EBU5303

Multimedia Fundamentals

Digital Broadcasting (Part 2)

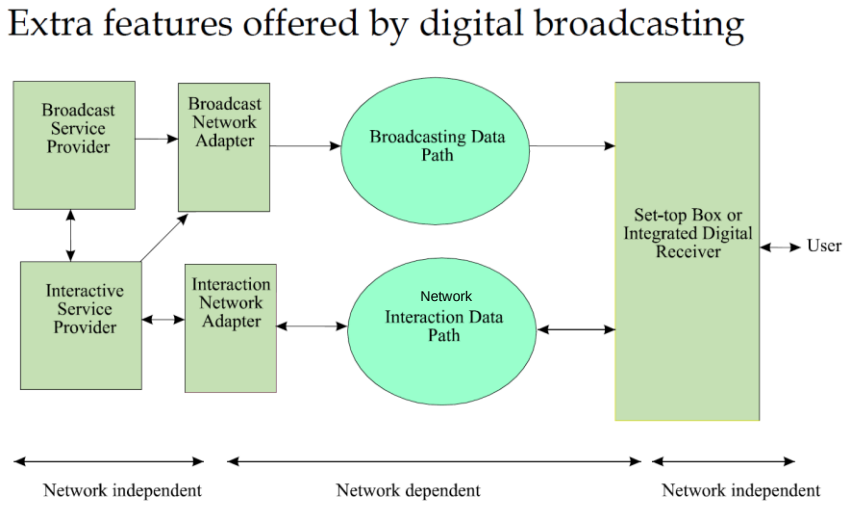
Agenda

- Interactive Services
- Connected TV
- IPTV and Internet TV

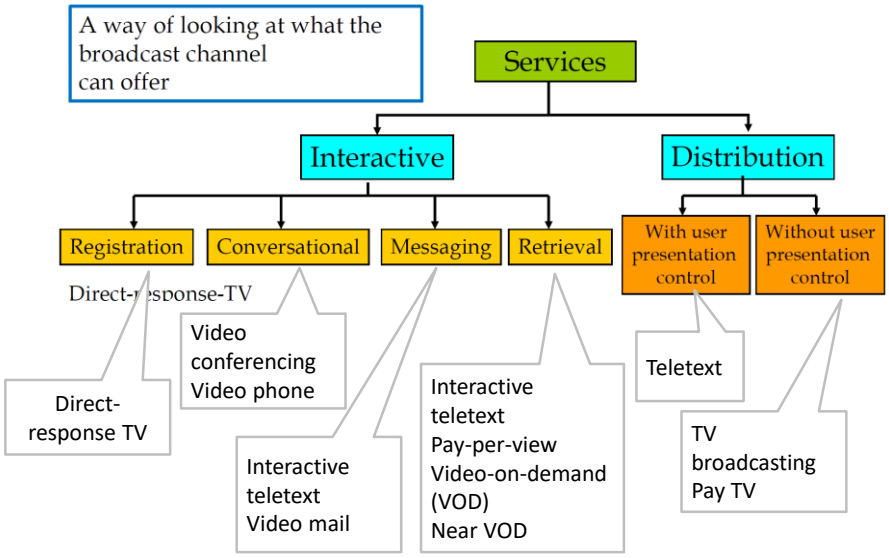
Interactivity

- User can (re)act to information presented by service provider (digital innovation).
  - E.g., purchase pay-per-view events, video-on-demand, voting, video mail, interactive teletext, interactive advertising, gambling, shopping channel purchases, etc.
  - Improves viewer's experience and enables broadcasters to generate extra revenue – a win-win situation.
- Most basic form: 'local interactivity' (no return channel required).

Interaction



Services Model



Services

- ***Direct-response TV****:* e.g. interactive quiz shows or interactive commercials.
- ***Pay-TV****:* encrypted programming package (i.e., uses Control Access system) can only be viewed using an authorised set-top box (STB).
- ***Pay-per-view****:* similar to Pay-TV, but authorises a programme instead of a package.
- ***Video on-demand****:* allows individual users to demand a programme from a server at a chosen time, with pause and rewind facility.

Teletext Services

Transmitted in a data channel that is multiplexed with the broadcast.

- ***Linear teletext***:
  - Several teletext pages embedded in the TV signal are broadcasted to the TV set via a transmission medium.
  - The selected teletext page is stored in memory, after which it can be watched.
- ***Interactive teletext***:
  - A teletext page is transmitted to an individual user or a user group.
  - The request for the page concerned can be processed via a **return channel** through, e.g., a public telephony network.

Interactivity

- All other forms require an **interaction channel** to enable users to respond and enable service provider/network operators to listen and react.

- Types of channels:
  - one-way (backwards) narrowband (e.g. pay-per-view, Video-on-demand, voting)
  - bi-directional narrowband (e.g. text, advertising, gambling, shopping, purchasing)
  - bi-directional broadband (e.g. request for extra information, video mail, selective advertising)

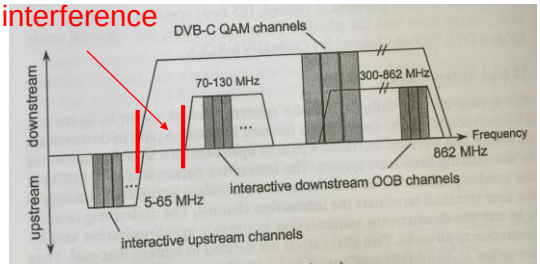
Interaction Channels

- **Upstream** channel: path from receiver to broadcaster.
- **Downstream** channel: path from broadcaster to receiver.
  - **out-of-band** downstream signalling: when downstream channel is separate from broadcast channel (i.e., control information transmits in a forward interaction path).
  - **in-band** downstream signalling: when downstream channel is mixed with programme data (i.e., embedding control info with MPEG-2 TS).

Frequency Allocation for Interaction Channels

- The return interaction channel and the forward interaction channel must be allocated in a different frequency range (to avoid interference).
- The diagram shows FDMA (Frequency Division Multiple Access). The available bandwidth is divided into slots – one slot for each message signal.

Guard interval to prevent interference



Frequency Allocation

- Previous diagram showed FDMA (Frequency Division Multiple Access)
  - available bandwidth divided into different frequencies for each interaction channel with small guard bands between channels.
  - Problem of interference when many channels.
- Alternative is TDMA (Time Division Multiple Access)
  - different time slots in the same frequency are used to give to the different channels.

Upstream Channel Control

- Each STB has unique **Media Access Control** (MAC) address (48 bits, usually hard-coded).
- MAC address allows data to be routed to the intended STB.
- MAC address allows service provider to identify origin of interactive service request.
- For TDMA, upstream channels are divided into time slots that can be accessed by the users.
  - Slots are allocated by the Interactive Network Adaptor (INA).
  - Synchronisation is crucial:
    - ensure data is only sent in valid time slots.
    - synchronisation for upstream transmission is provided by the downstream INA.

Upstream Access Modes

Ways of accessing the upstream slots:

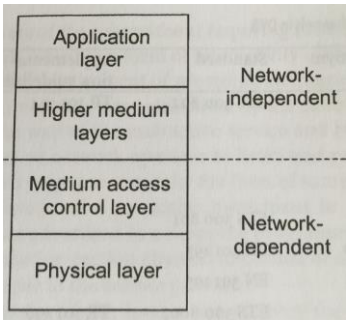
- **Contention:** All users have equal access and can send MAC messages or data. More than one may try at one time. Automatic Repeat Request (ARQ) operates to sent acknowledgement of reception of packets.
- **Fixed-rate access:** User has a reservation of one or more time slots in each frame allocated by INA.
- **Reservation access:** STB sends request for time slots to the INA. The INA then assigns these slots to a connection on a frame-by-frame basis.

Providing Internet Services via Broadcast Networks

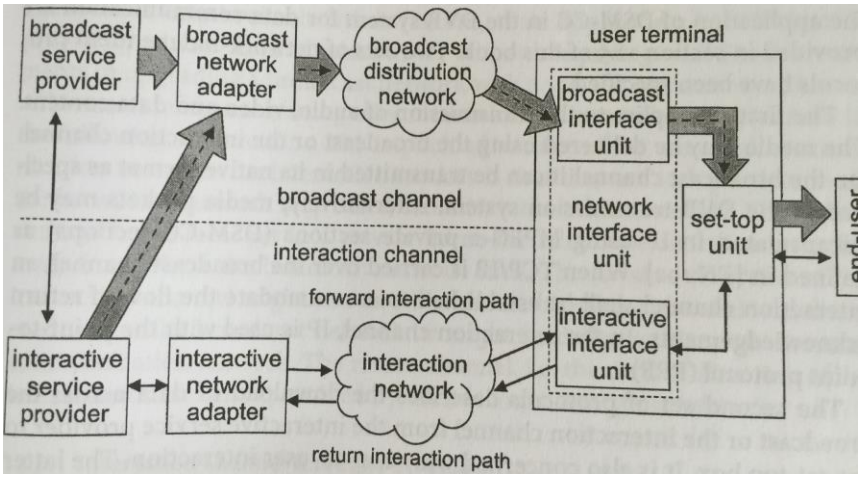
- Cable network providers derive much of their revenues by providing broadband internet connections with the cable TV service.
- A cable modem is used at the subscriber end and at the Internet Service Provider end:
  - cable modem: separate unit or integrated into STB.
  - cable modem modulates IP data onto carrier similar modulation of TS in MPEG-2.

Protocol stack for DVB interactive services

- **Physical Layer**: Modulation scheme, channel coding, frequency range, filtering, equalisation and transmit power.
- **Medium Access Control Layer**: interface to higher layer protocols, gives the data independence of the Physical layer.
- **Upper layer goals**: to develop interactive applications, which can be used commonly with different interactivity-enabled networks.



Generic System Model for interactive service



Generic System Model

- Network adapter provides connectivity between service provider and the network.
- Interface unit connects the network to the end user.
- Generally broadcasts MPEG-2 transport system over unidirectional broadcast channel to the STB.
- Interactive service provider offers bidirectional interaction channel:
  - Forward interaction path and Return interaction path.
  - To ensure high speed service, it can be embedded in MPEG-2 TS.
- Broadcast channel contains control and communication data.
- A bidirectional communication channel is also required between different service providers for synchronisation.

Agenda

- Interactive Services
- Connected TV
- IPTV and Internet TV

What is connected TV?

- Connected TV is a term used to describe equipment and services where **TV receivers have an Internet connection**.
  - Related terms are IPTV (TV services provided over the Internet).
  - OTT (Over The Top content) is on-line delivery of video and audio without the Internet service provider being involved in the control or distribution of the content itself.
- Connected TVs normally include applications to access services such as YouTube (Youku) and other user generated content video services, Internet radio, catchup TV services, subscription film libraries and often a web browser – sometimes video conferencing.

Streaming video

- Live TV cannot be distributed as files, but must be **streamed with a special protocol**.
  - RTSP (real-time streaming protocol) has been developed to support this.
- Streaming is also used to access previously broadcast TV programmes or movies stored on servers.
- Because the file sizes are large, it would take a long time to download a programme and need large quantities of storage at the client.
  - 6GB per movie, 50 minutes to download at 2Mbs.

IP video streaming

- Some internet video services (e.g., Youku) download a video to play it (but may start playing before it is all downloaded).
- Live IPTV services, rely on streaming
  - Streaming sends individual transport stream packets as IP packets as soon as they are available.
- Streaming video over the Internet gives several problems:
  - Available bandwidth
  - Packet loss
  - Jitter
  - Latency

HLS streaming solution

- **HTTP Live Streaming** (**HLS**) is an HTTP based streaming communications protocol.
- Implemented by Apple in QuickTime and iOS .
- Breaks the overall stream into a small HTTP-based file downloads, each download loading one short chunk of the transport stream.
- The client selects from alternate streams containing the same material encoded at a variety of data rates, so the streaming session can adapt to the network.

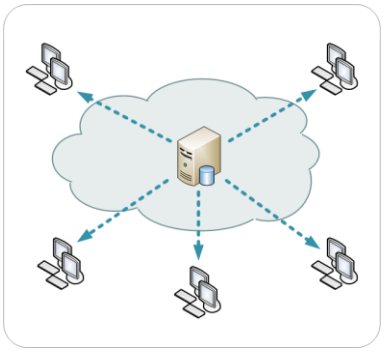
DASH streaming solution

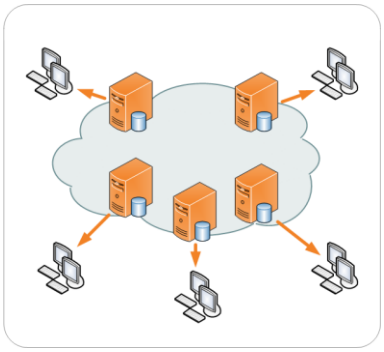
- **Dynamic Adaptive Streaming over HTTP** (DASH or MPEG-DASH).
- Similar to Apple's HLS solution, MPEG-DASH breaks the content into a sequence of small HTTP-based file segments made available at different bit rates.
- The client automatically selects from the alternatives next segment to download and play back based on current network conditions.
- The client selects the segment with the highest bit rate possible that can be downloaded in time for play back without causing stalls or rebuffering events in the playback and **seamlessly adapts to changing network conditions**, providing high quality play back.
- MPEG-DASH is the first adaptive bit-rate HTTP-based streaming solution that is an international standard.
- The solution can be used universally, unlike more proprietary solutions such as HLS by Apple, Smooth Streaming by Microsoft, or HDS by Adobe.

CDN

- The intelligent DNS (Domain Name System) server will direct an initial DNS request to the server nearest to the client.
  - If that server is overloaded, the direction will be to an alternative nearby server.
- This limits the demand on an individual server and reduces the bandwidth demand on any particular link in the network.
- The DNS management is *multicasting* as supported in IPv6.
- Well known CDNs are *Microsoft Azure* and *Amazon Cloudfront*. Netflix is building a CDN.

CDN (*cont.*)





Causes of Network problems for streaming

- The basic problem for streaming is **network congestion**:
  - If a buffer at a router is overloaded, packets will be lost.
  - Variable numbers of packets from other services inserted between the video packets will cause jitter.
  - There may be problems with the number of simultaneous requests made to the content server.
- These issues mean that live TV has to be treated specially in the Internet to give high quality at the customer.

Packet Loss

Packet loss is probable in the Internet because packets will pass through a series of routers, each of which has a buffer.

- If the buffer becomes full, new arrival packets are discarded.
- In TCP/IP, a request is made to re-send the lost packet, but this is not a solution for streaming video as packets are then massively out of order.
- A protocol is required that gives priority to the multimedia packets.
- This can be achieved relatively easily in a closed network where the ISP offers TV as a service, but is more difficult in the open Internet.

Solving the network problem

- Quality of Service (QoS) management and a broadcast-quality IP video gateway are needed.
- QoS is typically handled by routers and switches in the network. Important components are:
  - multi-protocol label switching (MPLS).
  - traffic classification, metering, shaping, and admission control policies.

IPTV Architecture

- Media and service discovery is the IPTV application server that is queried to find the services that are available.
  - Discovery and selection phase. User status is checked and a list of the allowed services is sent to the user.
- Media and control delivery is the server that streams the multimedia content.
  - The terminal capabilities are queried to determine the correct stream to use.

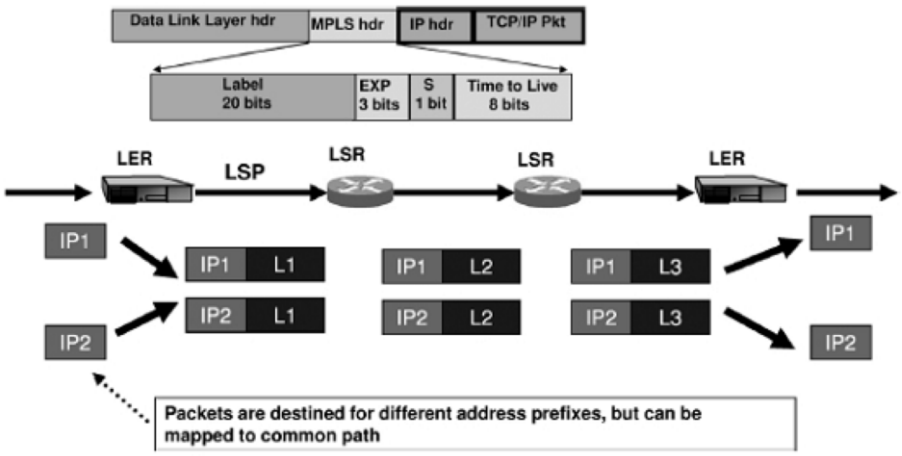
Multi-Protocol Label Switching (MPLS)

- **Multi-protocol Label Switching (MPLS)** is a type of data-carrying technique for high-performance telecom networks that directs data from one network node to the next based on **short path labels** rather than long network addresses avoiding complex lookups in a routing table.
- MPLS enables the creation of virtual connection-oriented paths within a network.
  - Bandwidth can be reserved for each virtual path.
  - Network performance parameters, such as loss and jitter, etc. can be guaranteed throughout the traffic flow.
  - MPLS can provide bandwidth guarantees for video traffic by separating these flows from other best-effort paths assigned to Web or e-mail traffic.

MPLS

- IP packets are encapsulated in a larger structure starting with **a label**. This is done at **label edge routers** (LERs).
- Other **label switching routers** (LSRs) then treat these packets preferentially and the packets take a **label switched path** (LSP).
- In the LSP, the packet is routed by the label, which is fast and efficient.
- MPLS allows the service provider to control the route for the IPTV packets.
- It also allows them to decide how much traffic is allowed to flow through a path and to divert to another path if there is an overload.

MPLS system



Standardising connected TV

- Standards allow all broadcasters to use the same software to deliver connected TV services on different hardware.
- Standards help economies of scale.
- Two standards that have been developed are **YouView (UK)** and **Hybrid broadcast broadband TV (HbbTV)** – a European standard.
- HbbTV is being adopted in several countries and uses the MPEG-DASH adaptive streaming over HTTP standard.
- The Hollywood studios have developed an Ultraviolet (UV) standard to protect content for use in connected TV systems.
- There are attempts to align these standards as much as possible.

China Connected TV Standard

- China Video Industry Association (CVIA) released China's first set of online TV multimedia communications standards in April 2011.
- The standards are the first to be drafted that address internet-connected TV sets and TV peripherals.
- 40% of the TV sets sold in China in 2012 were connected TVs.

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Differences between IPTV and Internet TV

- Different platforms
  - Internet TV leverages the **public Internet** to deliver video content to end users.
  - IPTV, on the contrary, uses **secure dedicated private networks** to deliver video content to consumers. These private networks are **managed and operated by the provider** of the IPTV service.
- Geographical Reach
  - Networks owned and controlled by the telecom operators are not accessible to Internet users and are located in **fixed geographical areas**.
  - The Internet, on the contrary, has **no geographical limitations** where television services can be accessed from any part of the globe.

Differences between IPTV and Internet TV

- Ownership of the Networking Infrastructure
  - Internet Protocol packets used to carry the video may get delayed or completely lost as they **traverse the various networks that make up the public Internet**. As a result, the providers of video content over the Internet **cannot guarantee a TV viewing experience**. In fact, video streamed over the Internet can sometimes appear jerky on the TV screen and the resolution of the picture is quite low. The video content is generally delivered to end users in a "**best effort**" fashion.
  - In comparison to this experience, IPTV is delivered over a networking infrastructure, which is **typically owned by the service provider** hence supporting the end-to-end delivery of **high quality video**.

Differences between IPTV and Internet TV

- Access Mechanism
  - A **digital set-top box** is generally used to access and decode the video content delivered via an IPTV system, whereas a **PC** is nearly always used to access Internet TV services.
  - Depending on the content, a dedicated media player and a robust digital rights management (DRM) system could be required to support the access to the content.

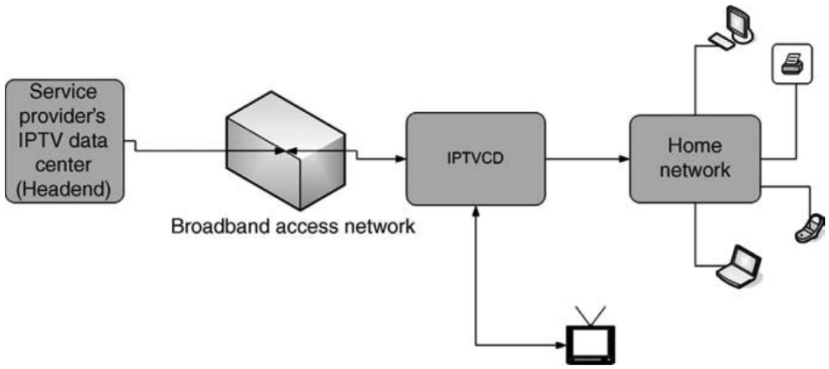
Differences between IPTV and Internet TV

- Costs
  - A significant percentage of video content delivered over the public Internet is available to consumers **free of charge**. This is however changing as an increasing number of media companies are starting to introduce fee-based Internet TV services.
  - The costing structure applied to IPTV services is **similar to the monthly subscription model** adopted by traditional pay TV providers.
  - Over time, many analysts expect Internet TV and IPTV to converge into a central entertainment service that will ultimately become a mainstream application.

Differences between IPTV and Internet TV

- Content Generation Methodologies
  - A sizeable portion of video content generated by Internet TV providers is **user-generated and niche channels.**
  - IPTV providers generally stick with distributing **traditional television shows and movies**, which are typically **provided by the large and established media companies**.

Simplified block diagram of IPTV system

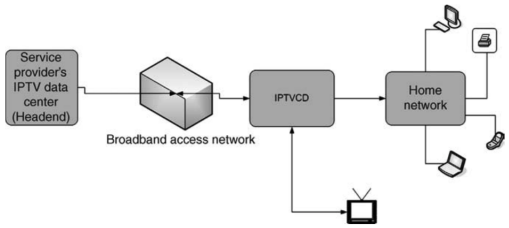


Simplified block diagram of IPTV system

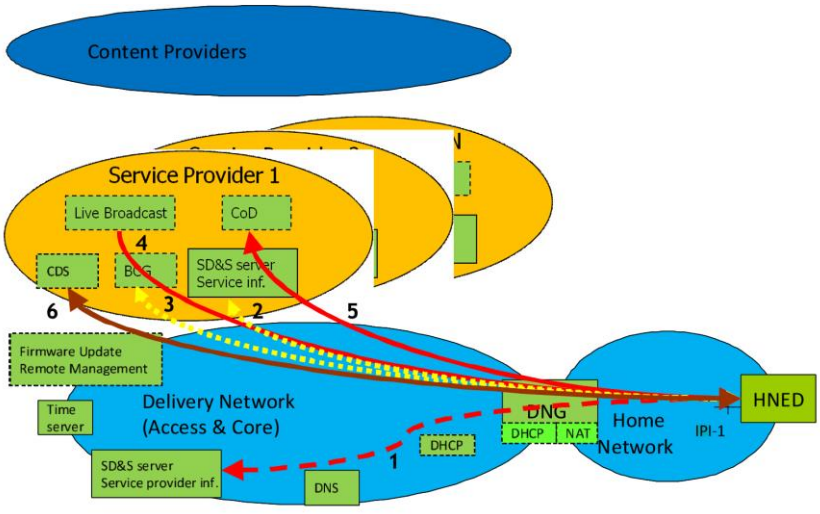
- Data centre (also called headend)
  - Ingestion of contents from various sources incl. local video, content aggregators, content producers, cable, terrestrial, and satellite channels.
  - Processing contents with number of components incl. encoders and video servers to IP routers and dedicated security hardware, subscriber management system.
- Broadband delivery network
  - To establish one-to-one connections using Hybrid fiber and coaxial based cable TV infrastructures and fiber based telecommunication networks.
    - Multicasting is also possible over fiber.

Simplified block diagram of IPTV system

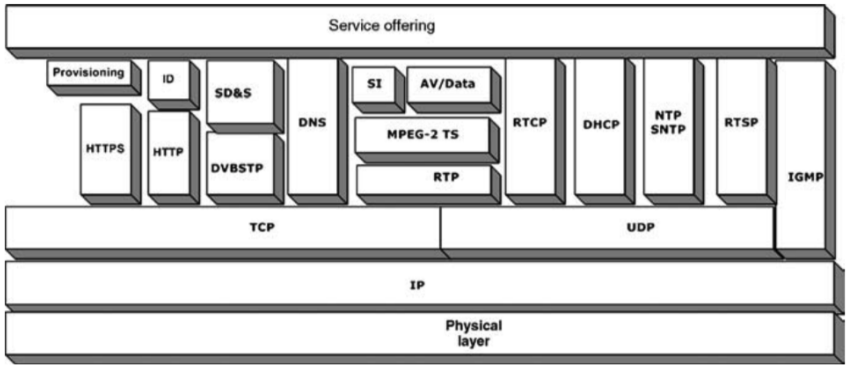
- IPTV consumer devices (IPTVCD)
  - Connects to the broadband line and responsible for decoding and processing the incoming IP-based video stream as well as eliminating the effect of the network on the quality.
- Home network
  - Small geographical area where all members of a family can connect their devices to the main hub such as IPTVDC.



Main service flow interactions in a DVB IPTV network



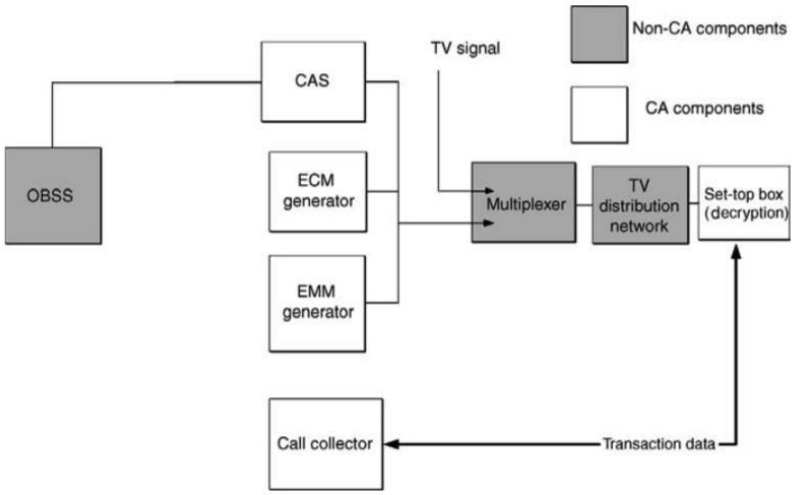
DVB-IPI protocol framework



Security in IPTV

- There are three alternative approaches to IPTV conditional access systems.
  - Hardware: it is based on a client-server networking infrastructure
  - Software
  - Hybrid hardware and software solutions
- Example:
  - End to end smartcard based conditional access (CA) system.
  - EMM: transfers user's rights upon purchasing IPTV services to the related smartcard. It can contain the following information:
    - Authorization keys to view IPTV servies (IP-multicast services, VoD content)
    - Credit for future services
    - Service cancellations and renewals
    - Other subscriber data such as address and billing details

Security in IPTV



Video-on-demand (VoD) over IP delivery network

- VoD: A VoD system enables an individual subscriber located in geographically dispersed locations to demand a program or movie when and where they want it.
  - It is a pull-mode service.
  - Steps to select a VoD title by IPTV users:
    - The subscriber selects a VoD title from the interactive TV application.
    - The IPTVCD accepts the command and sends this instruction to the headend or data center.
    - The conditional access system is checked to verify that the subscriber is authorized to view the particular VoD title.
    - Once authorization is complete, a unicast video stream is forwarded to the regional office and onward to the IPTVCD.
    - The IP stream is controlled by the subscriber.

Video-on-demand (VoD) over IP delivery network

– Type of IP-VoD services:
  - Push VoD: pushing contents from server to IPTVCD during off-peak time
  - Movie-on-Demand (MoD): delivery of DVD quality of contents with support of VCR type controls to IPTVCD
  - Subscription VoD (SVoD): same as MoD delivery but using subscription such as a fixed monthly fee
  - Television-on-Demand: recording real-time broadcast TV programs
  - High definition VoD
  - Subscription music on Demand
  - Network based digital video recording (nDVR): storage is at the IPTV data centre not locally
  - Free on Demand: free access to the library of contents
  - Bandwidth on Demand: allows users to increase bandwidth on the fly for specific services such as downloading HD contents
  - Extended VoD (EVOD): diverting contents from IPTVCD to another location(s).

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