Hierarchal Transmissions Of Elementary Streams In DVB-T/H systems

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1. What is Hierarchal Transmission (HT)

The following diagram depicts the block diagram of a DVB-T transmitter; DVB-H systems use the DVB-T PHY with several additions that will be explained later on, but other than that they are the same.

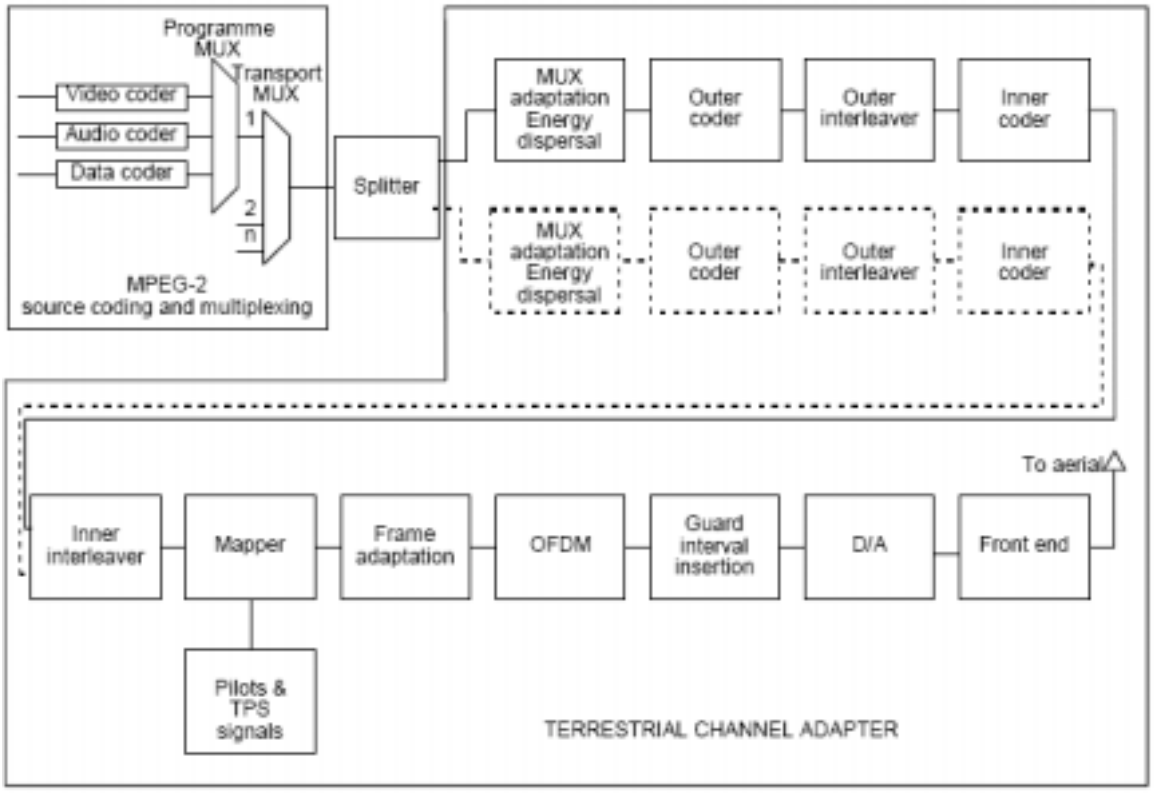

Figure 1 - DVB-T Transmitter Block Diagram

As shown above, the source data may appear in many shapes and forms. The intention is to provide flexibility for the network and service providers also in the PHY level. This introduces the hierarchical transmission.
A program is usually (although not always) compound out of a video, audio and data stream. All three streams are muxed into a single Program Elementary Stream, or PES.

Then, several programs may also be muxed together, onto a single Transport Stream, or TS. Then, comes the ability to split the stream into either one or two hierarchies[1]. This is performed in the dashed "Splitter" box right after the Transport Mux block. These hierarchies are referred to as the High Priority (HP) and Low Priority (LP) streams.
The Splitter receives packets in the MPEG2-TS format, i.e. packets of 188 bytes and may create up to 2 independent streams in the same format.

2. Why Use Different Hierarchies, and When

The ability to use hierarchies in the physical layers gives the network and service providers the flexibility they need in planning the network.

The hierarchies (may) differ from one another in the following aspects:

A. PN scrambling (energy dispersal part) and channel encoding (outer coder, outer interleaver and inner coder).
B. The mapping onto the signal constellation points.

In ***non-hierarchal*** mode, all the programs multiplexed onto the TS affectively undergo the same channel coding and mapping in the physical layer.
Since the physical layer performs both bit and byte interleaving, this means that there is no correspondence between the bits in the input and the constellation points at the output.
Applications for this type of mode are, for example, services that require a huge amount of BW for a single program (in this case there is only one program muxed onto the TS); the objective is to get high bit-rate or a large cover area.
Also, services that use several programs multiplexed onto the TS may use this mode.

In ***hierarchal*** mode, the simulcast and multicast modes are considered:
In ***Simulcast*** mode, the same program is split into the two streams; one of them if fed to the mapper using low bit-rate and better robustness, while the other is fed with high bit-rate and less better channel coding parameter. The HP stream uses a lower bit-rate and a more redundant coding rate, like the ½ or 1/3 rate. This makes the HP stream receivable under difficult conditions, such as mobile devices or on the border of the covered area.
Alternatively, the LP stream will contain a high bit-rate service, which will of course lead to better quality at the receiver but will also require better reception conditions.

Alternatively, two different programs can be each mapped to a different hierarchy, one as the HP and one as the LP. Each program with different bit-rate and channel coding parameters. This mode is refereed to as the Multi-Program Broadcast, or ***Multicast***.

In any case, the HP stream is not mapped "anonymously" onto the constellation points, but rather onto the non-uniform constellation points that show the best robustness in relation to other points.

[1] ISDB-T uses 3 hierarchies, typically used for high-definition, standard definition, and sub-standard definition – mobile/hand-held receivers.

The following diagram shows the difference between the HP and LP streams. It's obvious that the LP stream requires a better C/N performance to achieve the same BER:

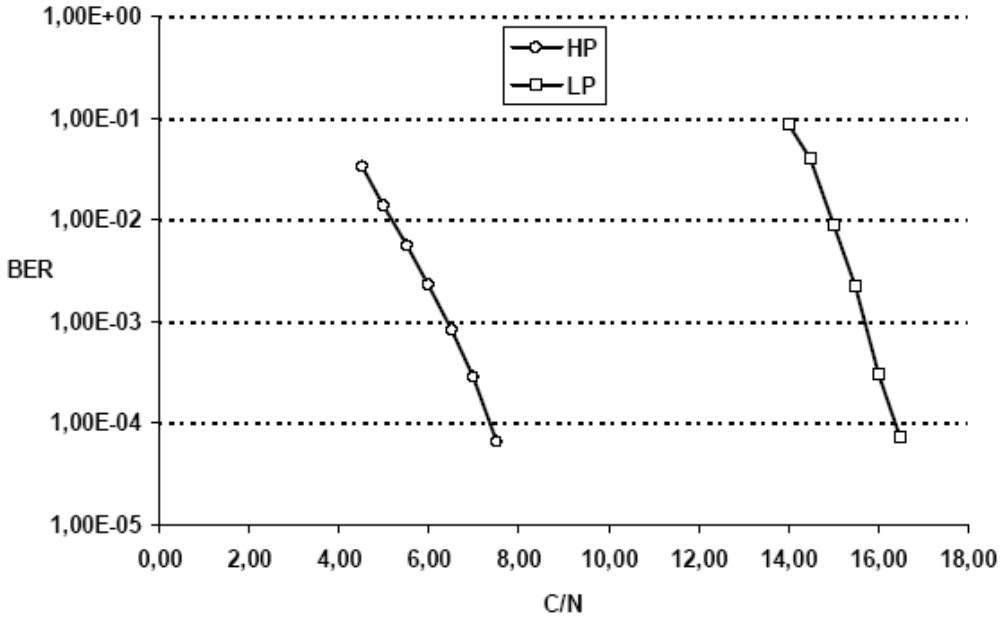

Figure 2 - BER Comparison between HP and LP

3. How can the Receiver Distinguish between the Hierarchies

The TPS (Transmission Parameter Signaling) information conveys to the receiver how to exactly receive and demodulate the signal. It is consisted of many fields, but specifically for the hierarchal transmission, it contains three bits that are used in the following manner:

Bits s_{27}, s_{28}, s_{29}	α value
000	Non hierarchical
001	α = 1
010	α = 2
011	α = 4
100	reserved
101	reserved
110	reserved
111	reserved

Figure 3 - Indication of hierarchies in the TPS

As shown, the 3-bits indicate whether the transmission is non-hierarchal (value 0) and if it is hierarchal, then what is the α used for the constellation (see section 2 above).

Also, when non-hierarchal mode is used, a single code-rate may be used. But in hierarchal mode, one can be used for each stream. This is indicated by the following bits in the TPS:

Bits s_{30}, s_{31}, s_{32} (HP stream) s_{33}, s_{34}, s_{35} (LP stream)	Code rate
000	1/2
001	2/3
010	3/4
011	5/6
100	7/8
101	reserved
110	reserved
111	reserved

Figure 4 - Coding Rate Indication for each Stream

4. Hierarchal Transmission and DVB-H

DVB-H introduces services delivered onto datagrams (usually IP) in addition to the legacy DVB-T services, i.e. the traditional MPEG2-TS content.
From the physical layer point of view, DVB-H adds nothing new. But from a "logical" view, it is known that when hierarchal transmission is used to deliver both datagrams and DVB-T content, the datagrams are ***always*** the High Priority stream.

4.1 Implications on the Receiver

The following design issues are important when discussing the architecture of the DVB-H receiver:

A. The receiver is not a mandatory requirement in order to receive and demodulate both streams. Given the information that is extracted from the TPS, the receiver can demodulate only one stream. This saves of course HW and SW development and reduces the chip size.
   However, when such a receiver would want to transit from one stream to another, there will be a "gap" in the service, i.e. an interruption in video and audio reception (in case of simulcast mode).
   Alternatively, in order to provide seamless transition from one stream to another, additional HW and SW may be considered.
B. How to decide if and when to transit from one stream to another?

5. Appendix - DVB-H Network Topology

As a reference and for "bigger-picture" purposes, following are the three possibilities of the network topologies for DVB-H systems:

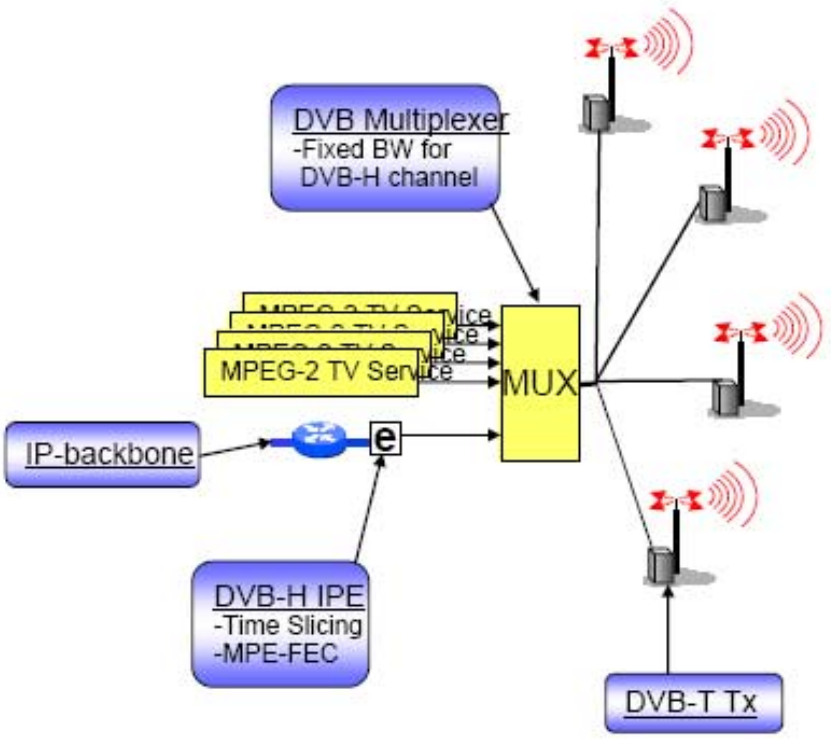

Figure 5 - DVB-T and DVB-H Muxed

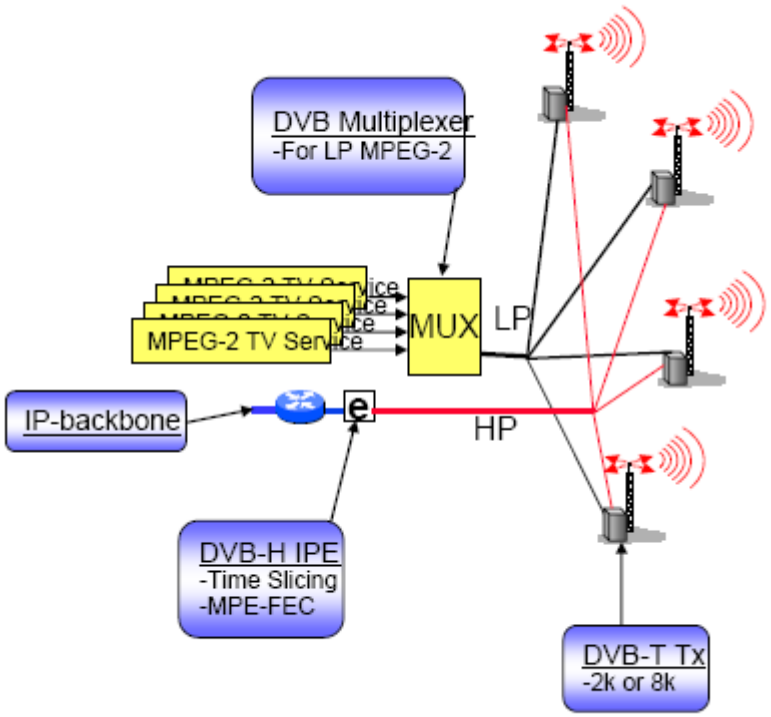

Figure 6 - DVB-T and DVB-H Hierarchal Transmission

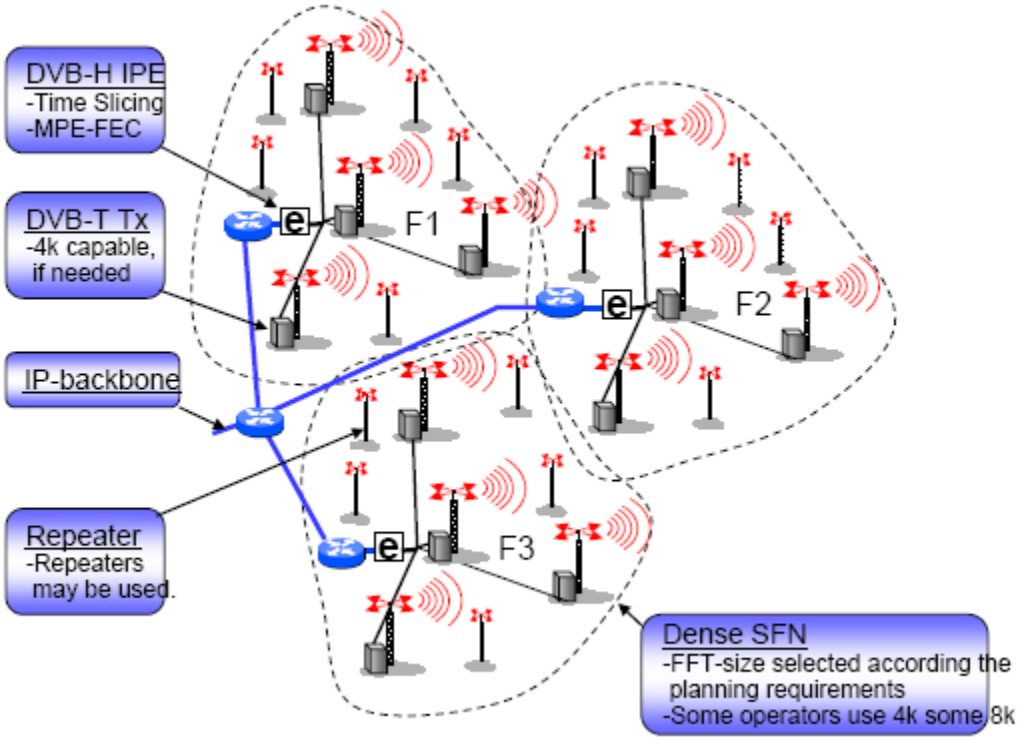

Figure 7 - DVB-H dedicated Network

6. Acknowledgements

The author wishes to acknowledge and indicate the following documents that are referenced in this document:

[1] ETSI EN 300 744 v1.5.1: Digital Video Broadcasting; Framing Structure, Channel coding and modulation for digital terrestrial television

[2] DVB-H Outline, by the AHG DVB TM-H, by Dr. J. Henriksson