Set Top Box TV Concept

Audio-video production
- Audio+Video are digitalized.
- Compressed: ES=Elementary Stream
- Packetized: PES=Packet Elementary Stream
- PES are multiplexed in Tp: Transport Packet

MPEG Transport Decoder
SI: Service Information
PSI: Program Service Information
1. Extraction of the PSI information
- Construct Program Association Table (PAT)
- Program Map Table (PMT)
- Network Information Table (NIT)
- Conditional Access Table (CAT)
- Other Tables
2. Separation of the Video and Audio Data
3. Descrambler for Conditional Access
4. Interface to external interfaces for Key Management
5. Extraction of other Private data
Depending on the media used for the transport between the head-end and the STB, the DVB standard defined the most adapted modulation:
- For satellite DVB-S, then later DVB-S2 used the QPSK modulation
- For cable DVB-C used QAM modulation
- For Terrestrial DVB-T, then later DVB-T2 used COFDM modulation
- For Mobile DVB-H used CODFM

STB functional blocks
-The functional block diagram shows the main features involved in a broadcast STB for the reception and the decoding of a free to air channel. Generally the tuner/demodulator part is called channel decoding, while the rest is called source decoding.
- Thanks to the CPU, the services discovery is done using the Tuner for the scanning of the transponders, then for each transponder extraction, parsing and analysis of DVB tables are used to find the PID for each service. Finally when the end user selects a channel each block is set with the appropriate configuration found during the service discovery.
IP STB functional blocks:
- IP STBs are generally connected to the ISP through a Gateway which selects IP packets from ADSL, Fiber... and routes them on an Ethernet cable.
- For bandwidth reasons, the Transport Stream contains only 1 channel => SPTS Single Partial Transport Stream with PAT describing only one PMT. Such TS is encapsulated in UDP/IP or TCP/IP or RTP/UDP/IP. 7 TS packets within 1 IP packet.
- Thus live channels are generally available through an IP multicast address when individual contents use a unicast IP address.
- Some additional standards exist like DVB-IPI or Open IPTV Forum to define the services discovery phase.

SectionTable
- A lot of other sections or tables are defined in standards related to DVB STB.
- These sections or tables are used by the STB software to extract useful data related to the bouquet (NIT, BAT), to the channel (PAT, PMT, SDT) or to the program (EITp/f, EITs). The STB software used this data to discover the service plan, to create a list of services, to allow zapping on services, to provide info on service like channel name, logical channel number, and to provide an EPG.
- The part of the STB software in charge of these sections/tables filtering and parsing is generally called SI-Engine.
- Video and Audio Decoders will be configured depending on the required codecs (MPEG2, MPEG4 for Video; MPEG2, AAC, Dolby AC3...) described in the PMT.
- Video encoder is configured for appropriate analog format depending on the country (PAL, SECAM, NTSC).

PAT/PMT/NIT/SDT for services discovery:

- The first step is to find the MUXes. On a DVB broadcast network the first solution is to scan the frequencies in order to lock the STB front-end on a MUX (transponder) which carries a Transport Stream.
- Once locked on a MUX, the STB uses the demux to retrieve PAT/PMT tables from the stream and create a channel line up.
- An alternative solution is to use a known home transponder frequency, tune/lock the front end on this MUX, then use the demux to retrieve the NIT/SDT tables to create the channel line up.
- On an IPTV network, in general the channel line up is created thanks to an xml file which contains the multicast address for all the services which are available in a single service MPEG2 transport stream.

EITp/f usage – zapping banner:

- The EITp (present) is used to describe the current event.
- The EITf (following) is used to describe the next event on the same channel.
- These events are cross distributed in the different MUX of a network (EIT actual and others). It allows us to present the information for the current and next event for the other channels.

EITs usage – EPG (Electronic Program Guide/Grid)

- The TV Guide displays the Electronic Program Guide/Grid, enabling the user to view programs and channel information.

Video and Audio codecs and containers:

1)
- In the broadcast world a few codecs are used. Historically MPEG2 for the video and MPEG2 layer 1 or 2 for the audio were the only seen codecs. Thus chipset vendors decided to hardcode such decoders in their chipset.
- But more codecs appeared like MPEG4-part10 for the video, AAC, Dolby AC3, DTS for the audio. Then more and more chipset vendors included dedicated DSP to the audio and video decoding in their chipsets.
- In the STB the Video and Audio Decoders are configured depending on the required codecs described in the PMT.
2)
- In the broadband world, a lot of new codecs available for PC appeared in the STB. Famous containers like AVI, MOV, ASF, MP4... are used to transport from a server to the STB audio/video content. The STB software extracts from the container the audio and video (generally in elementary stream ES) and injects them in the appropriate decoders with the proper rate and timestamps in order to ensure the audio/video synchronization.
- When audio and video are not well synchronized we talk about a "**lipsync**" issue.

Audio/video synchronization

• PCR is used to synchronize the STB local clock called STC (system time clock) used for the clock for all demux, audio and video decoders
• PTS are used to present the audio decoded and video decoded at the STB outputs. It is also used to synchronize the subtitles display.
• For a live content is played in PCR_MASTER mode to keep the STB clock synchronized with the source.
• For a local content playback the STB uses the VIDEO or AUDIO_MASTER as the decoders impose the content speed playback.

Premium contents – the CAS:

- The CAS (Control Access System) is required to protect the content. It is required by the operators to respect the owner requirements rights to use their contents.
- All these CAS are based on EMM (Entitlement Management Message) which are used to renew the rights in the smart card (generally every month provided the subscriber paid its subscription) and on ECM (Entitlement Control Message) which are used to transport the Control Word (CW) from the head-end to the DVB-CSA descrambler included in the STB.
- EMM and ECM are broadcasted in DVB sections or tables. Their PID are found in the CAT table and PMT. The ECM is broadcasted within a short period (called crypto period typically 10seconds) to fight piracy. Within the crypto period the ECM is repeated because it will directly impact the time required to get clear audio and video (zapping time).
- When the content is broadcasted in clear, everybody can access it with the appropriate STB. Such contents or channels are called FTA (Free To Air channel) in DVB.
-The CAS offers different method to protect the content (for instance subscription, Pay Per View, Video On Demand):
1. CAS allows subscription: which is the way a channel in a bouquet is scrambled so that only subscribers can access the content.

2. Pay Per View (PPV): the PPV is a way for the operator to give access to a content (a movie not a channel) pay to be viewed once. In general Pay Per View channel includes Preview which is a way to view a few minutes to invite the customer to buy the movie as an impulsive purchase.

3. Video On Demand: is rather seen as a content protected by a DRM. DRM manages the way the content will be made available for the end-user.

Connected CAS - DRM:

- With connected STB (using a return channel) or IP STB, new CAS Clients appear which do not require a smart card. The CAS client communicates with a server located in the ISP network. This CAS server provides a key (generally AES key), required to decipher audio/video content.
- The DRM (Digital Rights Management) is the feature allowing to manage the way a content can be used once it is available for the end user. The DRM leads to a license to be downloaded in the STB. The license provides rules like : view once, copy once, copy never, view for one month, view for one week...
- The DRM selected to protect contents over DLNA is DTCP-IP.
- As the premium content is protected it should be protected once it is available at the STB outputs. It is the goal of HDCP for HDMI, Macrovision and or CGMS-A for analog outputs. This is generally done under the CAS or DRM control.
- When the STB hw capabilities does not support the protection mechanism, then the outputs must be simply blanked or muted.

The watermarking

- In order to track piracy contents, watermarking technologies have been put in place. This allow to retrieve the source of illegal copies. This is based on the capability to hide a text string in a decoded video frame. Then a device will be able to rebuild the text string from the added pixels hidden in the video.
- For ETISALAT we are developing VideoMark which is a kind of watermark using OSD composition to add a visible mark under Verimatrix CAS control.

Parental control

- ECM or EIT can transport morality level for the content.
- The STB sw uses this information to check if the content morality level is allowed compared to the STB morality setting. If it is not the case the audio and video are cut and a PIN code is asked. The PIN code is supposed to be known by the one who has set the STB morality level setting.

Hybrid STB

- More and more legacy TV operators (satellite or terrestrial) want to add IP services like VOD and legacy ISPs want to add more TV services using broadcast channels.
- This leads to a new kind of STB called Hybrid STB equipped with one or more Broadcast tuner/demodulator + one or more Ethernet port.
- This becomes more and more common thanks to the OTT technologies.

PVR (Personal Video Recorder) or DVR (Digital Video Recorder):

-This feature enabled the recording of a content different from the one currently watched but of course it required a second Tuner/demod chain.

PlayBack:

- The playback is the process which consists in reading the TS files, injecting it in a Demux so that components can be decoded as in the Live process. The main difference is the fact that decoders will pull the data the audio/video synchronization needs to be managed differently.
- During the playback Trick Modes can be applied: pause, resume, rewind, fast rewind, fast forward. Because the MPEG stream is time oriented, it is required to seek a buffer to get enough data (especially one Intra picture) to be sure that decoding will provide something to be displayed.

Time shifting

- Time shifting is the process which consists in recording a channel and reading it using the playback mechanism.
- In general TimeShift is allowed on a limited duration 30 or 60 minutes. The file is used as a circular buffer. All trick modes are available, so the end user can navigate in the buffer.

The VOD:

VOD stands for Video on Demand. It can be available by different way:

1. Streaming VOD

- This solution is available for customers with enough bandwidth on IP to receive the video stream in real time.
- Generally it requires a unicast connection between the STB and the VOD server. The STB sends commands to the VOD server (play/pause/FFW/FRW) using protocols like RTSP or HTTP.

2.Push VOD:

- In this solution a complete catalog of movies is downloaded on the HDD. The catalog is renewed every month and is not seen by the end user before it is completely downloaded. The catalog should content many movies as it is the same for all subscriber but should propose enough choice.
- In general, it used the second front end (when not used) of the STB or standby period. The download is a file download (not a stream record) meaning that on the HDD the movie must not be affected by the potential loss of data during transport. The catalog is broadcasted periodically a special software in the STB is in charge to catch data and to build movie files on the HDD. When the user pays for a content he can access very quickly to the content as it is already on its STB.

3.Pull VOD:

- The pull VOD is available on connected STB. The catalog is pulled by the STB. It allows you to get a personalized catalog using recommendation software.

4.Progressive VOD:

- This VOD mechanism allows you to start watching the content before it is completely downloaded. It requires a local non-volatile memory with enough capacity to store the content (ie 4 GBytes minimum)

The trick modes

- The trickmodes is the possibility to access a content with a playback speed different from 1.
- This is possible during the playback of a content which is stored on a HDD (local or remote). So trickmodes are available for PVR or VOD contents, not for live.

Zapping – Channel change:

• The time required to retrieve the audio/video PID for the requested service (channel) . Need to parse PAT, get the PMT PID then parse the PMT get the A/V PID set the A/V the demux. This time depends on PAT/PMT repetition, in general 100ms. It is also possible to store the A/V PID in the STB during the service discovery. Then it will accelerate the PID setting until it changes in the signal.
• If the content is scrambled (protected by the CAS) then get the ECM associated with the service – communicated with the smart card or the key server then set the CW in the descrambler. Here we have 200 to 300ms.
==> Solution to reduce the zapping time: use FCC – Fast Channel Change
- FCC (Fast Channel Change) is a method which allows to reduce the zapping time. In general, it relies on a dedicated server which provides few packets(1second) from live channel in unicast mode with a higher bandwidth (130%). Such packets include PAT/PMT/ECM/StartOfGOP which allow to start the video decoding and display quickly.
- The FCC Client is in charge to connect the unicast server to get the first packets, then to join the multicast stream and to combine IP packets to create a correct Transport Stream to be injected in the Demux. In general it uses RTP protocol.

Catch up TV:

- The catch up TV (or replay TV) is the possibility to access live content which has already been broadcasted and stored on servers like VOD servers.
- If the end user missed a program he just has to connect the server, an unicast connection is established between the STB and the server and he can see the program from the server. In general RTSP or HTTP protocols are used.

Start Over:

- Start Over is a feature which gives the possibility during zapping on live channels to access the beginning of the event. It can be seen like a catchup TV extension for content which is not yet finished.
- To do so, every channel's content must be stored on a HDD in the network and this content must be available thanks to an unicast connection.