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Glossary

Abbreviation / acronym	Description
ADSL	Asymmetric Digital Subscriber Line
AVC	Advanced Video Coding
CA	Conditional Access
CC	Continuity Check
DSL	Digital Subscriber Line
ECM	Entitlement Control Messages carry the keys that are used to unlock the encrypted content
H.264/MPEG-4 AVC	Codec developed by the ITU-T Video Coding Experts Group
IDR	I-frame known as an instantaneous decoder refresh (IDR) frame
Metro Network	A metropolitan area network (MAN) is a network that usually spans a city. An MAN usually interconnects a number of local area networks (LANs) using a high-capacity backbone technology, and provides uplink services to wide area networks (or WAN) and the Internet.
MGS	Medium Grain Scalability
MPEG	Moving Picture Experts Group
NAL	Network Abstraction Layer
OP	Operation Point is defined as a unique combination of temporal and quality levels
PAT	Program Association Table
PCR	Program Clock Reference
PDA	Packet Dropping Algorithm
PDD	Packet Dropping Device
PID	Packet Identifier
PMT	Program Map Table
Priority ID	Priority ID is associated to the pair of {T (temporal layer), Q (quality layer)} provided by the NAL unit header.
PSI	Program Specific Information, metadata about a program (channel) and part of a MPEG transport stream, the PSI data contains five tables: PAT (Program Association Table) CAT (Conditional Access Table) PMT (Program Map Table) NIT (Network Information Table) TDT (Time and Date Table)
RTP	Real-time Transport Protocol
SPTS	Single Program Transport Stream
STB	Set-Top Box
SVC	Scalable Video Coding

TS	Transport Stream
UDP	User Datagram Protocol

1. Executive Summary

The main goal of this project is to develop an efficient solution for IPTV operators to provide HD video streams to users which have a limited access bandwidth and to optimize bandwidth usage for IPTV video streaming. WP7 deals with the System Integration.

This document describes the planning for system integration of the two approaches presented in [1] and [2] for providing an HD IPTV service of quality:

Approach 1: AVC video encoding with multiple profiles

For the system integration of this approach, live encoders are used, which generate multiple H.264/AVC [4] streams encapsulated in MPEG-2 TS [6] at different bit rates as indicated in [2]. The whole IPTV chain is built checking also with an existing commercial STB that the described solution works properly and the promised benefits under limited access bandwidth are achieved.

For this approach several streams of the same content are generated at the Head End at different rates and are encapsulated in MPEG-2 TS in a single program, i.e. a Multi-video SPTS is generated. This Multi-video SPTS is multicast and adapted at the Packet Dropping Device (PDD) [1], which forwards a unique version of the video contained in the Multi-video SPTS, i.e. the PDD forwards a Single-video SPTS. The PDD is responsible for switching from one video version to another depending on the available throughput and the signalization in the stream where switching points are marked, as described in [2].

Approach 2: SVC video encoding

For the system integration of this approach an offline encoder is used generating an SVC [5] stream using MGS SNR scalability which is encapsulated in MPEG-2 TS [6] packets and, subsequently, in a set of RTP packets as described in [2], achieving thus multiple bitrates mapped to different amount SVC layers. The whole IPTV chain is built and an emulated STB is used for testing that the described solution works properly and the promised benefits under limited access bandwidth are achieved.

For this approach a Single-video SPTS is sent from the Head End with the SVC encoded content. During the encapsulation process, a special tagging mechanism is performed consisting in signalling the different operation points that can be achieved by forwarding a different amount of data, i.e. performing bitstream shaping. This method is more explicitly explained in [2] but basically it consists in assigning different priority values (Priority IDs) to the different RTP packets depending on the contained data. Different operation points (OPs) are defined based on the *temporal_id* and *quality_id* in the SVC extension header of the NAL units [5] of the SVC stream. Then, based on the defined OPs, the MPEG-2 TS packets are encapsulated into RTP [10] streams where, depending on the OP to which the data in the MPEG-2TS belong to, a given Priority ID is assigned. This Priority ID is added into the SSRC field of the RTP, so that the PDD can find this information and decide whether to drop or keep a packet in the stream which is delivered to the STB. Thus, depending on the available throughput, a different amount of layers or different operation points are delivered to each STB.

2. Introduction

The deliverable D.7.1 - Integration plan describes the planning and procedures for the integration of the developed components of the IPTV system for achieving the goal of the OptiBand project of providing a HD video streaming solution for limited access bandwidth environments.

More concretely, the steps followed during integration are described and the relevant partners that carry out the tests are identified. Besides, a timetable is provided where the timeframe and deadlines for each of the carried out task are indicated.

3. Description of the Integration Plan and Steps

This section defines the steps followed during the System Integration, lists the system components developed for the proposed solution as well as the responsible partners and shows the architecture of the final IPTV system after finalising the integration process.

3.1 IPTV Components

The components (cf. Figure 1 and Figure 2), which the built up system consists of, are listed in Table 1 as well as their description and the partners responsible for their integration:

Table 1: IPTV System components

Component	Description	Partner
Live Multi-video-Encoder	This component refers to the H.264/AVC Multi-video SPTS with embedded Multiplexer defined in section 4.3 in [2]. The input of this component is video content via an HD/SDI interface and the output is a Multi-video SPTS over UDP.	TVN
Live Single-video-Encoder	This component refers to the Nx[H.264/AVC Single video SPTS] described in section 4.2 in [2]. The input of this component is video content via an HD/SDI interface and the output is a Single-video SPTS over UDP.	OPT
SVC Content generator	This component refers to the SVC based Head End described in section 5 in [2]. It encapsulates pre-encoded content and transmits it to the network. This component can be used as a VoD server, which provides content on request or can also emulate Live content from the pre-encoded content. The encapsulation into a transport format and scrambling are performed in a live manner.	HHI
MPEG Multiplexer	This component is described in section 4.2 in [2] and is responsible for creating a Multi-video SPTS out of several Single-video SPTS of the same content. Its input is several Single-video SPTS of the same content at different rates and the output is the corresponding Multi-video SPTS over UDP.	TVN
Middleware	As described in section 3.3 in [2] the middleware is a client-server software that connects end users to the video head-end, e.g. allowing end users to browse media content available in networks. The middleware at the server side contains information of the multicast channels and the middleware at the client (STB) exchanges information with the middleware at the server for service discovery.	LAMBDA
STB	This component is described in section 3.5.1 in [3] and it is an AVC-capable set-top-box.	LAMBDA
SVC STB Emulator	This component is described in section 3.5.2 in [3] and it is a PC based client that is used as a STB emulator capable of decoding SVC streams.	UDC/HHI
Encryption/Decryption component	These components are described in section 4.4 in [2]. The encryption component (at the server) takes the input MPEG-2 TS, scrambles the content and introduces the ECMs in the stream so that the	IRD

	decryption component (at the client, i.e. STB) can descramble it and produce as an output a clear MPEG TS content.	
MB-PDD	This component refers to the Multi-Bitrate Packet Dropping Device (MB-PDD) described in section 3.1.2 in [1]. The input of this device is different Multi-video SPTS and the output is the different channels with a Single-Video SPTS.	CSL
SVC-PDD	SVC-PDD refers to the device in Section 3.2.2 in [1]. The input is a Single-video SPTS with several layers transmitted over RTP for priority tagging, as explained in section 3.1.2 in [2]. The output of the SVC-PDD is a Single-video SPTS with a possibly varying number of layers of SVC over RTP or directly over UDP.	HHI
2 PCs	These PCs are configured as sniffers, in order to allow a better debug and a low level proof of the data flow.	TI
Further laboratory equipment	See section 8.1	TI

3.2 IPTV System

Figure 1 and Figure 2 show the result of the system integration, i.e. the complete IPTV system solution developed within this project, for the two different approaches: the multi rate and the SVC approach. It consists of all the components developed by all partners and is used for testing the correct interaction between them. These figures show the resulting IPTV system obtained following the integration plan described below.

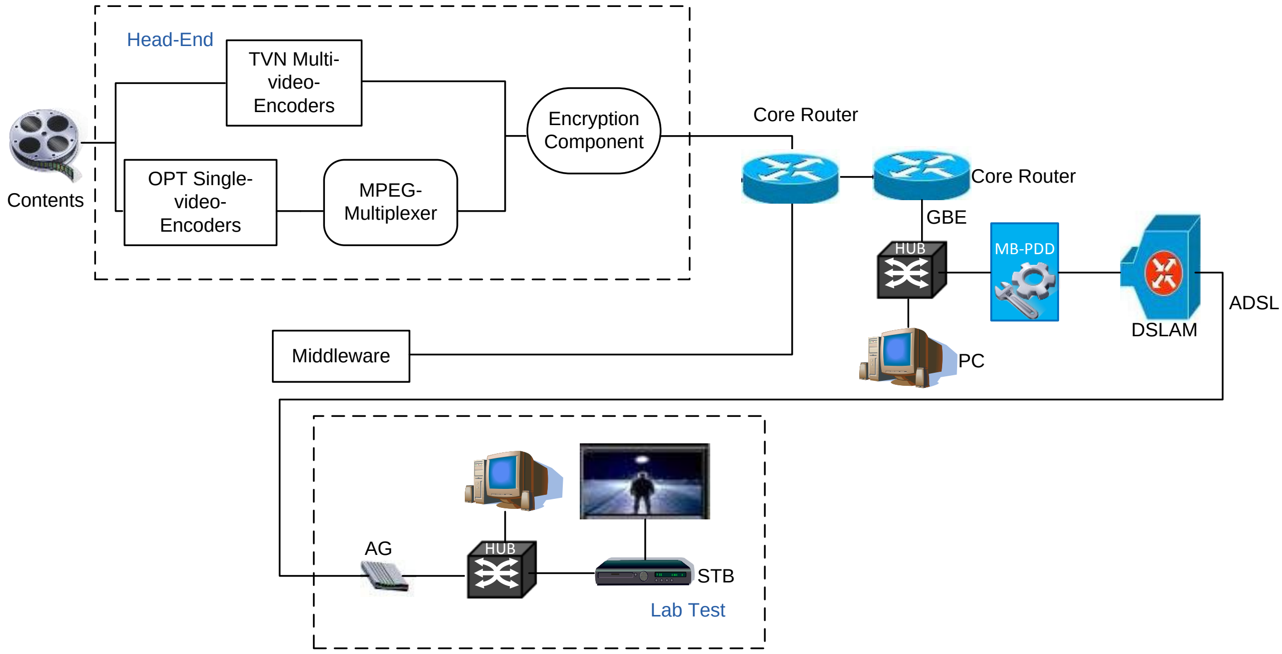

Figure 1: System Architecture of the complete integrated IPTV for the AVC multi rate approach

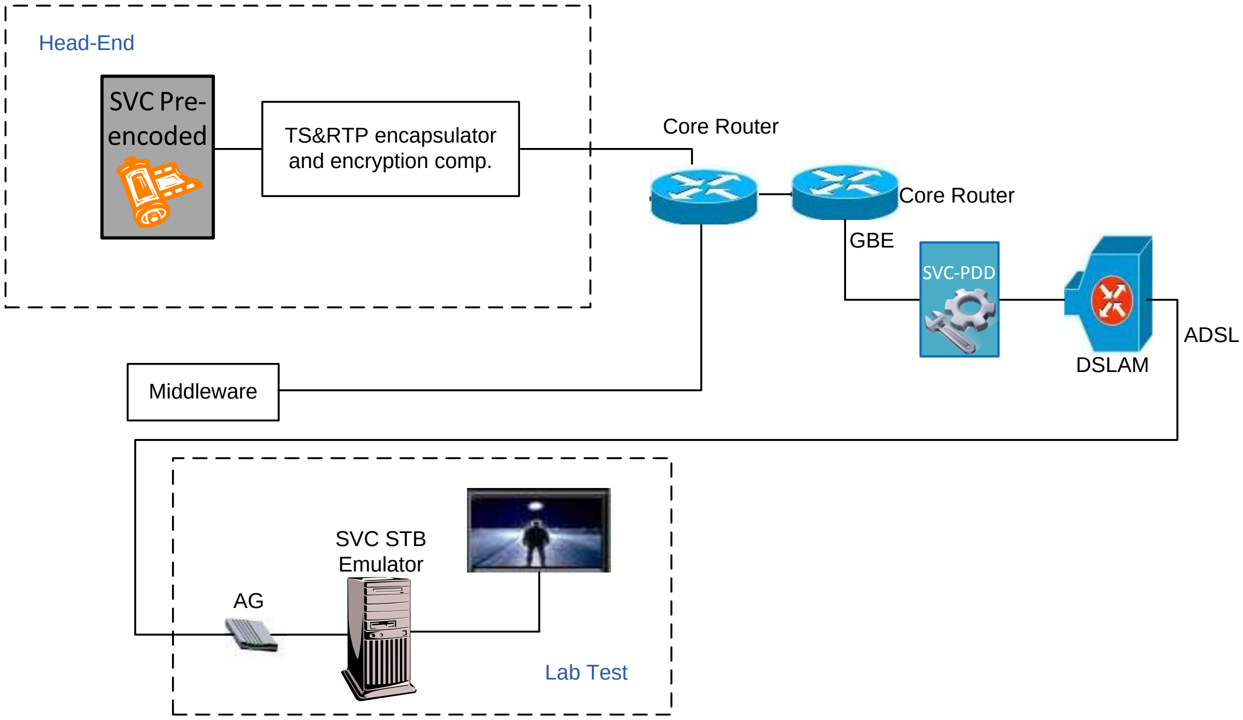

Figure 2: System Architecture of the complete integrated IPTV for the SVC approach

3.3 Definition of system integration steps

In order to check the correct operation of these system components, different steps are defined as well as the tests that have to be carried out for checking that these components are working properly. The system integration is done progressively in 3 steps preceded by a pre-integration step (c.f. section 4). These steps are:

- Stand-alone installation of components (c.f. section 5).
- First-integration phase (c.f. section 6).
- Second-integration phase (c.f. section 7).

4. Pre-integration step

Previous to the integration of components in the IPTV system illustrated in Figure 1 and Figure 2, some tests are carried out at Partners premises to check correct operation of the components listed in Table 1. The goal of these tests is to check the interoperability between neighbour components. The tests that have to be finished before the integration starts are eight, referred to as Pre-integration Tests (PT), and are described in section 4.1 to section 4.8 for both approaches: AVC-based approach and SVC-based approach.

4.1 PT-I: Interoperability between Middleware and STB

The first Pre-integration test (PT-I) consist in checking whether the middleware and the STB operate correctly together. For this purpose, the STB and the middleware are connected together, the middleware is configured so that it advertises some multicast channels and is checked that both devices exchange information for channel discovery and that the STB finds the information configured at the middleware.

For the AVC-based approach, the STB developed by LAMBDA is used, while for the SVC-based approach the SVC STB Emulator developed by UDC/HHI is used. The partners responsible for this test are UDC, LAMDA and HHI.

4.2 PT-II: Interoperability between Encoders and STB

The purpose of PT-II is to check that the content produced by the different encoders can be correctly processed by the corresponding STBs.

4.2.1 AVC-based approach

Since there are two different approaches and encoders for the multi rate approach based on AVC, i.e. Live Multi-video-Encoder and Live Single-video-Encoder, streams with each of the respective encoders are created and used for feeding the STB. The streams that are created for this test are a Single-video SPTS and the partners responsible for creating them are TVN and OPT. These streams are sent to LAMBDA and then, their correct processing is tested.

4.2.2 SVC-based approach

In case of the SVC approach, the SVC STB Emulator is fed with SVC content. The partners responsible for this test are HHI and UDC. The encoded SVC stream is encapsulated in TS forming a Single-Video SPTS and further encapsulated into RTP and the SVC STB Emulator is fed with this stream. Furthermore, since SVC is AVC backward compatible it is also tested that the AVC capable STBs can process the SVC Single-video SPTS, decoding the base layer. The partners responsible for this test are HHI and LAMBDA.

4.3 PT-III: Interoperability between Live Single-Encoder and MPEG multiplexer

PT-III consists of testing the correct interaction between the Live Single-Encoder provided by OPT and the MPEG multiplexer from TVN. For this purpose, the TVN multiplexer will be sent to OPTEC who will feed it with streams coming out of the OPTEC encoders. OPTEC will then check that the Multi-video stream at the output of the multiplexer meets the requirements. A remote connection to the multiplexer will be made available by OPTEC so that TVN can configure the multiplexer.

4.4 PT-IV: Interoperability between Encoders (and optional MPEG multiplexer) and PDD

In PT-IV, the correct interoperability between the different encoders and PDD implementations is checked.

4.4.1 AVC-based approach

For the AVC-based approach, there are two different ways of creating Multi-video SPTS: either with the Live Multi-video-Encoder or with the Live Single-video-Encoder plus an MPEG multiplexer. TVN and OPT will send to CSL a Multi-video SPTS and CSL will use it to check that the PDD can process it. At this stage, it is checked that the PDD is able to switch between the different versions in the Multi-video SPTS and that the output has a correct and constant video PID. It is also necessary to check that the switching happens at the Random Access Points (RAPs), i.e. MPEG-2 TS packets with the priority flag set, as well as that the output streams have consistent PCR and CC values.

4.4.2 SVC-based approach

For the SVC-based approach, SVC content is sent to the SVC-PDD and it is checked that the SVC-PDD can process properly the data, generating an RTP stream with a variable number of SVC layers. Since in this case, switching can happen at any point in the stream, it is only checked that the output of the SVC-PDD is consistent with the desired operation point, i.e. packets with a higher Priority ID than the desired one should be dropped and all incoming packets with a lower or equal Priority ID than the desired one should be forwarded as output. The partner responsible for this test is HHI.

4.5 PT-V: Interoperability between Encoders (and optional MPEG multiplexer) and Encryption component

4.5.1 AVC-based approach

For this test, Multi-video SPTS and Single-video SPTS streams created by the two methods will be sent to IRD (Live Multi-video-Encoder stream sent by TVN and stream coming out of Live Single-video-Encoders with MPEG Multiplexer sent by OPT). IRD will check that the NULL packet constraints are fulfilled and that the provided MPEG-2TS stream can be correctly scrambled. The Multi-video SPTS will be afterwards used for PT-VI and the Single-video SPTS for PT-VII.

4.5.2 SVC-based approach

As later explained (cf. section 5.4.2), for the SVC approach, a library has been provided to HHI by IRD. Encryption happens in this library at the head-end prior to the RTP encapsulation. Therefore, HHI will check that the SVC stream encapsulated in MPEG-2 TS contains a NULL packet at least every 300 ms to allow ECM insertion and will check that the library in the head-end scrambles the data correctly.

4.6 PT-VI: Interoperability between Encryption component and PDD

4.6.1 AVC-based approach

For this test, Multi-video SPTS scrambled during PT-V by IRD is used for testing correct operation of the PDD with encrypted content. The encrypted content is sent to CSL by IRD.

4.6.2 SVC-based approach

In this case the encrypted SVC content from PT-V is used for testing the correct operation of the SVC-PDD with encrypted content. The tests are performed by HHI.

4.7 PT-VII: Interoperability between Encryption component and STB

For this test, the scrambled streams generated at step PT-V are sent, for the AVC based approach, by IRD to LAMBDA and LAMBDA will check that the scrambled content can be correctly processed at the AVC-capable STB. In the case of the SVC-based approach, HHI will check that the content generated and scrambled by them can be still correctly processed by the STB or SVC STB Emulator respectively.

4.7.1 AVC-based approach

The partners involved in this test are IRD and LAMBDA for the AVC-based approach, IRD being responsible for providing LAMBDA with encrypted streams. Then, it is checked that the STB can still correctly process and decode the scrambled video data.

4.7.2 SVC-based approach

In case of the SVC-based approach, the involved partners are IRD, HHI and UDC. In this case, the encryption and encapsulation are done in the SVC head-end, since encryption is integrated between MPEG-2 TS encapsulation and RTP encapsulation as explained section 5.1 in [2]. Therefore, this test can be done by HHI on its own.

4.8 PT-VIII: Interoperability between output of PDD and STB

PT-VII consists of tests to check the interoperability between the output of the different approaches of the PDD and the STB.

4.8.1 AVC-based approach

In this case, it is checked that the output stream of the MB-PDD is a valid Single-video SPTS and can be correctly processed by the STB. The STB is fed with a Single-video SPTS that contains different version of the same media over the time, i.e. media at different bitrate over the time. The output described in PT-IV and PT-VI for AVC (c.f. section 4.4.1) is provided by CSL to LAMBDA so that it can be checked that the AVC-capable STB can correctly decode the content created at the MB-PDD. The partners responsible for this test are CSL, providing the content, and LAMBDA, testing that the STB processes correctly the received Single-video SPTS and that the decoded video is correctly displayed.

4.8.2 SVC-based approach

In case of the SVC-based approach, the SVC-PDD creates a Single-video SPTS with a varying number of layers as an output, from a complete SVC steam, as explained in PT-IV (cf. section 4.4.2). This stream, as well as the stream created at PT-VI, is provided to the SVC STB emulator or AVC capable STB (LAMBDA) and it is checked that the data can be correctly decoded and presented. HHI and LAMBDA are responsible for this test.

5. Stand-alone installation of components

This section describes the stand-alone installation of the components summarized in Table 1. Stand-alone installation of the system components is carried out to check the correct operation of the different components when installed at the TI laboratory and is done previous to the first phase of system integration, which goal is to check correct operation and interoperability between the system components. Each of the following steps is referred to as Equipment Installation (EI) and is numbered for each step.

Note that the figures shown in the following show the logical architecture of the system and logical connections among the different components. For more exact information about the network architecture (e.g. different WLANs and physical connections) the reader shall refer to section 8. In section 8, besides, more information about network configuration is provided, e.g. how remote access to the installed components is done.

5.1 EI-I: Middleware installation

The middleware installation is carried out by simply installing the middleware in one of the servers provided by TI, which is done remotely. It entails the further setting up of a couple of multicast channels with some content information such as title and the configuration of the middleware with credentials for authorising STBs to access the system. For this first step, testing correct operation of the middleware is carried out remotely, where it will be checked that the middleware answers to the requests done to the advertised URLs: either by answering “user not authorised” or by providing the information of the "available" multicast channels. Note that the advertised multicast channels supposed to be available do not have to really exist, i.e. not media data is multicast, but just the interaction with the Middleware is checked here, where some information is exchanged.

TIS and LAMBDA will participate in this installation.

5.2 EI-II: STB/SVC STB Emulator installation

The installation of the STB or SVC STB Emulator consists in connecting the STB or SVC STB Emulator to the network as shown in Figure 3 and Figure 4 respectively. Further, the STB has to be configured with the URL of the middleware server, as well as the credentials already configured in the middleware server.

5.2.1 AVC-based approach

During this step two AVC capable STBs are installed. In Figure 3, the network architecture is shown as an example with only one STB. After correct configuration of the STBs with credentials and URL of the middleware server, it is checked that the STBs receives the information about the configured multicast channels.

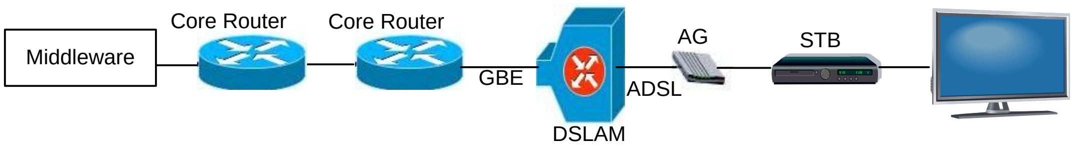

Figure 3: AVC capable STB installation

TIS and LAMBDA will participate in this installation.

5.2.2 SVC-based approach

For the SVC case, a similar installation is done. However, for the SVC case, a VoD service is tested, the transmission being done by unicast and not by multicast. The reason for that is that there is no live encoder as for AVC. However, a live service could be emulated and the data could be transmitted in a live manner, transmitting the content over multicast. Furthermore, the PDD prototype, as well as the SVC head-end, is running in PCs. The architecture for the installation of the SVC STB Emulator is similar to the AVC capable STB as shown in Figure 4. With respect to the SVC STB Emulator configuration, as well as for the AVC capable STBs, the URL of the middleware server is configured as well as the credentials for accessing the system.

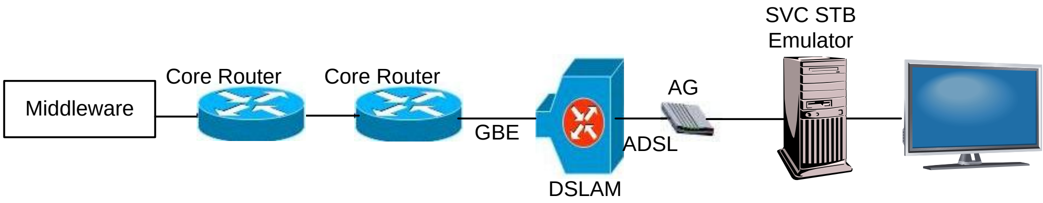

Figure 4: SVC STB Emulator installation

TIS, UDC and HHI will participate in this installation.

5.3 EI-III: Real Time Encoder or SVC Content generator installation

This section describes the installation of the real time encoders for the multi-rate approach based on H.264/AVC and installation of the SVC Content generator. This corresponds to a first step for installing the head-end, where correct generation and transmission of Multi-video SPTS for the AVC-based approach is tested and correct generation and transmission of the SVC SPTS over RTP is tested for the SVC-based approach.

5.3.1 AVC-based approach

For the AVC-based approach, there are two techniques as described in [2]:

- The 2 [Single-video STPS encoder] (here referred to as “Single-video-Encoder”) followed by a multiplexer, each Single-video-Encoder producing 4 versions of the same content.
- The 3 Multi-video SPTS encoder with embedded multiplexer (here referred to as “Multi-video-Encoder”), each Multi-video-Encoder producing 2 versions of the same content.

Installation of these two solutions entails connecting the original content player (see section 8.2) via an HD/SDI interface to the different encoders, connecting the Single-video-Encoders to the MPEG Multiplexer input ports and connecting the Multi-video-Encoders and the MPEG Multiplexer output to a switch. As later described in section 8.8, all this entails creating a VLAN for all this components where they can communicate to each other. In order to check the correct operation of the encoders and multiplexer, a PC is connected and is configured so that it receives the multicast data. This PC is capable of processing the different SPTS/UDP data and it is checked that the data is displayed for the selected videos, as well as that the MPEG metadata, such as Program number, PMT and audio/video PIDs are correct.

The tools used for processing the SPTS/UDP are:

- Internal tool to extract the TS file from the IP encapsulation
- VLC to play the TS video stream to control the correct streaming from the encoders
- Internal analyser to identify Random Access Points (RAP) in the transport priority flag in TS packet header, PCR synchronization analysis, T-STD simulation, and TS metadata analysis (such as Program number PID , PMT PID , Video PIDs, Audio PIDs).

Note that the PC is connected to a Hub (see Figure 6). The reason for this is that, when the complete IPTV system will be built, this PC will also be used (cf. Figure 1) as a sniffer for an easier debugging of the system.

The installation will be done in 2 steps: On the one side the Single-video-Encoders with the MPEG Multiplexer will be checked with the PC and on the other side, it will be checked that the Multi-video encoders provide correct streams to the PC. First of all, the PC is connected directly to the Encoders, as shown in Figure 5 checking that the generated streams are correct. Then, the PC will be connected to the Encoders through the network built for the IPTV system as shown in Figure 6.

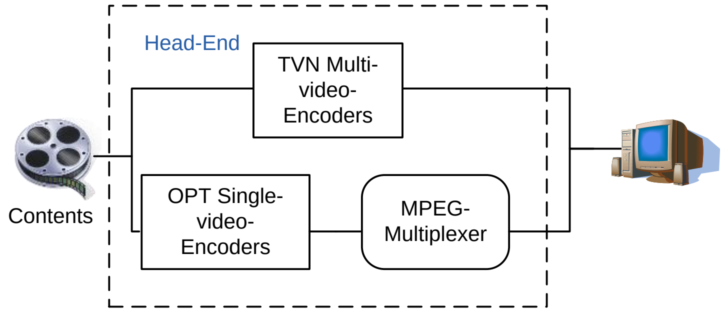

Figure 5: Direct connection of Encoders to a PC

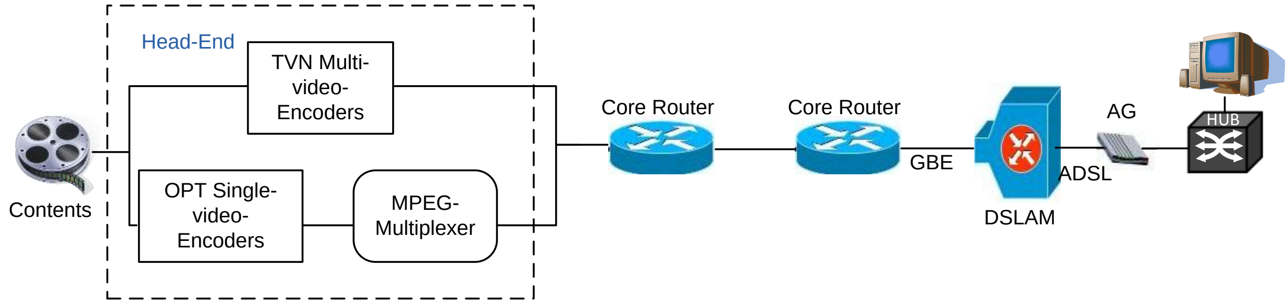

Figure 6: Installation of head-end of the multi-rate approaches without encryption component

As a baseline, for the Live Multi-video Encoder part, three encoders providing 2 synchronized streams will be installed in the network (3 x 2 configuration), while for the Single-vide-Encoder part, two 1U encoding units providing 4 synchronized streams will be installed (2 x 4 configuration). However, some flexibility for the Live Multi-video Encoder solution exists and studies on going at TVN when this deliverable is released show that the 3 x2 configuration could be replaced without changing the hardware by a 1 x 4 configuration, for instance.

Besides confirming that the generated content is displayable, at this stage it is possible to check whether the different encoders are well configured and the constraints necessary latter for the encryption are satisfied. At this stage it is possible to check at the PC whether the received streams contain a NULL packet at least every 300 ms.

More detailed information on the installation of the encoders, such as connection of the video sources with the encoders is provided in the Annex.

TIS, TVN and OPTEC will participate in this installation.

5.3.2 SVC-based approach

The SVC Content generator (the SVC Head-end) runs in a normal PC hosting also the encryption functionality which is not activated for this test. The SVC Head-end is configured so that the SVC SPTS/UDP data is sent to the IP address of the PC at the other side. In the latter, an SVC VLC client is running and it is checked that the sent data can be correctly decoded and presented. For this case, since the SVC Head-end is running in a PC, we can check with this PC that the streams are correctly generated prior to transmission, avoiding thus to have to connect an additional PC directly to the output of the SVC Head-End. Then it is checked that the PC at the other side of the network, shown in Figure 7 where the SVC VLC client is running, receives also the correct data and can decode and present the data correctly.

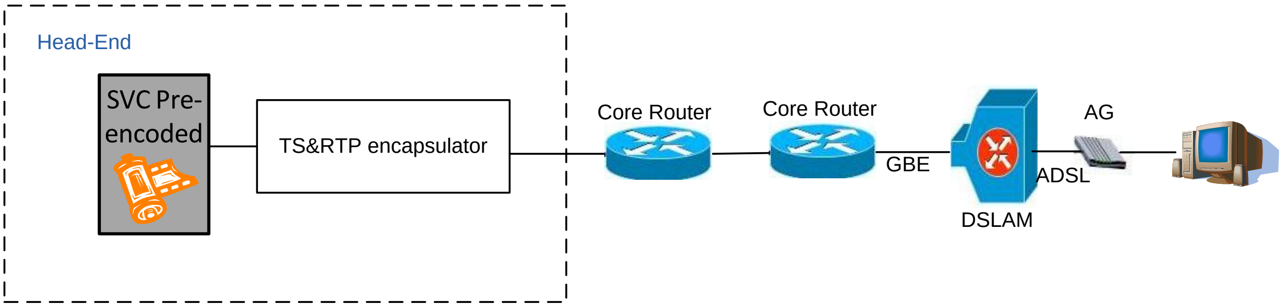

Figure 7: SVC Content generator (SVC Head End) installation

Furthermore, as for the AVC-based approach, at this point it is possible to check that the TS encapsulator is well configured and that the constraints necessary later for the encryption are satisfied, i.e. streams contain a NULL packet at least every 300 ms.

Note that in this case no Hub is used. Since for the SVC-based approach the SVC STB Emulator will be running in a PC, no additional PCs as sniffers are needed for debugging later when the STB is added, since the PC used for running the SVC STB Emulator can be used.

TIS and HHI will participate in this installation.

5.4 EI-IV: Encryption component installation

In this section the installation of the encryption component is described. As explained in 5.4.1 and 5.4.2, for the multi-rate approach it consists of adding an additional device, while for the SVC approach it consists of changing a configuration file so that the head-end scrambles the data before RTP encapsulation is carried out.

5.4.1 AVC-based approach

Installing the encryption component means simply connecting the output of the Multi-video-Encoders or the MPEG Multiplexer to the input of the encryption component and its output to the core router as shown in Figure 8.

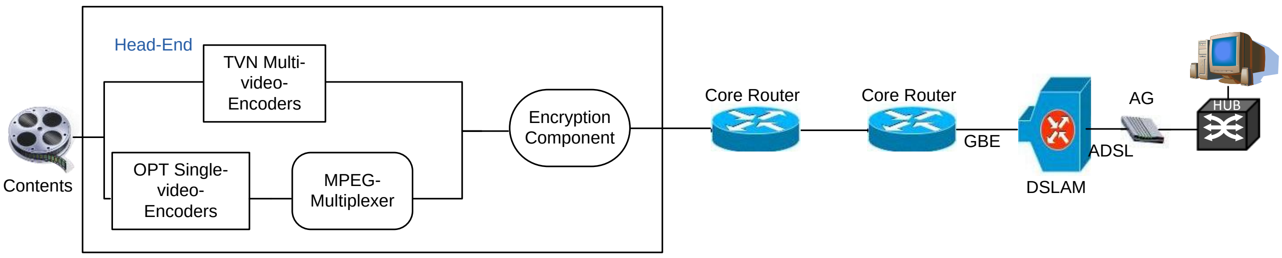

Figure 8: Encryption component installation for the multi-rate approach

The logical box in Figure 8 referred to as "Encryption Component" consists of the IPTV Scrambler, the KMS (Key Management Server) and the Key Server as shown in Figure 9. The IPTV Scrambler is a carrier class solution that is built around a modular platform hosting a wide selection of modules, thus allowing the IPTV Scrambler solution for the OptiBand project. The IPTV Scrambler is a hardware component that is designed to receive streams of live IP data, scramble them with a control word and transmit them to the consumer's STB. It performs the high-speed data encryption of up to 850Mbit/s.

The IPTV Scrambler creates control words and sends them to the KMS (Key Management Sever) Entitlement Control Message Generator (ECMG). The KMS ECMG then uses the control word to generate an encrypted message named ECM (Entitlement Control Message), which contains the control word and the required access rights. The KMS system depends on the Key Server to encrypt all messages intended for the Irdeto Smart cards of the operator, i.e. ECM messages and EMM (Entitlement Management Message) messages. The communication protocol between these components is an Irdeto propriety protocol on which the KMS system sends un-encrypted messages (ECM or EMM) to the Key Server and the Key Server returns the encrypted messages. The key material stored on the KMS system is encrypted with a secret operator specific key which is also contained in the Key Server to protect the communication between KMS and the Key Server.

For the goal of the OptiBand project only ECM messages are considered. Once the KMS has received the encrypted ECM, the KMS forwards it to the IPTV Scrambler. The IPTV Scrambler uses the control words to scramble the data, and then transmits the scrambled data together with the encrypted ECMs to the STBs.

The IPTV Scrambler performs scrambling at the MPEG-2 transport level using DVB/CSA (Common Scrambling Algorithm). It supports the selective scrambling of MPEG-2 and H.264 video streams, which enables, among other things, the scrambling of the SVC base layer only which can be used to limit the processing power needed in CPEs when they descramble the received data.

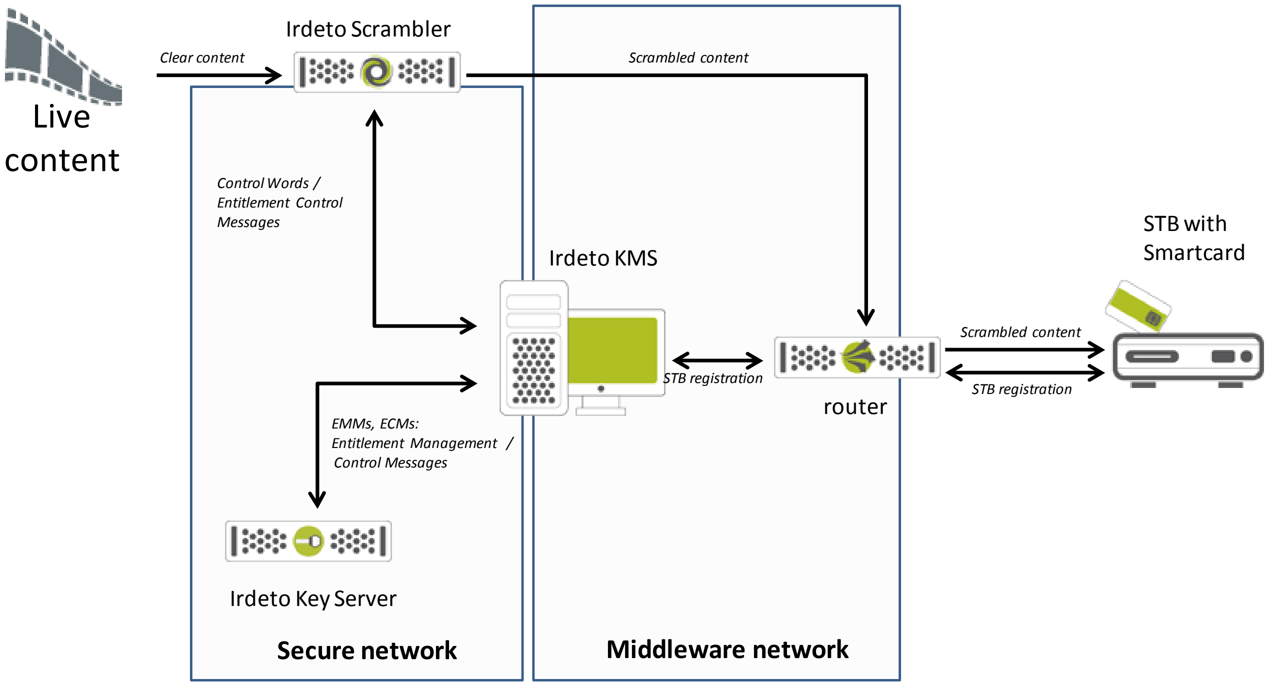

Figure 9: Description of the Encryption Component

Since in the previous step, during the installation of the encoders, it has been checked that the different TS streams contain the necessary NULL packets at least every 300 ms, encryption should be done without problem. As well as, for the previous case it is checked that the received data at the PC can be descrambled and correctly presented.

TIS and IRD will participate in this installation.

5.4.2 SVC-based approach

Installation of the encryption component for the SVC approach does not entail introducing any further component to the network. Encryption happens in a module in the software of the SVC Live Encoder Emulator, as described in section 5.1 in [2] and therefore can be activated / deactivated by a configuration file.

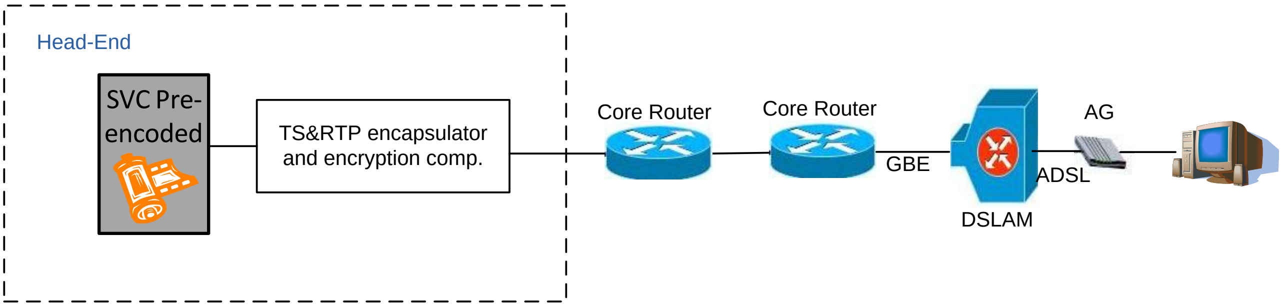

Figure 10: Encryption component installation for the SVC approach

At this point it is checked that the STB emulator can descramble the data and that even some RTP packets are dropped, changing to another operation point, the received stream can be still correctly descrambled and the data can be decoded and presented.

TIS and HHI will participate in this installation.

6. First Integration Phase (without PDD)

During this step of the system integration, the full IPTV eco-system transmitting a Single-video SPTS can be verified. As described more in detail in the following, all system components listed in Table 1 but the PDD are integrated in this first integration phase and the correct operation of the IPTV system is tested. This phase is divided into two steps: FP-I and FP-II (First Phase 1 and 2)

6.1 FP-I: IPTV eco-system Integration without encryption component

In this section, the integration of the head-end (without encryption), middleware and STB is described. It is tested that the video data produced by the head-end can be correctly processed, decoded and presented.

6.1.1 AVC-based approach

Up to this point, all components of the system used for this step have been installed and it has been checked that they are working correctly. At this stage, it is tested how these components work together. Figure 11 illustrates the resulting IPTV architecture for the tests, which goal is to check that the STBs can present correctly the video data produced by the different encoders.

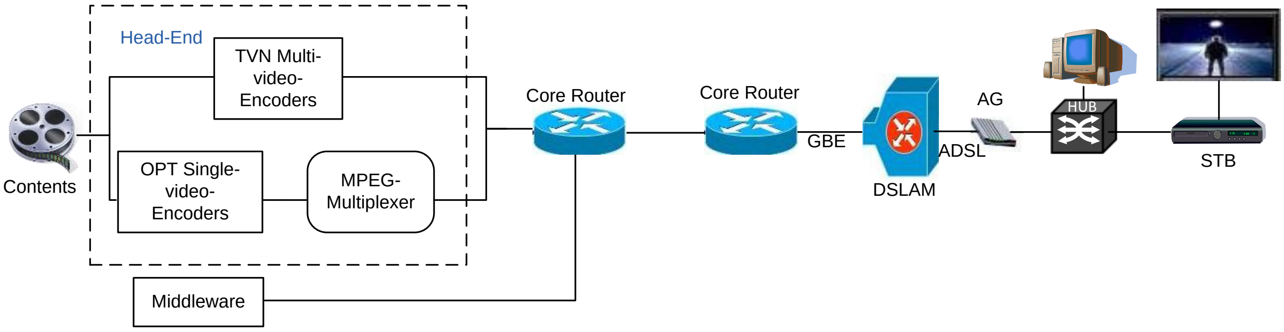

Figure 11: Full IPTV eco-system without encryption for multi-rate approach

During the installation stage of the STBs, interaction with the middleware has been already tested. Therefore, the STB should be able to discover the multicast addresses by accessing the middleware at the server. The data generated by the encoders is sent to the multicast addresses advertised by the middleware. During this integration phase, where no PDD is integrated, the multiplexer functionality is bypassed and the streams which are sent are Single-video SPTS streams, at a single bitrate, in order to be able to test if the IPTV eco-system without the solution proposed in the OptiBand project works properly.

Furthermore, a PC is configured as a sniffer in order to allow debugging in case the STBs cannot present the data and thus allows a deeper analysis of the transmitted data.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix. Therefore there will be someone available in all partner premises during this phase of the tests.

6.1.2 SVC-based approach

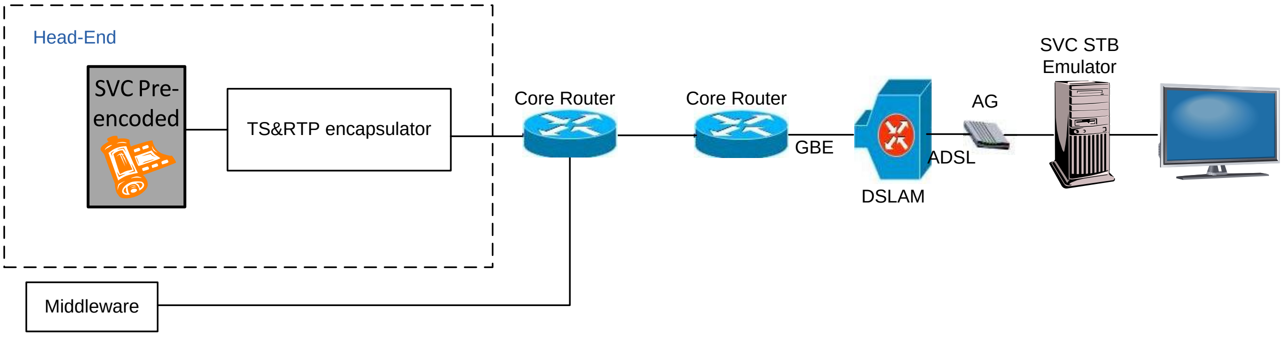

Figure 12: Full IPTV eco-system without encryption for SVC-based approach

In the SVC case, the architecture shown in Figure 12 is tested. A VoD service over a unicast connection is checked due to the fact that not live encoders are available. Therefore, for this first phase, the head-end is configured to send the data to the IP address SVC STB Emulator. Additionally, it is possible to test that an AVC-capable STB can at least decode the base layer of the SVC content, showing the backward-compatibility of the proposed approach with already existing hardware. For this purpose, the STB should be configured to be able to receive the RTP packets sent by the SVC head-end and the data generated at the head-end is sent to the IP address of the AVC-capable STB. In case the Pre-integration tests show that the STB cannot process RTP packets, it will be analysed if removing RTP headers and transmitting TS packets directly over UDP is possible for the SVC approach.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix. Therefore there will be someone available in all partner premises during this phase of the tests.

6.2 FP-II: IPTV eco-system Integration with encryption component

Once the full eco-system is tested without the encryption component and the tests are successful, the encryption components are integrated. The resulting architecture of the network for the AVC-based approach and for the SVC-based approach is shown in Figure 13 and Figure 14 respectively.

6.2.1 AVC-based approach

As detailed in the installation of the encryption component, in this case, the output of the Live Multi-video-Encoders and MPEG Multiplexer are sent to the encryption component. This component outputs the same Multi-video SPTS over UDP data as the received one but encrypted. It is tested once more that the STBs can decode and present the data. A PC is configured as a sniffer as shown in Figure 13 in order to allow a better debugging of the IPTV system. Note that, as for the previous case, since there is no PDD, the multiplexer functionality is bypassed and the streams which are sent are Single-video SPTS streams, at a single bitrate.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix. Therefore there will be someone available in all partner premises during this phase of the tests.

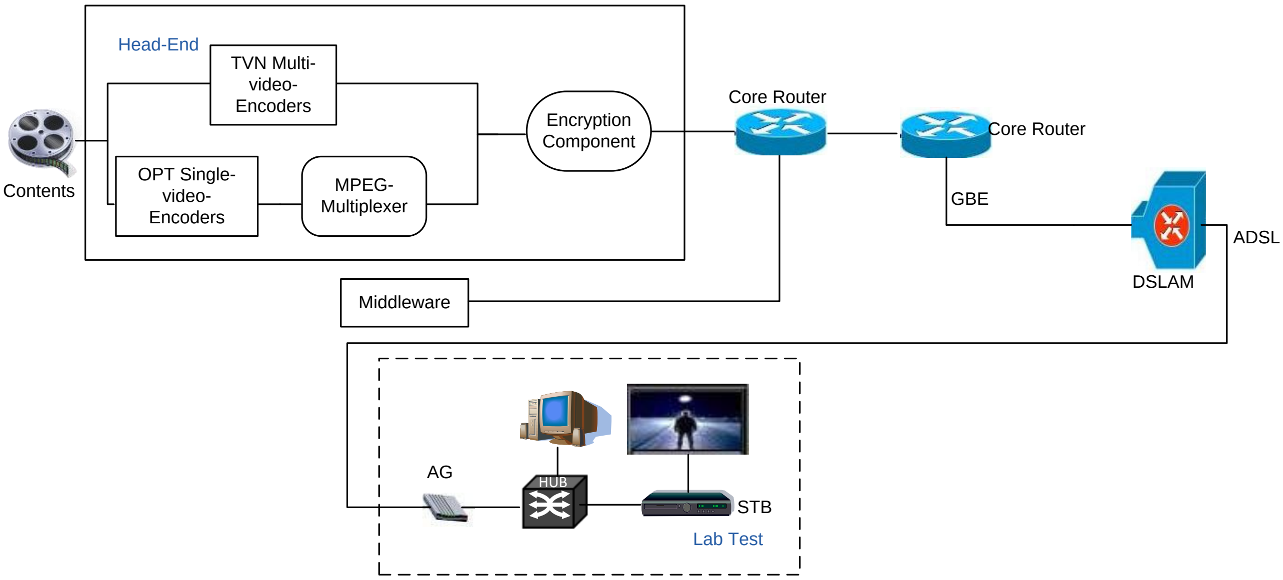

Figure 13: Full IPTV eco-system with encryption for multi-rate approach

6.2.2 SVC-based approach

For the SVC case, as aforementioned, the configuration file of the head-end is changed in order to activate the encryption module and to scramble the MPEG-2 TS packet prior to the RTP encapsulation. Again, the data is sent to the SVC STB Emulator and it is checked that the video can be correctly displayed.

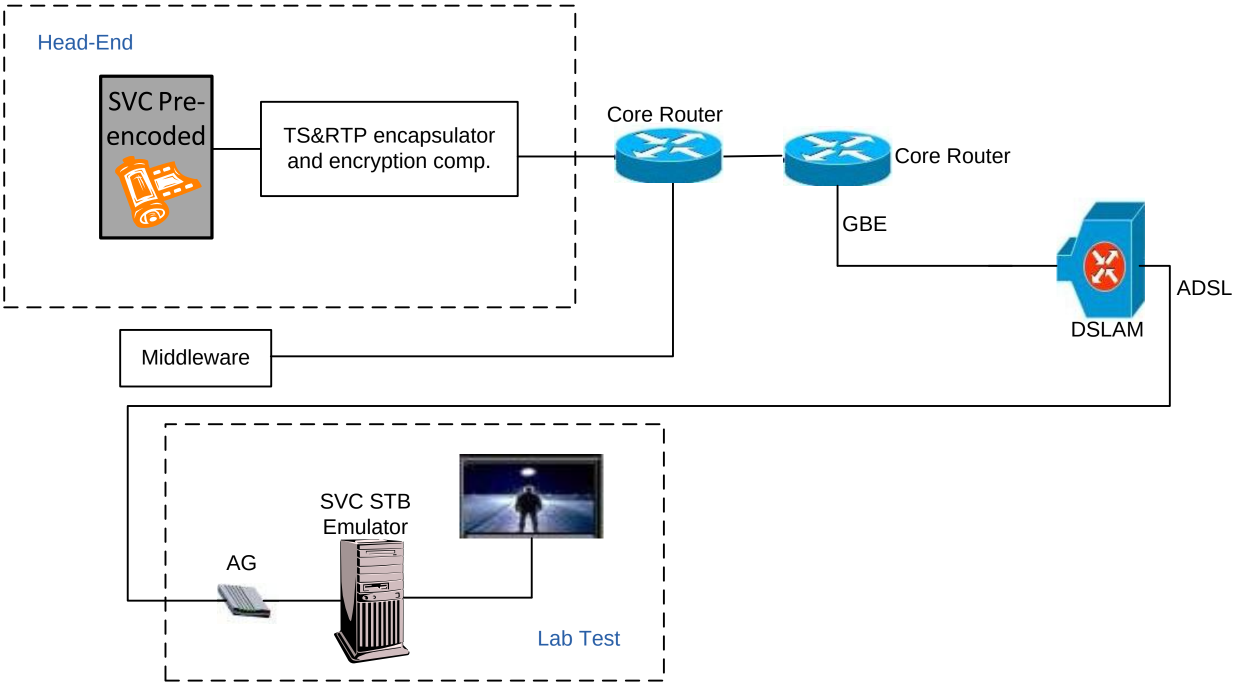

Figure 14: Full IPTV eco-system with encryption for SVC-based approach

As aforementioned, it is also tested that the AVC-capable STB can process the data and correctly presents the video, although only the base layer is decoded and the presented video has a lower quality than the generated SVC stream.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix. Therefore there will be someone available in all partner premises during this phase of the tests.

7. Second integration phase (with PDD)

In this second phase of the integration, i.e. the last step in the integration plan of the OptiBand project, the packet dropping device (PDD) is integrated. In this case, the proper operation of the PDD and of the whole solution is tested. This phase is divided into two: SP-I and SP-II (Second Phase 1 and 2).

7.1 SP-I: Integration of PDD without encryption component

First the PDD will be integrated without the Encryption tool. Although, it has been already checked that the solution (without PDD) and encryption works properly, this first approach allows a simpler debugging of the system, in case the integration does not work correctly at first. This is again done for both approaches (AVC-based approach and SVC-based approach) as shown in the following.

7.1.1 AVC-based approach

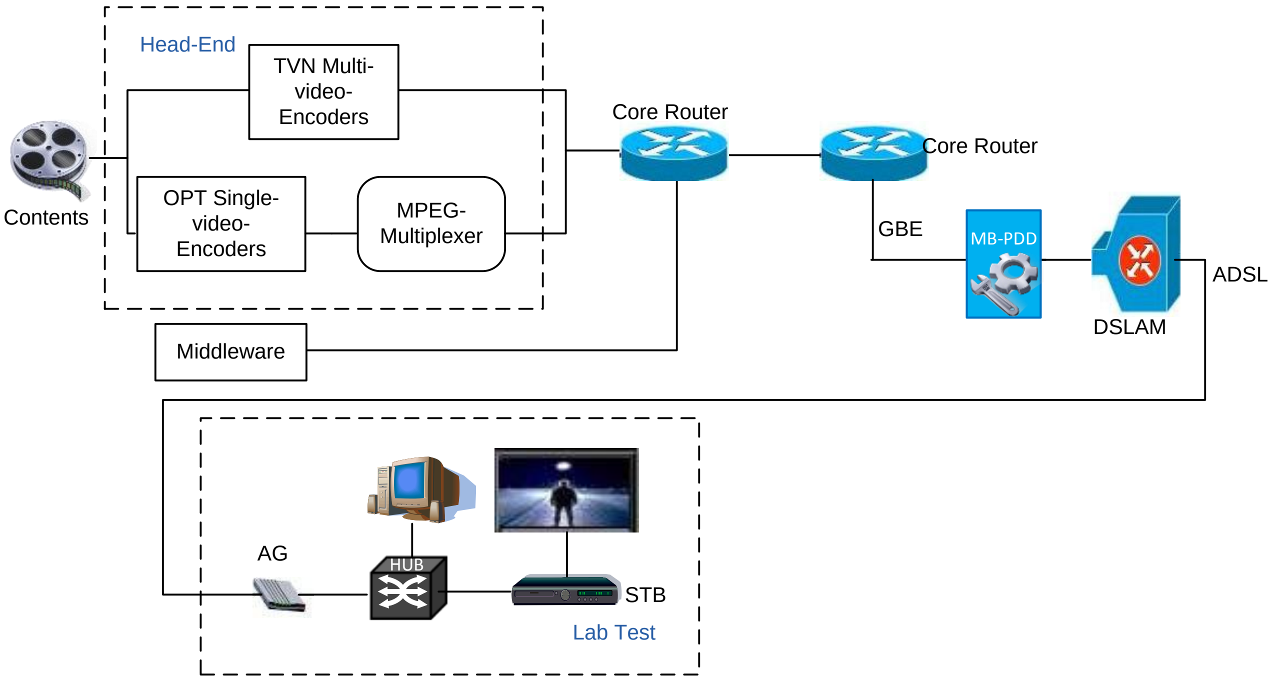

Figure 15: IPTV system without encryption component with PDD integrated for the multi-rate approach

Figure 15 shows the IPTV system proposed in OptiBand with the PDD integrated. Similar tests to the ones done without the PDD are carried out. The middleware advertises a couple of multicast addresses and the Multi-video SPTS streams generated by the different encoders are transmitted to these multicast addresses. This time the MB-PDD is integrated in the system prior to the DSLAM, as seen in Figure 15, and it will forward only one stream to the STBs.

First, the PDD is configured manually so that it forwards a given bitrate and, a certain time later, the forwarded stream is switched to another bitrate, checking thus that the created stream can be decoded and presented at the client side, i.e. the STB. Once this works, the PDD is configured in its normal operating mode and it is checked that when a new STB comes into the network, the resources are shared among both receivers and that the bitrate of the stream forwarded to a STB changes depending on whether the STB is the only one in the system or another STB joins another multicast address.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix.

7.1.2 Therefore there will be someone available in all partner premises during this phase of the tests - SVC-based approach

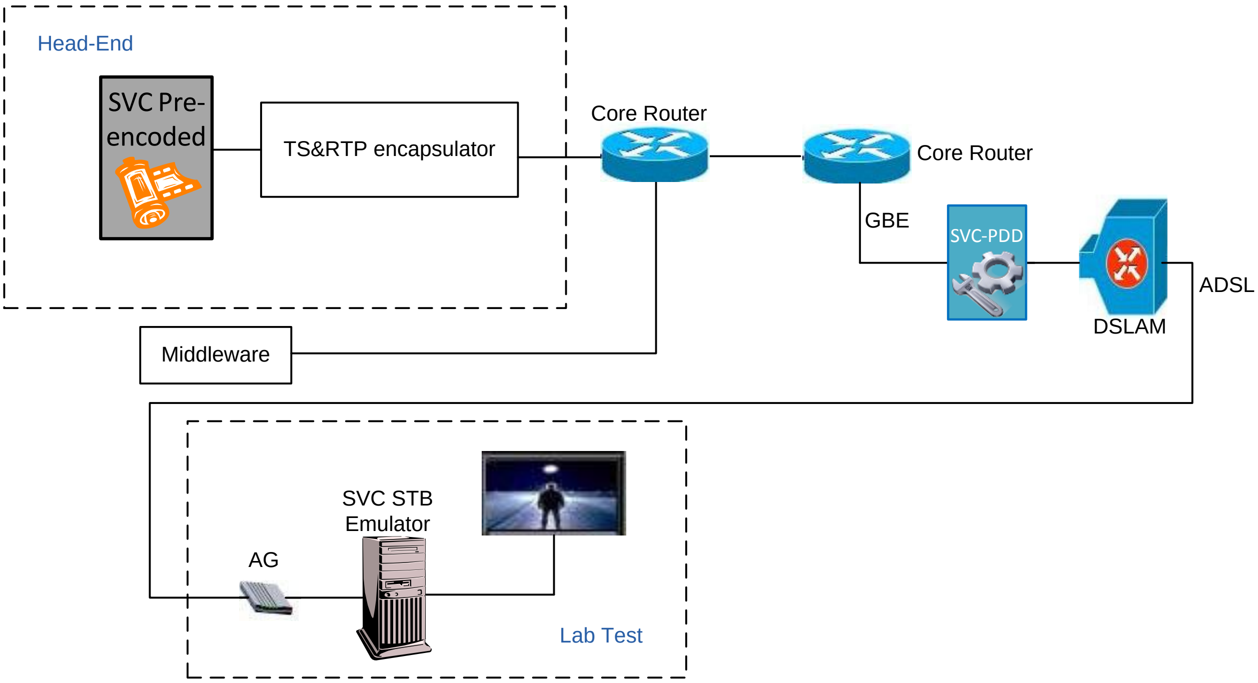

Figure 16: IPTV system without encryption component with PDD integrated for the SVC approach

As for the AVC-based approach, the SVC PDD is integrated between the head-end and the SVC STB Emulator as shown in Figure 16. In this case, the data generated at the SVC head-end is sent to the IP address of the SVC STB Emulator, being routed through the SVC PDD. Note that in this case the SVC PDD is a layer 3 device, and therefore the network, as shown in section 8, has to be configured so that the packets sent to the STB pass through the SVC PDD. The PDD is also manually configured so that a varying number of layers are transmitted over the time. Once it is check that this can be correctly presented at the clients, the decision of which video version to send (amount of SVC layer to forward) is done depending on whether more users connect to the network or not. Tests will be carried out when an additional client joins a multicast channel and leaves it, to check that the SVC-PDD adapts the streams correctly, depending on the available throughput for each stream, which is related to the number of clients connected. Furthermore, as for the tests without the PDD being integrated, an AVC-capable STB is connected and checked that the SVC base layer can be decoded and played back. As mentioned before, if it will be checked if AVC-capable STBs can process RTP packets. If this is not the case it will be analysed the possibility of removing the RTP at the PDD and sending the TS packets directly over UDP.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix. Therefore there will be someone available in all partner premises during this phase of the tests.

7.2 SP-II: Integration of PDD with encryption component

In this step, the encryption component is added resulting in the complete IPTS system integration. The architecture for the AVC-based approach and the SVC-based approach is shown in Figure 1 and Figure 2 respectively. Similar tests as the ones describe in section 7.1 are carried out for this complete solution.

TI will check the correct operation and that the remote access for all partners is allowed in case there is anything to fix. Therefore there will be someone available in all partner premises during this phase of the tests.

8. Configuration of the IPTV test environment

This section outlines configurations, requirements and the list of pieces of equipment available in TI laboratories for the integration job and for the live tests to be carried in TI under WP8.

The section describes:

- What will be provided by TI.
- The constraints the project musts comply with, as the live tests must coexist with the other on-going activities.

8.1 List of pieces of equipment available from TI

- Abobe Premiere CS3 tool for providing HD-SDI input to the live encoders.
- Final Cut authoring tool for providing HD-SDI input to the live encoders.
- BlackMagic HDLink boards for HD-SDI input/output to/from the authoring tools
- Blackmagic Design SDI/HD-SDI switch.
- 4 HP 2RU servers in one rack for application server installation.
- GbE LAN with sub netting for head-end, servers and network resources.
- Fast Ethernet LAN with sub netting for management and clients.
- Network servers: DHCP, DNS, NTP, FTP, …
- Siemens DSLAM with ADSL2+ ports configured in igmp-snooping.
- Some Pirelli AGs.
- Pirelli STBs (for optional supplementary checks with commercial STBs).
- PCs and laptops equipped with Windows XP/Vista or Linux for management, debug, traffic control and for the VoD client.
- Television: Panasonic Viera mod. TH42PZ700E Plasma Television

8.2 Feed of the live encoders

The HD-SDI input to the live encoders can be provided in the following way:

- ADOBE PREMEIRE CS3
  - HP xw6600 workstation with
    - 2 quad-core Intel Xeon E5450 processors @3GHz
    - RAM: 3.25 GB
    - windows XP SP3
    - external 4 TB hard-disk with high speed connection via fiber channel
  - Tool: Adobe Premiere CS3 + Blackmagic Design DeckLink HD Extreme 3 input/output board
  - The Blackmagic Design board and its codec (FourCC: HDYC) are seen by Premiere as plugins.
  - Format of source content: uncompressed YUV 4:2:2 in AVI container
  - Resolution: 1080i or 1080PsF or 720p (both Adobe Premier CS3 and the encoders do not support 1080p)
  - A project in Premiere CS3 is created with audio/video configuration suitable for the encoders
  - The source content file is imported in Premiere CS3. The output of the rendering window is sent to the SDI/HD-SDI switch (coax connections) which is cross-connected to the encoders
- FINAL CUT PRO
  - MAC PRO workstation with:
    - 2 six-core Intel Xeon processors @2.66GHz
    - RAM: 12 GB
    - Mac OS X 10.6.8
    - external 6 TB hard-disk with high speed connection via fiber channel
  - Tool: Apple Final Cut Pro + Blackmagic Design DeckLink HD Extreme input/output board

    - The Blackmagic Design board and its codec (FourCC: HDYC) are seen by Final Cut as plugins.
    - Format of source content: uncompressed YUV 4:2:2 in AVI container
      Resolution: 1080i or 1080p or 720p
    - A project in Final Cut is created with audio/video configuration suitable for the encoders
  - The source content file is imported in Final Cut. The output of the rendering window is sent to the SDI/HD-SDI switch (coax connections) which is cross-connected to the encoders

8.3 Laboratory network architecture

The network architecture is emulated in laboratory using two routers and a set of Ethernet switches.

The head-end will be connected to one of those routers which can be considered as the border router of the transport network. The second router can be considered as the border router of the metro network, to which the PDD and the DSLAM are connected. All connections at this level are 1 GB connections.

The laboratory network is a set of LANs. All IP addresses, both static and dynamic, are private. All the machines are under a firewall protection. Access to the servers from outside the laboratory must be agreed with the laboratory responsible and will be allowed for a limited time and from specified IP static and public addresses and ports (editing the access lists will be required).

Access to the public internet is allowed for http, https and ftp through a proxy (172.16.183.120:8080).

8.4 Laboratory network configuration

- Addressing
  - All of the addresses must lie within those available in the laboratory and must be agreed with the laboratory responsible in advance.
  - All of the addresses will be within a set of C classes in the range from 172.16.183.0/24 to 172.16.188.0/24
    - Servers will have static addresses from the 172.16.185.0/24 C class
    - Clients (STBs) will have dynamic addresses from the 172.16.183.176/29
  - Subnets (VLAN) with mask /29 (8 addresses) or /28 (16 addresses) or /27 (32 addresses) or /26 (64 addresses) or /24 (a whole C class) are available
  - Servers will have static addresses, clients will have dynamic address. The two subnets are separate each other
  - TTL must always be ≥ 8 It is strongly suggested to set TTL = 64

- Multicast addressing:
  - Multicast addresses must be chosen within the C class 225.2.2.0/24 for compatibility with other existing activities which already use multicast IP
  - The request of a multicast group must be done using **IGMPv2** by any client. IGMPv3 is not supported by network equipment

8.5 Laboratory support servers

- A DHCP server is available (address: 172.16.183.105). It provides dynamic addresses for any subnet defined for clients
  - The DHCP server provides any client with the following information:
    - option domain-name-servers 172.16.183.105
    - option domain-name "iptv.ita"
    - option time-servers 172.16.183.105
    - option ntp-servers 172.16.183.105

- DNS server (address: 172.16.183.105)
  - Only one second layer zone is defined which corresponds to the “iptv.ita” domain
  - It is required to define a third layer domain of kind *.iptv.ita. For OPTIBAND it will be “optiband.iptv.ita”

    - The server is able to resolve the logical names of all the public domains
- NTP server (address: 172.16.183.105)
    - Allows synchronization of the clock to any server and client in the laboratory network

8.6 Siemens DSLAM

- Model: HIX110
- Firmware version: hiX5635/R2.3
- Suitable ADSL2+ profiles will be built to support the bitrates required in the use cases
    - The bit rate is defined at physical level (line alignment)
    - Some amount of error protection is included (INP/Delay)

Some high level presentation of the DSLAM is reprinted from the Siemens documentation: SURPASS hiX 5635 R1.3 System Description (SYD)

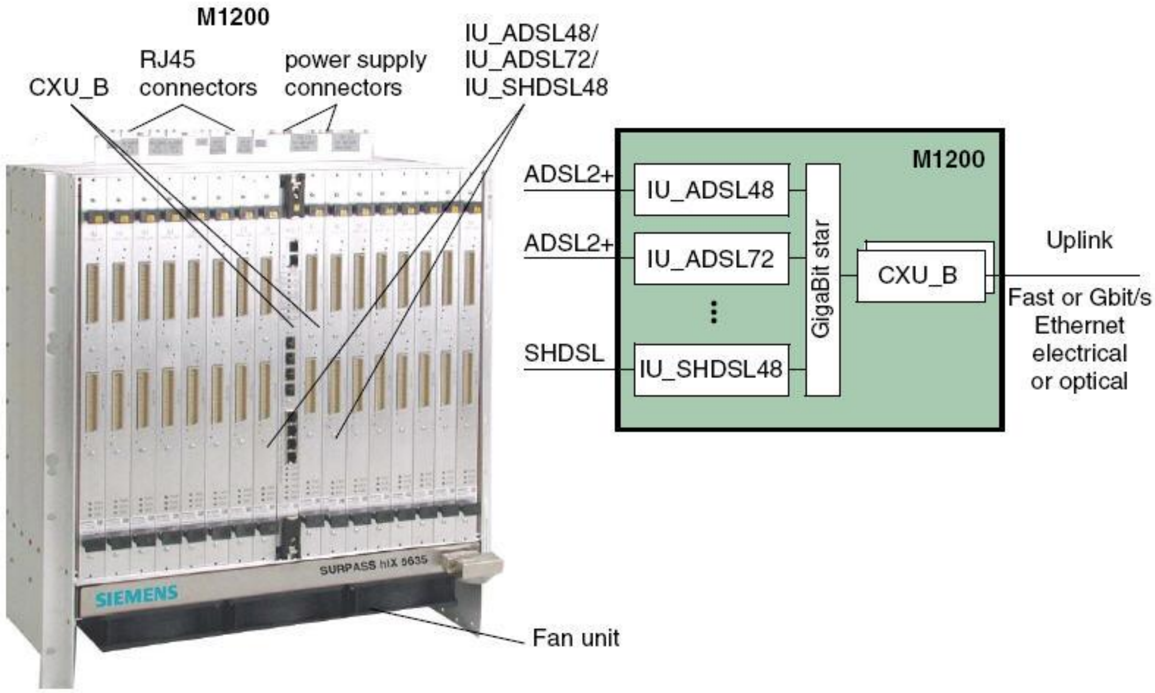

Figure 17: HiX110 DSLAM

The mentioned documentation outlines the implementation of IGM snooping, shown in Figure 18, as follows:

"In IGMP snooping implementations, messages are generated from the STB and from the multicast router located on the edge of the IP network. The DSLAM only snoops the IGMP requests from the users. All messages are forwarded to the multicast/IGMP router. By snooping the messages, the DSLAM can notice which channels do the users want to subscribe to. By doing so, the DSLAM can replicate channels currently being delivered to new requesting users."

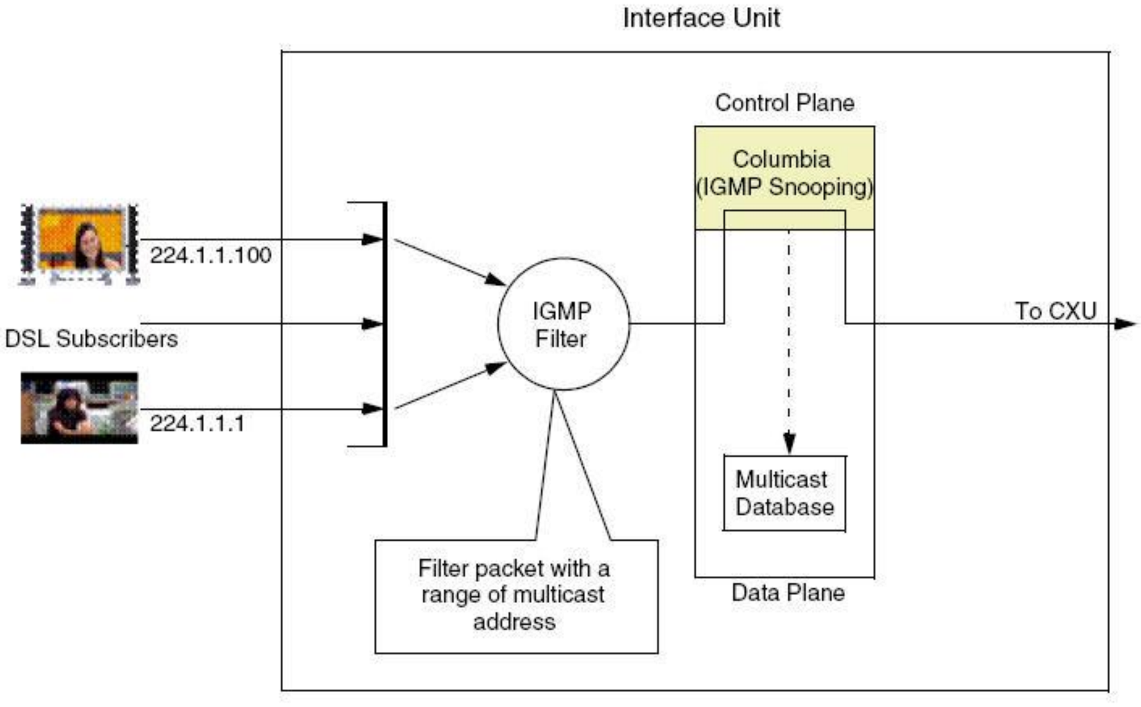

Figure 18: IGMP Filtering

Currently three lines have been configured on the Siemens DSLAM with the profiles reported below . The main features of each profile are highlighted in yellow:

- The rate-mode has been chosen to be fixed instead of adaptive to ensure that the expected bitrate is always available
- The maximum downstream bitrate is the parameter which distinguishes each profile and corresponds to the required physical layer bitrate for each defined profile
- The maximum theoretical downstream bitrate will be always the same for any line (22.240 Mbps)
- The upstream bitrate is 1.216 Mbps and is the same for all of the lines
- The noise protection (INP = 0.5 and Delay= 8 ms.) is kept at very low levels to limit the weight of redundancies

See details of each profile in the following:

- **profile Profile7M adsl2plus**

  adsl add line-config-profile Profile7M adsl2plus
  adsl line-config-profile Profile7M atuc rate-mode fixed
  adsl line-config-profile Profile7M atuc interleaved max-tx-rate 6976
  adsl line-config-profile Profile7M atuc fast max-tx-rate 22240
  adsl line-config-profile Profile7M atuc max-interleave-delay 8
  adsl line-config-profile Profile7M atur dnshift-snr-mgn 0
  adsl line-config-profile Profile7M atur upshift-snr-mgn 120
  adsl line-config-profile Profile7M atur min-upshift-time 0
  adsl line-config-profile Profile7M atur min-dnshift-time 0
  adsl line-config-profile Profile7M atuc min-snr-mgn 10
  adsl line-config-profile Profile7M atur interleaved max-tx-rate 1216
  adsl line-config-profile Profile7M atur fast max-tx-rate 1216

adsl line-config-profile Profile7M atuc interleaved min-tx-rate 6976
adsl line-config-profile Profile7M atur interleaved min-tx-rate 896
adsl line-config-profile Profile7M atuc fast min-tx-rate 6976
adsl line-config-profile Profile7M atur fast min-tx-rate 896
adsl line-config-profile Profile7M atur min-snr-mgn 10
adsl line-config-profile Profile7M atur max-interleave-delay 8
adsl line-config-profile Profile7M gs rs-int-correct-dn 1MS
adsl line-config-profile Profile7M gs rs-int-correct-up 125US
adsl line-config-profile Profile7M atuc inp half
lre 1/1 adsl line-config profile Profile7M

- **Profile12M adsl2plus**

adsl add line-config-profile Profile12M adsl2plus
adsl line-config-profile Profile12M atuc rate-mode fixed
adsl line-config-profile Profile12M atuc interleaved max-tx-rate 12000
adsl line-config-profile Profile12M atuc fast max-tx-rate 22240
adsl line-config-profile Profile12M atuc max-interleave-delay 8
adsl line-config-profile Profile12M atur dnshift-snr-mgn 0
adsl line-config-profile Profile12M atur upshift-snr-mgn 120
adsl line-config-profile Profile12M atur min-upshift-time 0
adsl line-config-profile Profile12M atur min-dnshift-time 0
adsl line-config-profile Profile12M atuc min-snr-mgn 10
adsl line-config-profile Profile12M atur interleaved max-tx-rate 1216
adsl line-config-profile Profile12M atur fast max-tx-rate 1216
adsl line-config-profile Profile12M atuc interleaved min-tx-rate 12000
adsl line-config-profile Profile12M atur interleaved min-tx-rate 896
adsl line-config-profile Profile12M atuc fast min-tx-rate 6976
adsl line-config-profile Profile12M atur fast min-tx-rate 896
adsl line-config-profile Profile12M atur min-snr-mgn 10
adsl line-config-profile Profile12M atur max-interleave-delay 8
adsl line-config-profile Profile12M gs rs-int-correct-dn 1MS
adsl line-config-profile Profile12M gs rs-int-correct-up 125US
adsl line-config-profile Profile12M atuc inp half
lre 1/2 adsl line-config profile Profile12M

- **Profile18M adsl2plus**

adsl add line-config-profile Profile18M adsl2plus
adsl line-config-profile Profile18M atuc rate-mode fixed
adsl line-config-profile Profile18M atuc interleaved max-tx-rate 17984
adsl line-config-profile Profile18M atuc fast max-tx-rate 22240
adsl line-config-profile Profile18M atuc max-interleave-delay 8
adsl line-config-profile Profile18M atur dnshift-snr-mgn 0
adsl line-config-profile Profile18M atur upshift-snr-mgn 120
adsl line-config-profile Profile18M atur min-upshift-time 0
adsl line-config-profile Profile18M atur min-dnshift-time 0
adsl line-config-profile Profile18M atuc min-snr-mgn 10
adsl line-config-profile Profile18M atur interleaved max-tx-rate 1216
adsl line-config-profile Profile18M atur fast max-tx-rate 1216
adsl line-config-profile Profile18M atuc interleaved min-tx-rate 17984
adsl line-config-profile Profile18M atur interleaved min-tx-rate 896

adsl line-config-profile Profile18M atuc fast min-tx-rate 6976
adsl line-config-profile Profile18M atur fast min-tx-rate 896
adsl line-config-profile Profile18M atur min-snr-mgn 10
adsl line-config-profile Profile18M atur max-interleave-delay 8
adsl line-config-profile Profile18M gs rs-int-correct-dn 1MS
adsl line-config-profile Profile18M gs rs-int-correct-up 125US
adsl line-config-profile Profile18M atuc inp half
lre 1/3 adsl line-config profile Profile18M

8.7 Access Gateway (AG)

- Pirelli : 4 promiscuous ports
- Two VP/VC on the ADSL2+ line
  - 8/36 IPTV (bridge mode; higher priority)
  - 8/35 data only (PPPoE; route mode; lower priority)
    - Currently only the 8/36 VP/VC has been configured on the DSLAM.

The STB must include the vendor-class-identifier set as "pirelli-stb" in its dhcp request in order to be routed to the IPTV service on the AG port it is connected to.

8.8 IPTV Network Architecture

Based on all this information from section 8.1 to 8.7 the following VLANs for the Head-end are created and the following addresses are assigned to the different components. Figure 19 and Figure 20 show the network architecture for the multi-bitrate approach.

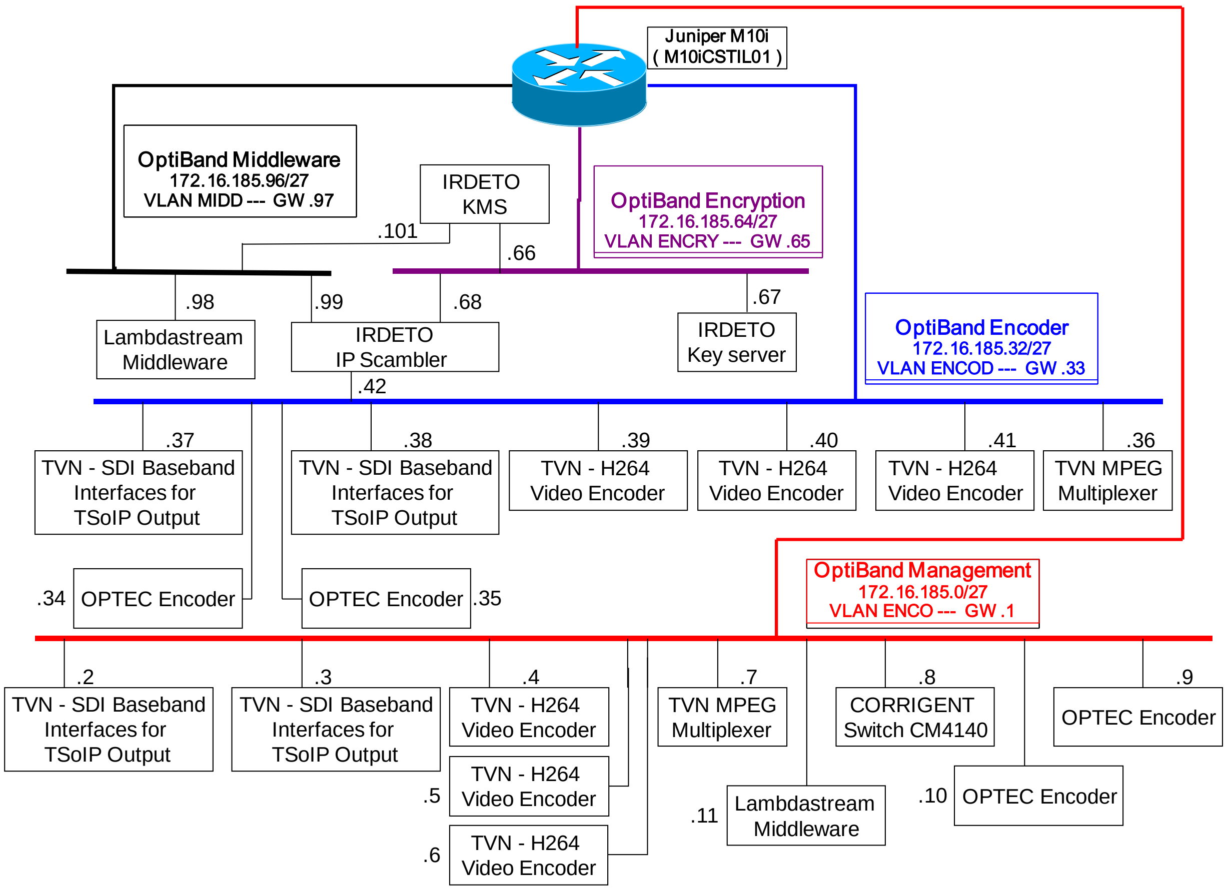

Figure 19: Head-end organization in VLANs

As shown in Figure 19, the head-end network is divided into 4 VLANs. One VLAN (blue lines) is for the encoders, which comprises Multi-video-Encoders (TVN-Encoders), SDI Baseband Interfaces for TSoIP output, the Single-video-Encoders (OPTEC Encoders) and MPEG Multiplexer and the input port of the IP scrambler. Another one (purple lines) is for the Encryption internal communication, which is a secure network, cannot be accessed from outside and comprises the IP scrambler, the Key Server and the KMS as described in section 5.4.1. Another VLAN (black lines) is for the Middleware and the output of the IP scrambler and the last one (red lines) is for management. The IP addresses for each of the components in each VLAN are indicated in the figure, as well as the Gateway for each VLAN.

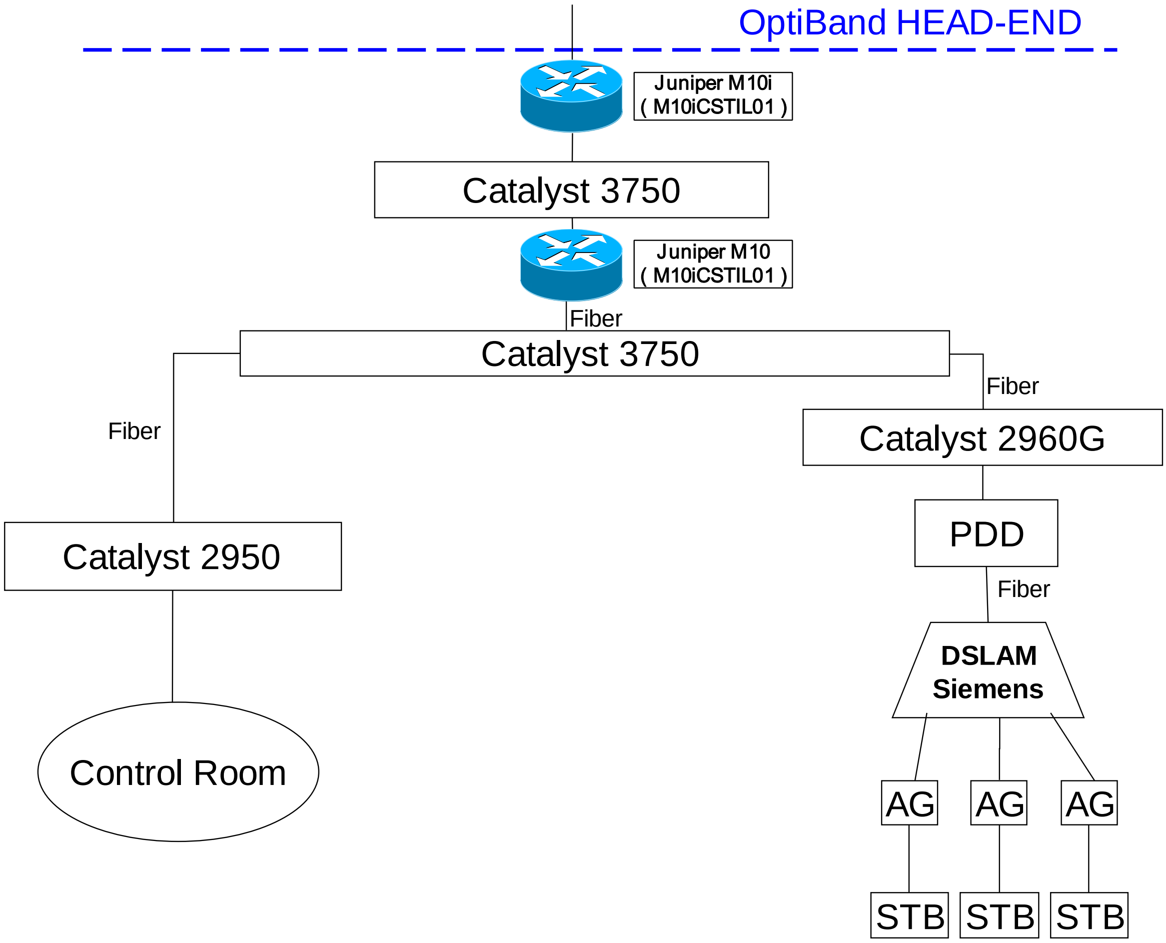

Figure 20: Architecture of Metro Network and Access Network for STBs

Figure 20 shows the architecture of the network emulating a metro network and access network for STBs. The figure shows how the routers Juniper M10i are connected, as well as the PDD, DSLAM and STBs. The STBs are within a VLAN with 172.16.183.176/255.255.255.248, i.e. there are 4 addresses to accommodate 4 STBs.

Figure 21 shows the network architecture and the assignment of the SVC Head-End, SVC PDD and SVC STB Emulator to VLANs.

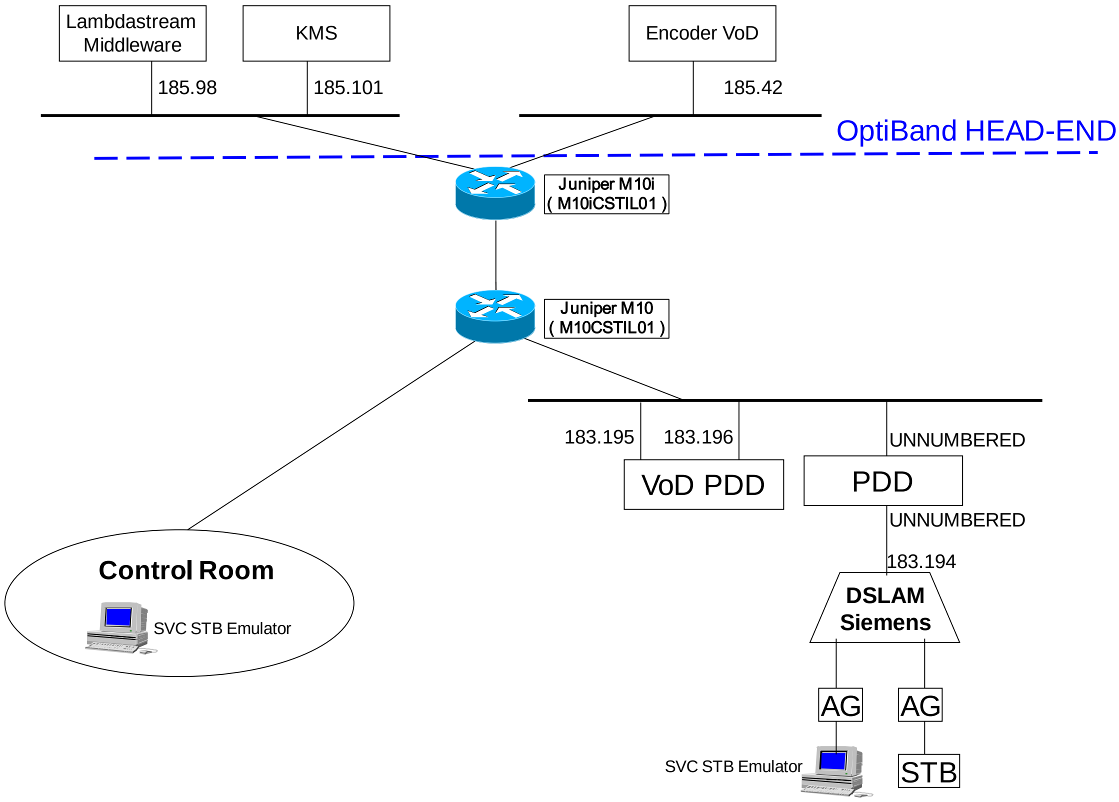

Figure 21: Network architecture and VLANs for the SVC-based approach

9. Summary of important dates for Integration Plan and important information for Lab organization

Table 2 summarizes the most important information for organizing TI´s laboratory for system integration. Furthermore the shipping dates for each component are presented in Figure 22, where SE_n refers to Shipping date of Equipment number n. The fields with N/A mean that equipment available at TI will be used for installing software and no equipment will be send to TI.

Equipment number	Manufacturer	Model Type	Quantity	Sending Equipment Date	Installation Date
1	TVN	H264 Multirate Video Encoder	3	12/12/2011	20/12/2011
2	TVN	SDI Baseband Interfaces for TSoIP outputs	2	12/12/2011	20/12/2011
3	TVN	MPEG Multiplexer	1	12/12/2011	19/12/2011
4	CSL	MB-PDD	1	15/12/2011	12/12/2011
5	OPT	Encoder	1	15/12/2011	19/12/2011
6	IRD	KMS	1	15/12/2011	29/12/2011
7	IRD	Key server	1	15/12/2011	29/12/2011
8	IRD	IP scrambler	1	15/12/2011	29/12/2011
9	LAMBDA	Middleware**	1	N/A	01/12/2011
10	LAMBDA	STB	3	15/12/2011	20/12/2011
11	HHI	Live SVC Encoder Emulator (PC)**	1	N/A	20/12/2011
12	HHI	PDD (PC with 2 network cards)**	1	N/A	20/12/2011
13	HHI	SVC STB Emulator (Laptop PC)	1	15/12/2011	20/12/2011

Table 2: Equipment sending and installation date

Equipment number	Model Type	Dimension (RU)	Power Supply	Power Consum-ption
1	H264 Multirate Video Encoder	1	100V to 240V AC	460W
2	SDI Baseband Interfaces for TSoIP outputs	1	100V to 240V AC	460W
3	MPEG Multiplexer	1	100V to 240V	180W
4	Switch CM4140	3	48 Dc → AC to DC unit	300 W
5	Encoder	1	220	50
6	KMS	1	220	250 W
7	Key server	2	220	76 W
8	IP scrambler	1/2	220	500 W
9	Middleware**	2	220	N/A
10	STB	N/A	220	N/A
11	Live SVC Encoder Emulator (PC)***	N/A	220	N/A
12	PDD (PC with 2 network cards)**	N/A	220	N/A
13	SVC STB Emulator (Laptop PC)	N/A	220	N/A

Table 3: Information about equipment characteristic

* SFP Interface will be sent with the equipment – Support Single Mode
** PC provided by TI

Figure 22 shows the important dates at which each of the steps defined in the current document are carried out. In the figure the following actions are shown: Pre-integration Test (PT), Equipment Shipping (ES), Equipment Installation (EI), First integration Phase (FP) and Second integration Phase (SP). Note that ES-9, ES-11 and ES-12 are not indicated in the graph, since TI will provide the PCs/Server and the necessary software will be installed and managed by remote connection.

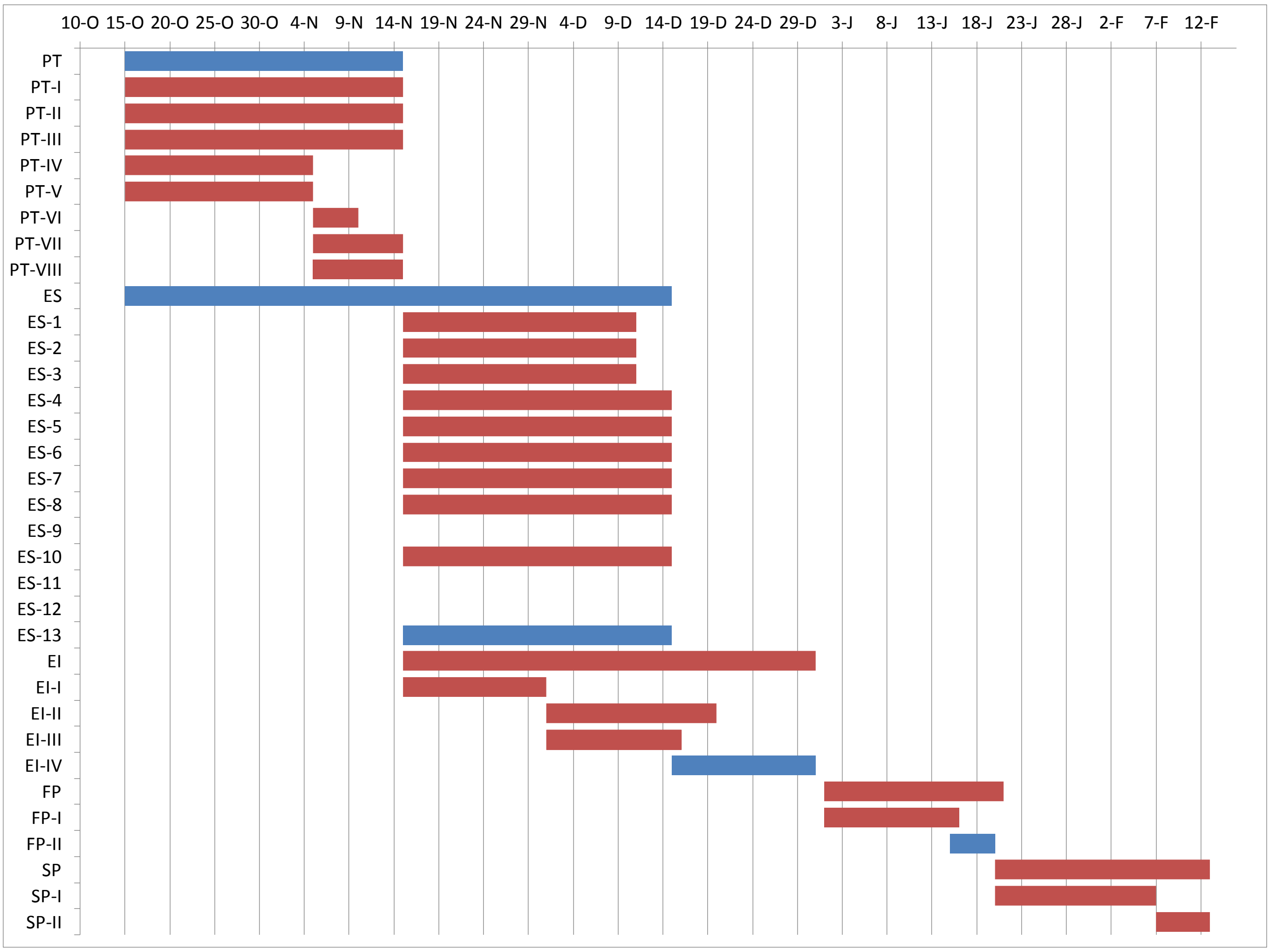

Figure 22: Gantt chart of Integration Plan Progress

10. Bibliography

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11. Annex

This Annex provides further information about the installation of Encoders. It describes, for instance, more in detail how the YUV players are connected to the encoders or how the Single-video-Encoders are connected to the Multiplexer.

Installation of the Live Multi-video encoders

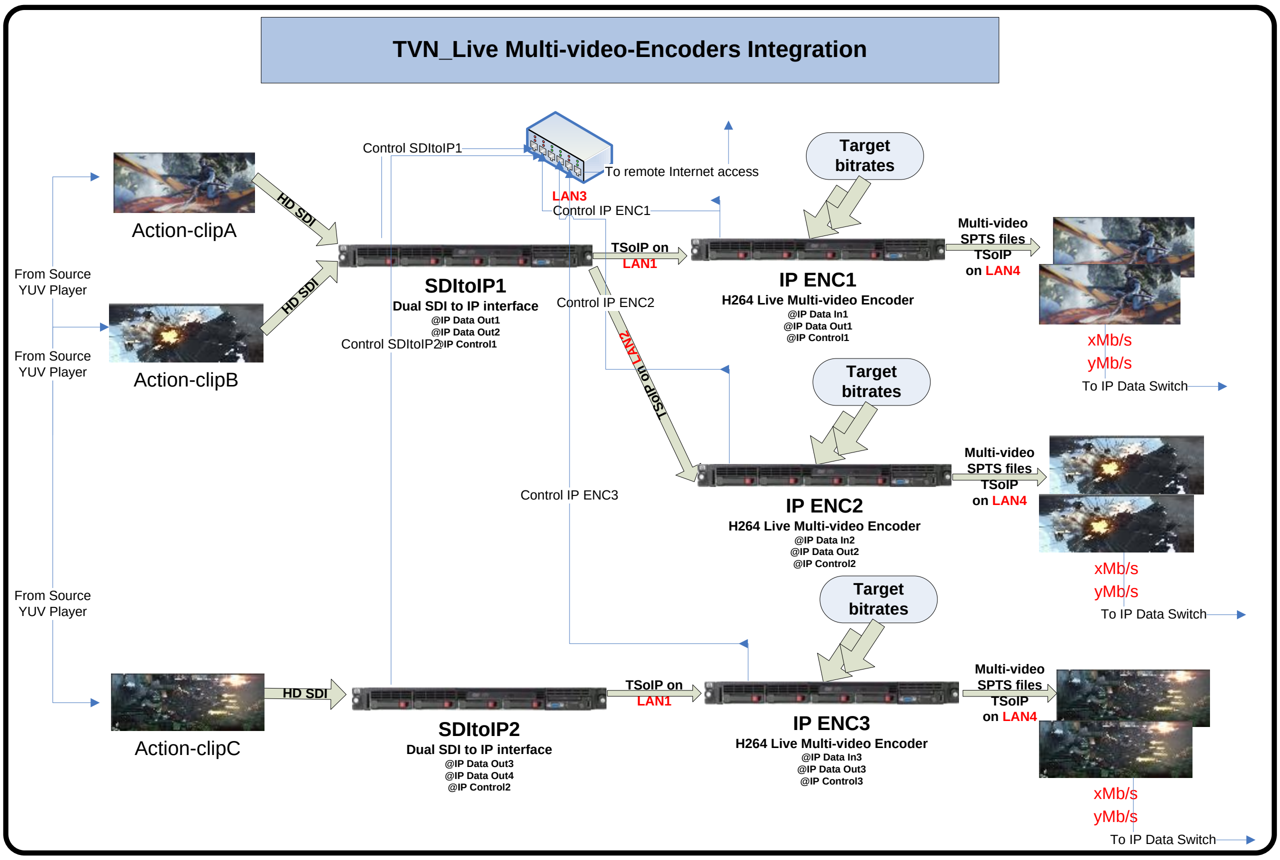

Figure 23: Integration of the Multi-video-Encoders in the IPTV System

The logic box in Figure 5 and Figure 6 for Multi-video-Encoders is detailed exactly in Figure 23. Three Multi-video-Encoders are installed in the system. Their installation entails connecting the video sources (YUV players) to the SDI to IP converters. As shown in the figure, two YUV players (as an example here, for Action-clipA and Action-clipB) are connected to one SDI to IP converter and the other YUV player (for Action-clipC) is connected to another SDI to IP converter. The SDI to IP converters are then connected to the IP port of the Multi-video-Encoders so that they can forward the content with TS over IP to each of the encoders, as shown in the figure. Finally, the Multi-video-Encoders are connected to a switch as mentioned before.

Installation of the Live Single-video encoders

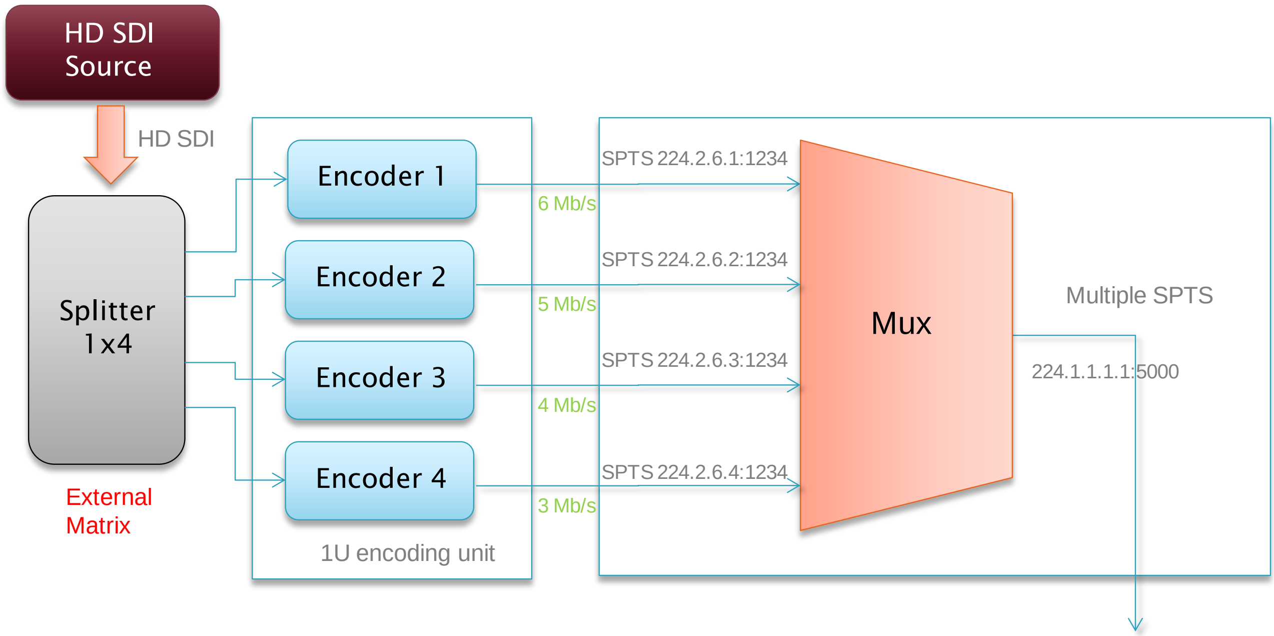

Figure 24: Integration of the Single-video-Encoders in the IPTV System

Figure 24 shows how the installation of the Single-video-Encoders is done. An encoding unit is capable of encoding 4 streams. For this purpose an external matrix is used as shown in the figure to provide the same SDI source to each of the encoders in the encoding unit. Thus, the same content is encoded into four different bitrates and forwarded to the Multiplexer.

The MPEG Multiplexer is used to convert the Single-video SPTS solution into Multi-video SPTS so as to have a compliant and standardized solution towards the PDD. The input to the multiplexer is several Single-video SPTS of the same channel at different bitrates and it outputs a unique Multi-video SPTS. During this multiplexing operation, the PSI tables are changed accordingly as described in [2].

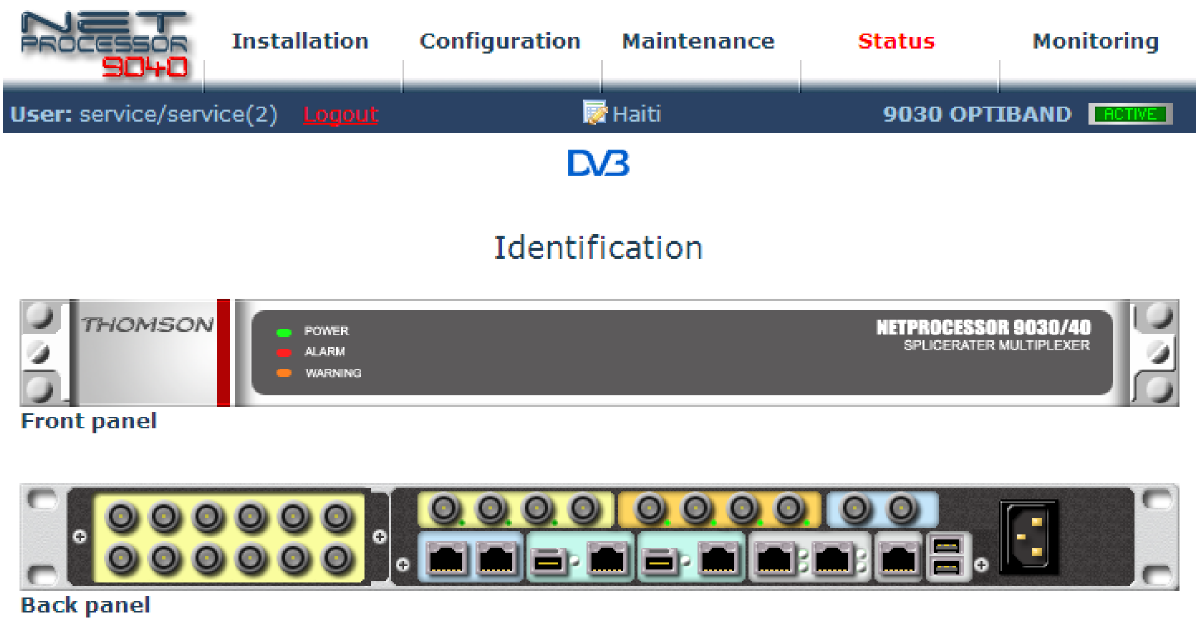

Figure 25: TVN MPEG Multiplexer

Figure 25 shows the front panel and back panel of the multiplexer, where the input and output ports can be seen. The configuration for its IP inputs, IP outputs and multiplexing processes can be done as shown in Figure 26. The Gigabit Ethernet setup is done for the different LAN RX according to the number of input Single-video SPTS provided. Set up is done for “Data in” IP LAN port and the required IP Multicast address. Gigabit Ethernet setup is done for the different LAN TX according to the number of output Multi-video SPTS produced. Set up is done for “Data out” IP LAN port and the required IP Multicast address.

Figure 26: TVN MPEG Multiplexer Configuration example

The multiplexer complies with MPEG-2 and MPEG-4 standards and high-definition transport streams. It supports MPEG-2 MP@ML, MPEG-2 MP@HL and MPEG-4-AVC Main and High Profiles for video and MPEG-1 layer 2/3, AC3 (Including 5.1), AAC LC, AAC HE audio Standards. It is capable of multiplexing/remultiplexing up to 64 MPEG2-TS received over ASI (asynchronous serial interface) and telecom interfaces, generating up to 6 multiplexes delivered over ASI/Gigabit Ethernet/ATM. For this purpose the multiplexer has two Gigabit Ethernet/IP ports that can be used for the reception or transmission and two additional Gigabit Ethernet/IP ports only for output, being able to transmit a maximum of 520Mbps. The MPEG Multiplexer main capabilities are advanced management of PSI/SI/PSIP tables, service filtering and remapping, performing table injection/filtering from the Ethernet and TS inputs. A further capability of the multiplexer consists in duplication capability of the output stream. For management, Web and SNMP interfaces can be used.