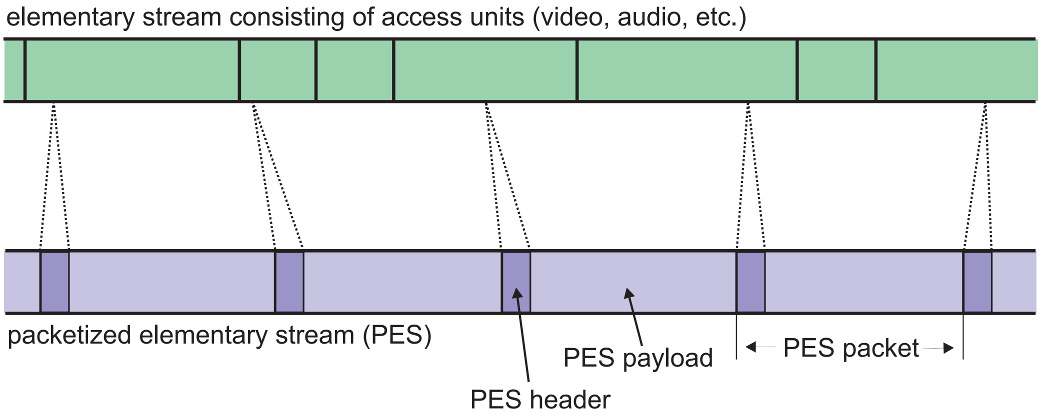
2.7 DVB System - Packetized elementary stream

The MPEG-2 multiplexer does not directly multiplex sequences of the access units from its inputs. All elementary streams consisting of the access units are transformed into so called *packetized elementary streams* (**PES**). Each PES consists of PES packets as can be seen in next Figure [21].

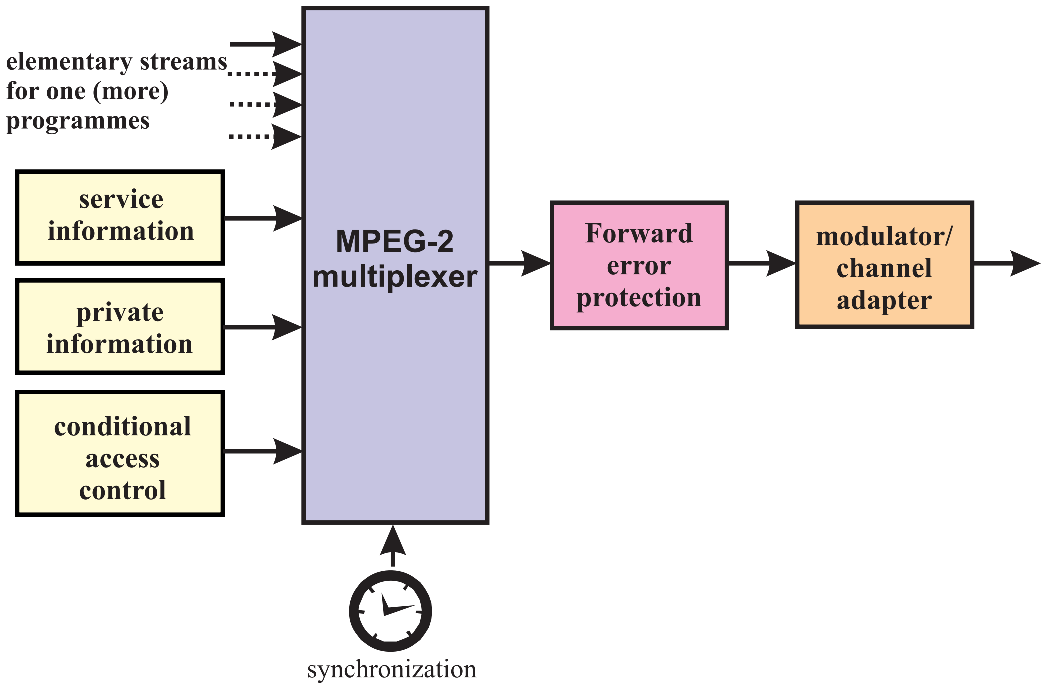


Principle of forming the packetized elementary stream

Every PES packet contains a header and a payload. The payload is a field where data of the original elementary stream are grouped in one after another. There is no limitation on synchronization of PES starts and access unit starts. That means a starting byte of the access unit can occupy any place (byte) of the PES packet payload. Several small-sized access units can even be put in the payload of one PES packet. PES packets can have a variable length but up to 64 kB in size. There is certain freedom for designers of the MPEG-2 multiplexer to utilize this flexibility. They can decide to apply PES packets of a fixed size or variable size to ensure that first byte of any PES packet payload will carry first byte of some access unit. Every PES packet header contains a start code (to identify a start of the PES packet), an identifier of stream (within programme), a length of the PES packet and its header, optional header subfields and flags (indicators of subfields).

2.8 DVB System - Stream multiplexing

When the elementary streams are in a form of packetized elementary streams they are multiplexed (grouped) by the MPEG-2 multiplexer with all other special information to form a resulting contiguous byte data stream. Figure below depicts a principle of multiplexing in the MPEG-2 systems layer.



The principle of multiplexing

As can be seen from Figure an output multiplexed signal contains a lot of other information [21]:

- Time stamps – time stamps allow to ensure a synchronization among elementary streams (e.g. video and audio streams of one programme have to be synchronized).
- Tables – tables contain service information (SI) data which identify programmes within a multiplexed signal (multiplex) as well as their elementary streams, network parameters, etc. There are also tables for a conditional access related to scrambling but this type of control was not defined by MPEG (or DVB).
- Other support data – support data for additional data streams whose content is not specified by MPEG. These data streams can carry contents of various data services, other system information (e.g. modulation) or e.g. teletext.

The MPEG-2 multiplexer can produce two types of multiplex streams: a programme or transport stream. The *programme stream* (**PS**) is intended for the storage and retrieval purposes of digital content from storage medium (e.g. DVD) and it relies on error-free environments. Unlike the programme stream the transport stream (TS) enables to multiplex more programmes and is not so much susceptible to errors because it is protected by **FEC** (*Forward Error Correction*) code. Therefore, TS is suitable for broadcasting via terrestrial or satellite environments. The other difference is that TS consists of transport packets with fixed length of 188 bytes.

2.9 Digital Video Broadcasting via Satellite

Satellite systems provide the operators with a lot of benefits in offering services to end users. A natural ability of satellites to distribute signals to large areas of the Earth surface has been utilized for broadcasting of analog television and radio for decades. This ability mainly relates to geostationary satellites that are placed in a geostationary orbit i.e. in latitude about 36000 km (over the equator).

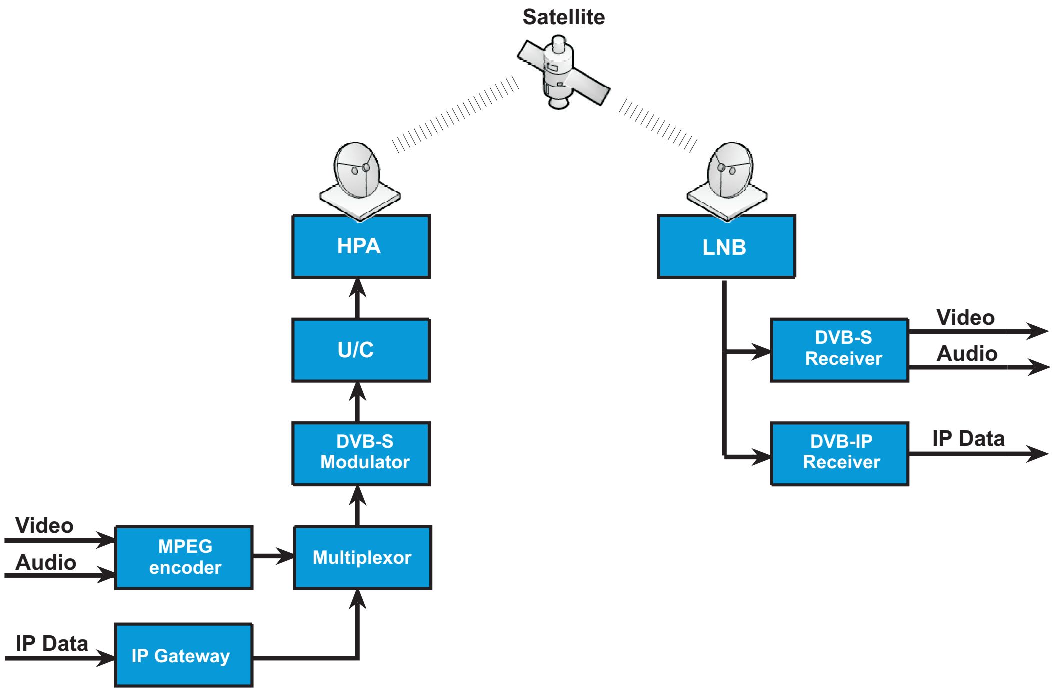
Each geostationary satellite appears for Earth user fixed in the sky so there is no need for an antenna tracking system.

On the other hand satellite transmissions suffer from error prone satellite links therefore every signal before transmitting has to be adapted for such difficult propagation conditions [20].

A communication payload of satellites consists of transponders. Their function is to receive, restore, amplify, process, re-modulate and sent signal back to Earth.

Currently, the conventional geostationary satellite contains about 20 to 30 transponders and a single transponder can most often have a bandwidth ranging from 26 to 72 MHz (e.g. 36 MHz on the ASTRA 3A satellite).

In case of the satellite analog television a single transponder took care of one TV channel. Applying the DVB technology to the satellite systems a single 33 MHz satellite transponder can carry 4 to 8 TV channels or 150 radio channels. A noisy satellite channel required from DVB project to define for the DVB-S systems efficient modulation techniques and error correction codes [22].



Simplified block diagram of DVB-S system (platform)

Figure above depicts a block diagram of a general DVB-S system. The MPEG-2 multiplexer multiplexes video and audio PES streams from the MPEG-2 coder with data in PES data streams coming from an IP gateway in the same way as was written in previous section. The multiplexed transport stream is randomized to spread its spectrum within its bandwidth. The randomized transport stream is equipped by an outer code (Reed Solomon code with a coding rate 188/204), interleaved (to make it more resistant to block errors) and encoded by an inner FEC code (convolutional code with a coding rate from 1/2 to 7/8). In the next phase the encoded transport stream is modulated on a carrier. DVB-S uses **QPSK** (*Quaternary Phase Shift Keying*) modulation, DVB-S2 uses 8-PSK, 16-APSK or 32-**APSK** (*Amplitude and Phase Shift Keying*) modulation. Afterwards, the signal is up-converted to a carrier from Ku band, amplified by a **HPA** (*High Power Amplifier*) and radiated by an antenna system to the satellite. The receiver performs opposite actions to demultiplex particular video, audio and data streams and to provide them to users using some end device (e.g. TV set, PC).

2.10 Digital Video Broadcasting via Terrestrial

The first commercial DVB-T service was implemented by the Digital TV Group in United Kingdom in 1998. Currently, digital TV broadcasting replaces classical analog TV broadcasting all over the world.

The DVB-T technology utilizes the same signal processing as was already described above to prepare the multiplexed transport stream. Differences that are relating to DVB-T standard are due to terrestrial transmission medium used for broadcasting and can be summarized as follows [18]:

- Transmission medium – DVB-T services are aired terrestrially within the *ultra-high frequency* (**UHF**) band covering frequencies in a range from 300 MHz to 3 GHz. DVB-T shares the same band with analog TV therefore its implementation is based on releasing of frequencies occupied by analog television channels. An 8 MHz channel carrying single analog TV channel can carry within DVB-T several digital TV and radio channels with other information.

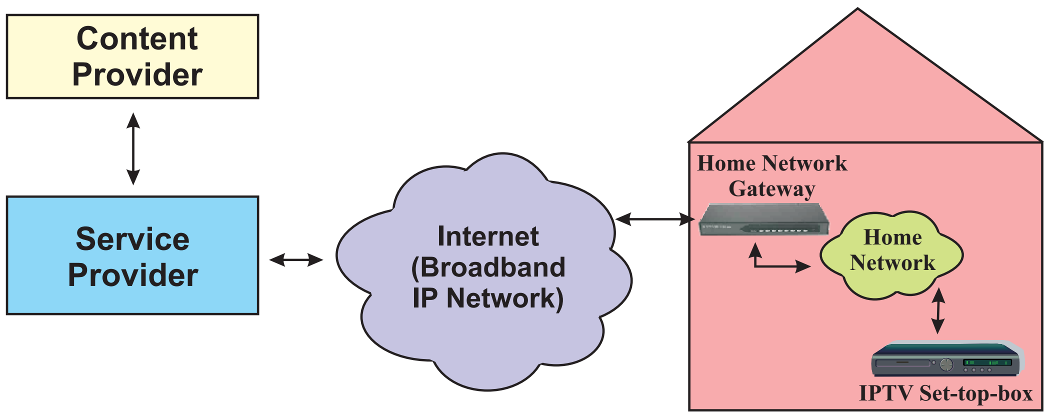
- Transmitting and receiving platform – DVB-T technology can reuse the same infrastructure used by analog terrestrial television (the existing broadcasters and transmitters). At the receiving side users have to buy a new end receiver that can be in the form of a standalone device – set-to-box – or as an *integrated receiver decoder* (**IRD**) in TV set.

- Modulation schemes – a DVB-T transmitter (as well as a receiver) realizes almost the same operations on the transport stream so as was already described in chapter about the DVB-S system. The transport stream is also randomized, protected by error correction codes (RS and convolutional), interleaved, modulated (mapped into a base band). Valid modulation schemes are QPSK, 16-QAM, 64-**QAM** (*Quadrature Amplitude Modulation*). Because a terrestrial environment is characterized by a multipath propagation, i.e. transmitted signals travel to destination (a receiver antenna) via several paths (due to reflections on various geographical objects: buildings, trees, hills, ground, etc.) another modulation/multiplexing method was defined for DVB-T. It is **OFDM** (*Orthogonal Frequency-Division Multiplexing*). This method transmits a signal on a number of carrier frequencies [20].

2.11 Digital Video Broadcasting over IP (DVB-IPTV)

DVB-IPTV means a delivery of DVB-Services over IP-based networks [23]. DVB-IPTV standard (formerly **DVB-IPI** as *DVB – Internet Protocol Infrastructure*) provides a set of technical specifications to cover the delivery of DVB MPEG-2 based services over bi-directional IP networks, including specifications of the transport encapsulation of MPEG-2 services over IP and the protocols to access such services.

Another important issue is the specification of the *Service Discovery and Selection* (**SD&S**) mechanism for DVB MPEG-2 based audio/video services over bi-directional IP networks to define the service discovery information and its data format and the protocols.



Basic IPTV architecture

A basic IPTV architecture can be seen in Figure above. The IPTV architecture and technology in detail will be characterized in IPTV section.