate a single TS from several TSs from different CMSs and from other service providers, such as ISPs (Internet Service Providers). The GW's functions are ordered by the CMSs, as well as the configuration of its output transport stream.

In the Figure 5 it does not appear the separation between the three functions: Carousel, DVB-IP GW and MUX. It shows the communication stacks if it was only one sub-system.

3.3.5 Return Channel Server

The Return Channel Server (RCS) is the first point in which all return data provided by set-top-boxes and other end-user devices will end up.

The objective of SAMBA Architecture is, as far as possible, not to limit the technology possibilities for the return channel, with or without mobility. As was mentioned in the Introduction, the use of IMS concepts and standards will grant to the SAMBA Architecture this possibilities and even the possibility of using more than one technology at the same time.

The basic Architecture will use PLC as the return channel. In an integrated and simplified view, the part of the applications and services that deal with the user interactions will be inside the CMS sub-systems. This is represented in the Figure 5 when the CMS has a sub-layer named "Return Channel" in the Application Layer".

Probably in a more complex business environment the CMS Application will be distributed and will be coordinated with the operation with the Return Channel Servers.

It is important that return channel may be also used in order to send some information to the user. One of these reasons is that users who receive data from DVB-T can only receive data from PLC network (which is its return channel). In the case of mobile users, the DVB-H is capable to send the results of the user interactive action to the end-user equipment.

3.4 User Domain

3.4.1 Introduction

The User Domain comprises the area where the primary user is reached to consume the services and products offered by SAMBA and reach the SAMBA, because offer the return channel technologies to provide interactivity.

As was identified in the other work groups of the project, and considering that the main objective is to implement a low cost return channel solution, the PLC is the first technology to be defined, specified and implemented in the prove-of-concept.

In the Chapter 4, **Mobility Support In SAMBA**, will be defined an Architecture with support for mobility, including the return channel.

3.4.2 Architecture with PLC Return Channel

The idea to reach in a sustainable solution is to use an existing infrastructure and to have in mind the shared use of this infrastructure. The electric power grid and the use of Power Line Communication – PLC technology could be the infrastructure needed, considering specially that the PLC networks have been used by the electric power operators to implement some services needed by them to measure the customer consumption, the quality of energy and to communicate with their customers, and in experimental way for controlling the electrical power grid (smart grid concept).

From the architectural point-of-view, a PLC network is a metropolitan fixed access technology.

There is a number of customers in a low-voltage electrical power supply network that can share the transmission capacity of a Power Line Communication - PLC access network. So, it seems a good medium for Interactive Digital TV Return Channel, as proposed in the SAMBA project. However, the PLC systems are more sensitive to disturbances from the network environment and the transmission capacity of the PLC systems could be limited.

3.4.3 The Set-Top-Box

The STB (Figure 6) contains the hardware for DVB-T reception and PLC transmission and reception and the basic software for the DVB standard functionalities, including Transport Stream processing with the respective formats, reception and running of applications in the required standards.

In the PLC interface, the STB must support the required standard for the metropolitan access local network considering the physical layer and the MAC sub-layer.

Warning: It is important to point out that the deliverable D-3.2.1 defined specific requirements about all these parameters, but in the case of PLC technology in the world and in the case of Digital TV in Brazil, some of them are in a moment of very fast transition, and that a revision will be necessary before the end of the project.

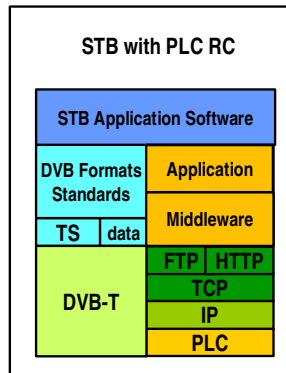


Figure 6: Set-Top-Box Protocol Stack

3.5 SAMBA Complete Protocol Stack

The Figure 7 depicts the proposed SAMBA Protocol Stack and the relationships between SAMBA architecture division and their components.

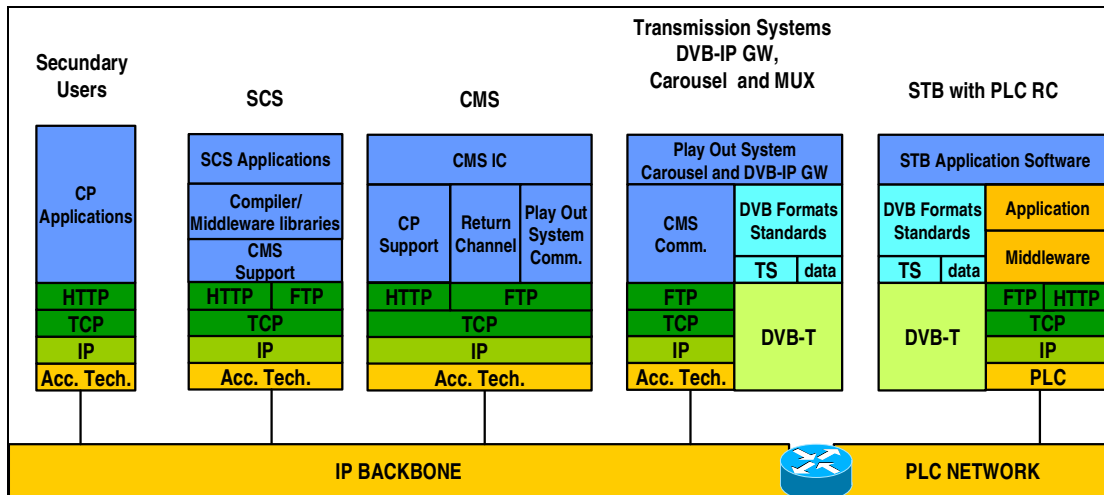


Figure 7: SAMBA Architecture Complete Protocol Stack

This initial protocol stack is taking into consideration the PLC network as the only communication path that interconnects all SAMBA architecture components. It is a premise that all communication using PLC network is based on IP protocol and there are some equipments that bridge the contents from IP network to DVB network.

3.6 SAMBA and IMS

Taking into consideration the above equipments and its functionalities, it is quite clear there are several features which should be included in the SAMBA Platform Domain in order to make all parts interoperate. The IMS architecture ([MAGEDANZ06], [WARD06], [GEER]) proposes some components, mainly in the Control layer, which brings key features for this project. The concepts are:

- Call State Control Functions (CSCF): features and functions related to the control of user session;
- Home Subscriber Service (HSS): controls the user profile;
- Policy Decision Function (PDF): it is related to the QoS traffic decision.

There are other components and concepts from IMS which is present in the SAMBA architecture functionalities, such as Media Gateway and Application Server. The Application Server is quite related to the CMS and the Media Gateway is related to both DVB-IP Gateway and Return Channel Server.

Considering that all components, except that ones with the functionalities of Media Gateway, work in an IP network, it is proposed that all communication between components may use the following protocols in order to exchange control information: ([WARD06], [FREIRE02])

- SIP (Session Initiation Protocol);
- SDP (Session Description Protocol);
- COPS (Common Open Policy Protocol);

SIP may be used to exchange control information between SCS and end-user equipment, such as control the state of the communication and establish the communication itself. Such messages will be used in order to inform the SDP of a specific communication session.

The SDP is used to describe the multimedia session and its main functions are describe the session duration, name, purpose, type of media, transport protocol and media format.

In IMS, COPS protocol have been used to exchange data about QoS between the Policy Server and user equipment (client) PUSP is studying whether this protocol may handle all required QoS information.

The CSCF related functions will handle SIP and SDP protocols and it is divided in some functionality presented in some SAMBA components:

- Proxy CSCF (P-CSCF): it is the first contact point between the SAMBA Platform Domain and the user equipment. The P-CSCF will send the QoS data to the user equipment.
- Interrogating CSCF (I-CSCF): contact point between the network operator (for one administrative domain) to the subscriber, which assigns the S-CSCF and do CRD (Charging and Resource utilization).
- Serving-CSCF (S-CSCF): maintain session state data in order to network operator supports services.

The S-CSCF uses the HSS in order to provide the right quality of service for a specific user. However, it must be studied if a centralized approach (in an administrative domain) for the HSS is the best way to use in this architecture.

In the SAMBA Platform Domain the RCS has several features of P-CSCF, because it will be the first contact point between user equipment and the service provider when the user equipment receives data from both broadcast (DVB-T) and DVB-H. The DVB-IP Gateway also has some features of P-CSCF because it may send contents requested by the user when this user is receiving information from DVB-H; however, the user equipment does not send any kind of information to the DVB-IP Gateway. This may be considered a difference between the IMS and SAMBA architecture, because for one communication the P-CSCF is distributed in two different equipments.

This feature brings a challenge: how to provide reliability and data consistency if two equipments handle complementary information and there is not a direct relationship between them. One possible approach to solve this problem is to create one central point to coordinate all data related to P-CSCF. This point may be the user equipment.

The SCS has all features related to the I-CSCF because it is the equipment in which is stored information about the service, such as what quality is been transmitted and what kind of service resources (or features) will be under use. The SCS also needs data from HSS, which was not considered in the DoW. In IMS the HSS is a machine located in the user's home network. However, the user's home network is not only one if is under consideration a hybrid user equipment. For that, it is interesting to store the user profile in the user equipment. The HSS information would be always with user and a copy could be stored in the SCS, since the service contract is a deal between the SCS and user. Some security mechanism (such MD5 CRC or something like that) should be used to guarantee the user information authenticity.

The S-CSCF functions will be also located in the SCS, but it is also located in the user equipment. This information must be also located in the user equipment, since it can determine some service change during handover operation (since this change is to maintain the contract parameters).

The PDF may be located in the network operator infrastructure and must contain sets of data, one for each QoS contract. When PDF receives the service specification and user QoS contract specification (SLA) it will provide such information to a distributed application and this application will configure a network path to the requested service.

The Figure 8 represents where in the SAMBA architecture the IMS features may be located. It is under consideration the IMS Control Layer.

3.6.1 Return Channel Server and IMS

As in SAMBA project there is more than one type of return channel, and one end-user device may transmit data using more than one network interfaces (hybrid devices), such server should handle several types of network communication at the same time. This is a convergent application.

It is necessary at least one RCS for each administrative domain. The signalization between the RCS and other devices may use the concepts and follow the recommendations of IMS, because the RCS interface to the SAMBA Platform Domain is an IP interface.

The initial proposal is to create hybrid equipment with several network interfaces in order to attend incoming connections from end-user equipments. Those connections are converted into an IP connection in order to send data to the other equipments, especially the SCS, when the user interaction is handled.

It is important that return channel may be also used in order to send some information to the user. One of these reasons is that users who receive data from DVB-T can only receive data from PLC network (which is its return channel). In the case of mobile users, the DVB-H is capable to send the results of the user interactive action to the end-user equipment.

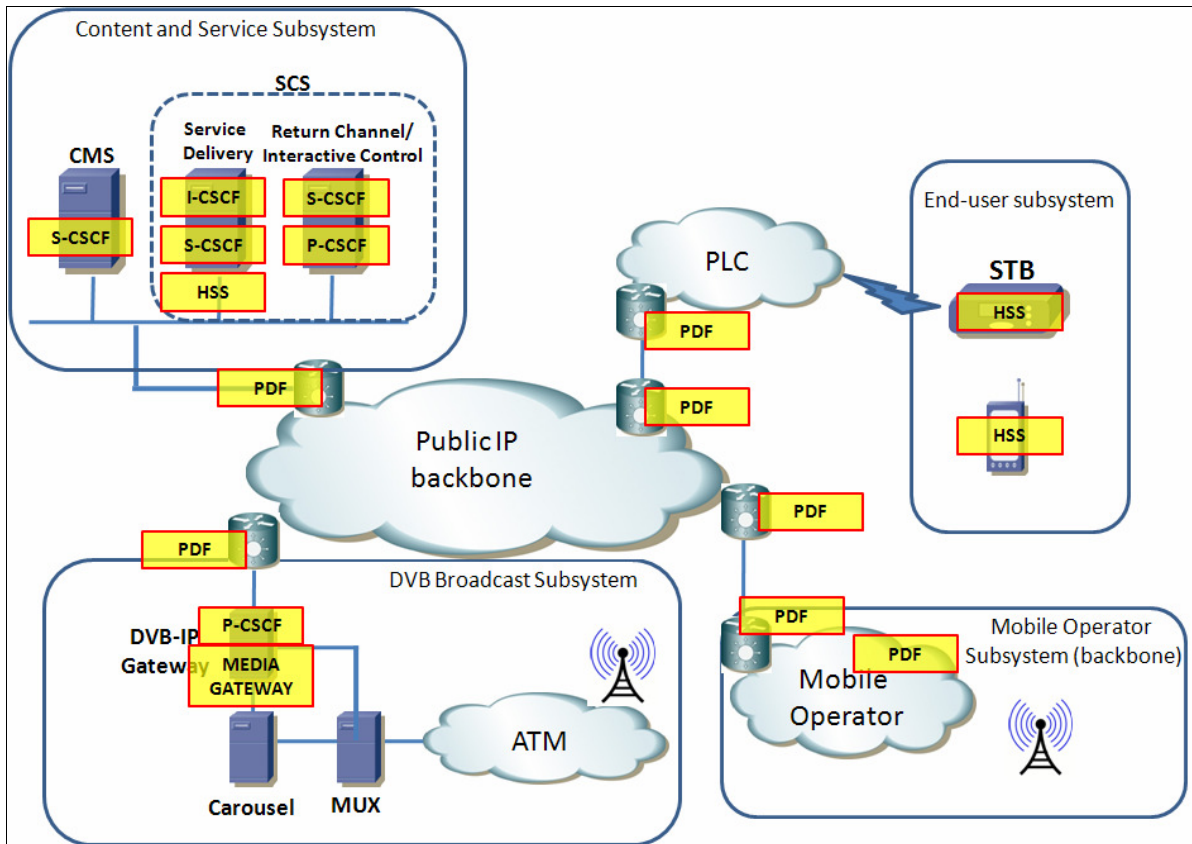


Figure 8: IMS features in the SAMBA Architecture

4 MOBILITY SUPPORT IN SAMBA – RETURN CHANNEL

4.1 Introduction

The support for mobility in the return channel in iDTV can be supplied by several technologies, but considering the target environments and main scope of SAMBA Project, two technologies will be investigated: GSM/GPRS and WIMAX.

GSM/GPRS is a widespread technology with presence all over the world and its evolution will keep most of its architecture elements. So, it is important to investigate the support of mobility in SAMBA Project with GSM/GPRS.

The WIMAX technology is one of the most promissory broadband metropolitan mobile access networks due to its technical characteristics.

In the next items the two technologies will be briefly presented, considering only the system and protocol aspects necessary to understand the impact of the technology as a return channel for Digital TV. After these initial background information, the network architecture and protocol stack for return channel in the SAMBA Project are presented and analyzed.

4.2 GSM/GPRS

4.2.1 Basic Technology Background

A GSM network is composed of three basic elements (Figure 9 and Figure 10): the GGSN (Gateway GPRS Support Node) is a gateway to external networks; the SGSN (Serving GPRS Support Node) is a gateway between the GPRS backbone and the Core Mobile Network; and the BSS (Base Station System) is the last element before Mobile Device and it includes the antenna.

When a packet arrives at the GGSN from the external network, it is encapsulated within the GPRS backbone network through the GTP (GPRS Tunnelling Protocol). It is important to notice that the GPRS also employs TCP/IP to route the packets through the backbone. When the packet arrives at the SGSN, it has to deal with the Air Interface and utilize the SNDCP (Sub-network Dependent Convergence Protocol) to transfer packets of the network layer. A logical link is established between the SGSN and the Mobile Device (MD) through the LLC (Logical Link Control) layer. There is also a reliable link between the MD and the BSS, established through the RLC (Radio Link Control) layer. The set of layers and protocols used are:

- **IP:** IP packets are encapsulated within the GPRS network;
- **IP (GPRS), TCP/UDP:** These protocols are utilized to provide a transfer connection on the GPRS backbone network and to route the packets from the GPRS tunnel;
- **GTP:** Employs a tunnel mechanism to transfer user data packets between the GGSN and the SGSN;
- **BSSGP (Base Station System GPRS Protocol):** It is defined on Layer 3. It is derived from the BSS Management Application sub-Part (BSSMAP). The BSSGP delivers routing and QoS-related information between the SGSN and the BSS;
- **LLC:** LLC defines the logical link control layer protocol to be used for packet data transfer between the MS and a SGSN. LLC spans from the MS to the SGSN and is intended for use with both acknowledged and unacknowledged data transfer. There are important differences between LLC and other protocols, in particular with regard to frame delimitation

methods and transparency mechanisms. These differences are necessary for independence from the radio path;

- **SNDCP**: It is used to transfer packets of the network layer between the MS and the SGSN;
- **GSM-RF**: Physical RF (Radio Frequency) Layer.

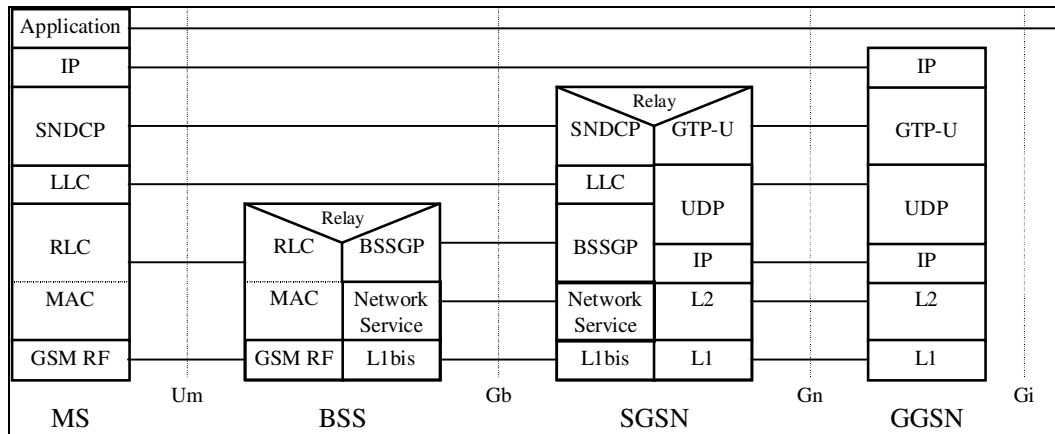


Figure 9: GPRS Protocol Stack
(Source: 3GPP TS 23.060 V7.1.0 (2006-06))

4.2.2 GSM/GPRS Network Architecture

Considering the basics of technology of item 4.2.1 “*GSM/GPRS Basic Technology Background*” and applying that directly in the architecture of SAMBA Project in a simplified view of the Network Architecture (Figure 10) it is possible to see all the network path of the information flow to implement interactivity with mobility using GSM/GPRS. The mobile operators normally build regional mobile core networks to integrate the voice systems and implement also GPRS IP Backbones to integrate the data access networks into public IP backbones.

It is possible to see that in the case of GSM/GPRS the flow of information in the return channel for mobility support will go up to the IP public backbones, due to the very different nature of the networks involved: the PLC is a pure access network and the GSM/GPRS is a cellular network.

4.2.3 Protocol Stack Analysis – GSM/GPRS Return Channel

4.2.3.1 Mobile Device With GSM/GPRS Support

A mobile device with GSM/GPRS support (Figure 11) must implement all the functionalities to send data to the air interface and also to allow the information navigate through the mobile core network and GPRS backbone. So, it is required to develop all the 3GPP sub-layers previously presented: MAC, RLC, LLC and SNDCP

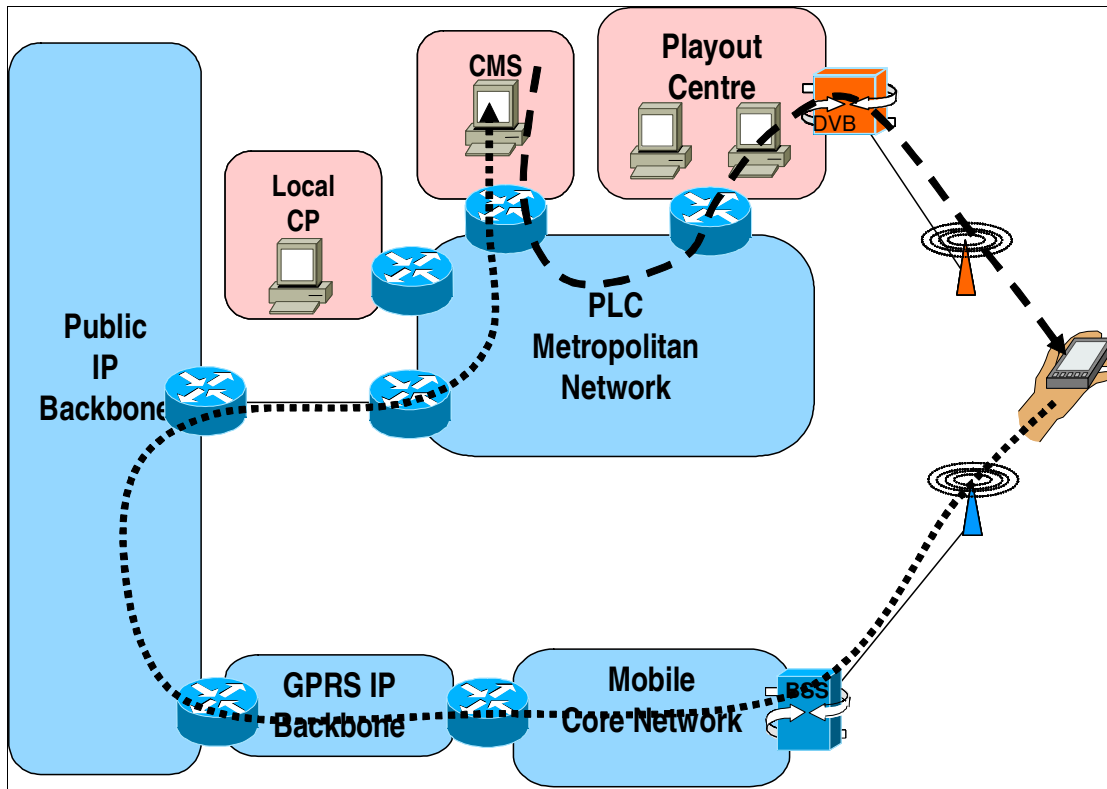


Figure 10: GSM/GPRS as Return Channel in SAMBA

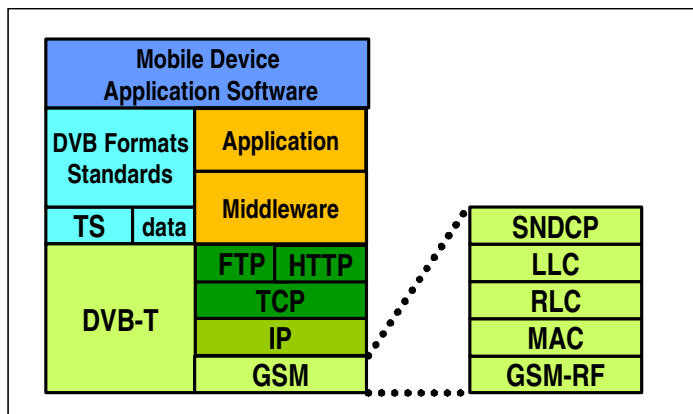


Figure 11: Mobile Device with GSM/GPRS Support

4.2.3.2 Network Protocol Stack

The Figure 12 depicts the complete protocol stack of the path between the mobile device and the CMS in the conceptual view of the SAMBA Platform, that is the part of the system that will deal with the feedback of the primary users. In a more detailed analysis in the item 3.6 “SAMBA and IMS” it is possible see that the return channel can be ended up in the Return Channel Server.

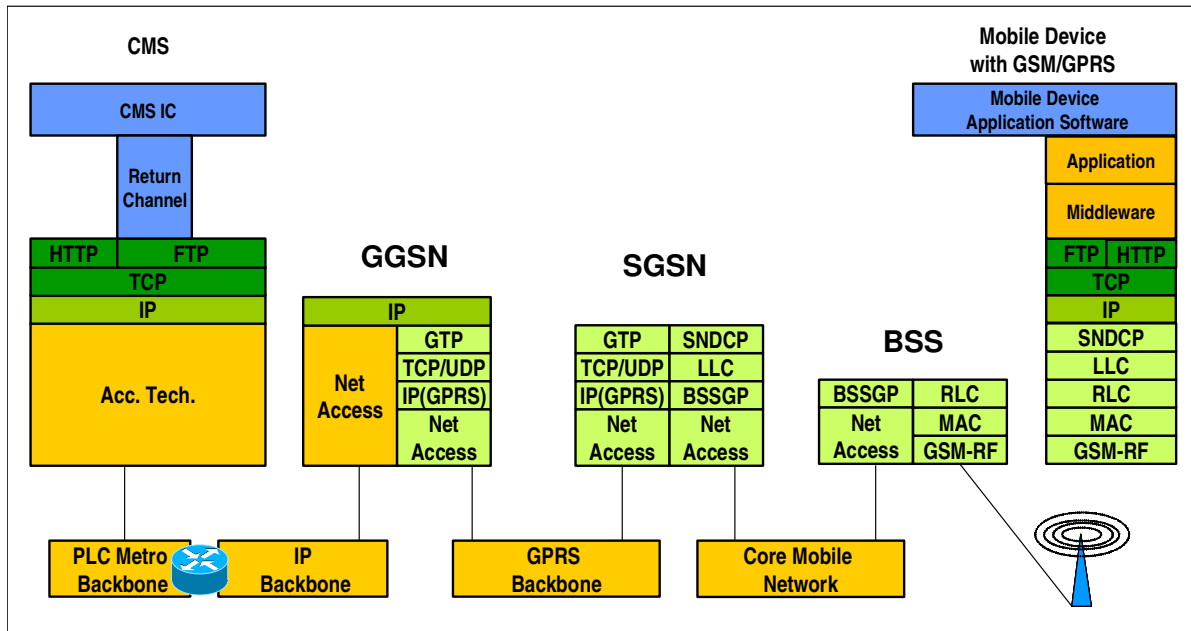


Figure 12: Protocol Stack for Return Channel with GSM/GPRS

4.3 WIMAX

4.3.1 Basic Technology Background

WiMAX means Worldwide Interoperability for Microwave Access, and is a metropolitan data communication technology aimed at providing wireless data over long distances in a variety of ways, from point-to-point links to full mobile cellular type access. It is based on the IEEE 802.16 standard, which is also called WirelessMAN. WiMAX is a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL.

802.16 is a Point-to-Multipoint Protocol, which are a standard providing equipment manufacturers and operators with a standard for access providers as well as known interoperability levels allowing for multi-vendor environments. WiMAX can be used in a star or meshed configuration and is itself protocol independent in that it can transport IP or any other kind of protocol.

The 802.16 Standard has many fundamental properties:

- It supports multiple services simultaneously;
- Specify two convergent service layers that form the basis of protocol: ATM and IP;
- It operates in a bandwidth on demand style;
- It has a link adaptation (4QAM, 16QAM, 64QAM);
- Point-to-point topology integrated with mesh topology;

Using CIDs (Connection Identifiers – 16 bits long) a SS (Subscriber Station) can have three types of connections with the base station:

- Basic Connection: used to transport short and critical messages;
- Primary Management Connection: transport longer and not so critical messages regarding time, such as authentication, connection set up, DHCP, TFTP, SNMP, etc;

- **Transport Connections:** They are data connections. They are omni directional, and are negotiated by peers with independency. They can have different values for the QoS parameters.

The WiMAX standard defines four classes of services for QoS differentiation:

- **Unsolicited Grant Services (UGS):** support services of type Constant Bit Rate, like E1/T1 lines and VoIP without silence suppression and compression;
- **Real Time Polling Services (rtPS):** support real time services with variable bit rate, like MPEG flows and VoIP with silence suppression;
- **Non Real Time Polling Services (nrtPS):** support to non real time traffic, with variation and that needs to support burst with some regularity;
- **Best Effort (BE) Services:** typical services offered by Internet.

The 802.16e specify three handoff mechanisms to mobility:

- **Hard Handoff (HHO):** this procedure does not keep the QoS values of parameters;
- **Fast Base Station Switching (FBSS):** keeps the control and values of QoS parameters and use more network resources;
- **Macro Diversity Handover (MDHO):** keeps the QoS of the network and does not expend so many network resources like FBSS.

The objective of the handover procedures is to keep the delay below the 50 ms.

4.3.2 WIMAX Access Network Architecture

The Figure 13 depicts the network architecture for using WIMAX in the return channel for the SAMBA Project. The WIMAX provider probably would use a metropolitan layer two high-speed backbone to reach the gateways that transmit to the antennas. It is possible not to have this internal backbone and the metropolitan are be covered by a meshed network.

Considering that WIMAX is typically an access technology it is possible that the operator maintain an interconnection with other kind of access networks, like, for example, the PLC metropolitan network. In doing so, the ISP will provide a direct path to the SAMBA SMS without passing through the IP public backbone, but only, using the local metropolitan one.

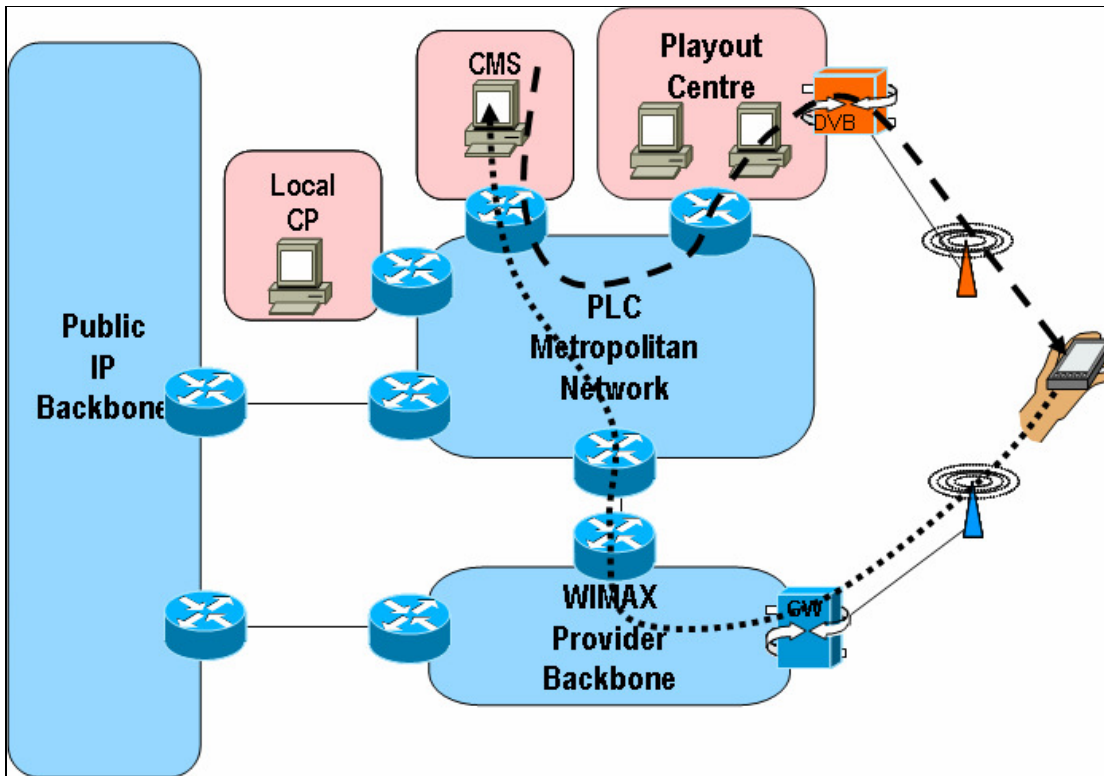


Figure 13: WIMAX as Return Channel in SAMBA

4.3.3 Mobile Device Protocol Stack

The protocol stack analysis (Figure 14) for the case of WIMAX network is very simple because it is a pure access network. In this case, it is necessary only to replace the PLC technology to WIMAX in the STB.

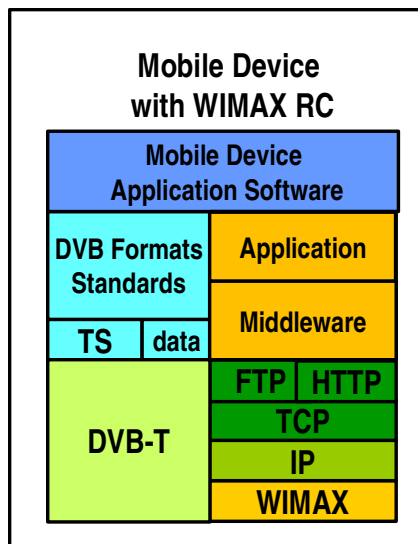


Figure 14: Protocol Stack – Mobile Device with WIMAX RC

4.4 Considerations about Mobility Support

Comparing the two return channel technologies modeled in this report, some preliminary considerations can be made, analyzing the differences. These differences comes from, of course, the kind of technology and the initial purpose for what they were created: GSM/GPRS is a cellular, circuit switching technology, created for voice (and data) communication, and WIMAX is a broadband wireless MAN access technology. Both were born in different moments with different proposals. Due to these reasons, its service provider's network architectures are completely different.

The first difference appears in the network architecture. A mobile network operator in the area of GSM/GPRS has two backbones: the Mobile Core Network that interconnect the Base Transmission Stations and antennas to the switching centers in a metropolitan area and the GPRS backbone, that is a data communication network like frame relay, ATM or even IP. Normally this infrastructure goes to the IP public infrastructure. In the case of a WIMAX network, it is a pure access network and so, it probably will be connected to the local metropolitan backbone. This difference will be very important to analyze QoS and handover aspects and procedures.

A second aspect to be analyzed is the radio connection between the mobile station and the access antenna. The WIMAX provide several logical connections between the antenna and the station. It is possible to configure the basic configuration and signaling connections and several data transfer connections. This was created to allow connections with different QoS profiles. This is not possible in a GPRS access. This can be made using the TCP/UDP ports, but only in an end-to-end style.

The implementation of end-to-end QoS in the case of GSM/GPRS has the addition of one more IP domain that is the GPRS Backbone that needs to be incorporated in the entire solution.