BENEFITS OF USING MULTIPLE PLP IN DVB-T2

ENENSYS Technologies, France : http://www.enensys.com

DVB-T2 has already achieved incredible success for delivering digital terrestrial television. More than 28 countries around the world have selected it for their DTT standard. The first deployment was in the United Kingdom in December 2009. 2010 and 2011 saw the launch of DVB-T2 services in Sweden, Finland and Italy. Both new rollouts and trials are planned for the rest of 2011 in Europe, Africa and Southeast Asia. DVB-T2 is the world's most advanced DTT system offering higher efficiency, robustness and flexibility. It greatly increases the channel transmission capacity to meet HD and 3D bandwidth demands and offers flexibility through a range of business models using Multiple Physical Layer Pipe (M-PLP) technology, which provides services-specific robustness.

INTRODUCTION

The DVB-T2 standard includes state-of-the art technology allowing a highly efficient use of the terrestrial spectrum. It provides higher data rate and more robust signal than first generation DTT standards. DVB-T2 combines many innovations including new FEC techniques and higher modulation schemes. All these innovations contribute in enhancing performances and provide a great deal of flexibility to operators opening to a wide variety of new business models. The Multiple Physical Layer Pipes (M-PLP) mechanism allows different modulation schemes and robustness for different services within a DVB-T2 multiplex. M-PLP allows operators to transmit, for example, at the same time HD services for reception by a rooftop antenna and SD services for portable indoor reception. M-PLP is also a fantastic tool to facilitate regional TV service insertion in a national wide multiplex/frequency.

This paper presents in its first part an overview of the DVB-T2 standard to get the reader familiar with its main concepts. It then describes how to migrate from a DVB-T to a DVB-T2 network, explaining the key differences between these two setups. It then highlights the PLP technology in more details, uncovering its high potential in Digital Terrestrial Networks. Building on the flexibility of the standard and the Multiple PLP feature, the paper proposes a non-exhaustive list of business models that can be implemented when broadcasting M-PLP DVB-T2 based services.

DVB-T2 OVERVIEW

The European-based DVB consortium elaborated the DVB-T2 specification as an extension of the existing standard DVB-T, in order to allow a better use of the spectral resources by integrating the latest signal processing technologies. DVB-T2 multiplexes can reach an overall throughput of 50Mb/s compared to the 32 Mb/s in DVB-T.

Like DVB-T, DVB-T2 relies on the OFDM (orthogonal frequency division multiplex) modulation to transmit the signal but supports a wider range of transmission parameters. It enables higher FFT size (16K and 32K) that can be extended to deliver more data. It defines new Guard Interval Fractions (GIF) to maximize the bandwidth utilization and to provide a better robustness against impulse noise. New pilot patterns have been also specified to provide more flexibility in order to reduce the pilot overhead. Whereas DVB-T is limited to a constellation of 64 QAM, DVB-T2 can support in addition a constellation of 256 QAM that increases the capacity of the spectrum by about 30%.

	DVB T	DVB T2
FFT size	2K	32K
Guard Interval	1/32	1/128
Modulation	64 QAM	256 QAM
FEC	2/3 CC + RS (8%)	2/3 LDPC + BCH (0.3%)
Scattered Pilots	8%	1%
Continual Pilots	2,6%	0,35%
P1/P2 overhead	0%	0,7%
Bandwidth	Standard	Extended
Capacity	**24,1 Mbit/s**	**40,2 Mbit/s**

Capacity of DVB-T2 = DVB-T + 66%
5 -6 HDTV channels in MPEG-4 (or 15–20 SDTV)

Table 1: UK network capacity comparison between DVB-T and DVB-T2

The Forward Error Correction (FEC) scheme used on the physical transmission layer relies on the LDPC and BCH algorithm to support a higher robustness during reception under bad conditions. In addition, the DVB-T2 standard benefits of several interleavers at the bit, cell, time and frequency level allowing a better robustness against impulse noise.

DVB-T2 standard takes also care of transmitter equipment. Particularly in 32k, where the high power peaks are generated and thus minimize the amplifier efficiency (or can even damage it). A special feature called PAPR (Peak Average Power Ratio) reduction has been included in the standard specifications to limit these power peaks without losing information.

T2 Signal structure

The DVB-T2 standard defines a new framing structure for the DVB-T2 signal. The physical frame structure is composed of super frames, T2 frames, FEF and symbols. Super-frames can contain up to 255 T2 Frames (2 are recommended). Future Extension Frames shall carry frames defined in the future DVB standard, possibly NGH. The maximum duration length of a T2 frame is 250 ms so that all the system is set up to be as close as possible to this maximum value to have the better performance. A T2 frame is divided into three parts: one P1 preamble that is a robust symbol to identify a DVB-T2 signal, one P2 preamble that carries the signaling describing the content and the structure of the T2 frame and data symbols that carries the DVB-T2 services within OFDM symbols.

The logical framing structure includes BB-Frames, Interleaving frames and TI-blocks. Within a DVB-T2 system, BB-frames are the basic unit in the logical framing structure of DVB-T2: allocation and scheduling are performed in whole number of BB-Frames. One FEC-Frame carries exactly one BB-Frame adding BCH and LDPC FEC information.

Single Frequency Network

DVB-T2 allows single frequency networks (SFN) operation within a given geographical area, where two or more transmitters carrying the same data operate on the same frequency. In such cases the signals from each transmitter in the SFN needs to be accurately time-aligned, which is done with synchronization information in the T2MI stream added by the T2 Gateway. The DVB-T2 standard also includes Multiple Input Single Output (MISO) based on Alamouti coding mode. The key benefit coming from the MISO SFN is observed by less degradation in term of minimum receiver input power, while a degradation of several dB is measured in SISO-SFN (caused by the fading effects that are leading to the spectral cancellations).

Physical Layer Pipes (PLP)

The PLP concept is inherited from the DVB-S2 standard. It allows service-specific robustness. Every PLP can have its own modulation, FEC code rate and interleaving. All PLPs are broadcast over the same frequency so that it is considered as a single DVB-T2 channel.

Figure 1: PLP concept

A DVB-T2 multiplex can carry a single PLP, defined as input mode A, or multiple PLP, defined as input mode B of the T2 system. A T2 system can broadcast a maximum of 255 PLP per multiplex.

There are 3 types of PLP : common PLP of type 0 that carries information extracted from the other data PLP such as program guide, or other common information.

PLP type 1 contains 1 slice per T2 frame while type 2 contains several slices to carry the actual data.

The data PLP of type 1 can be used for services that require a good power saving.

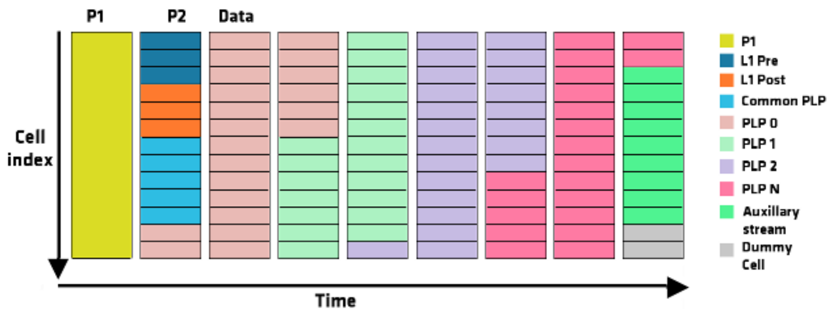

Figure 2: PLP type 1 with one slice per T2 Frame

The data PLP of type 2 is carried in multiple sub-slices per T2 frames increasing time diversity and then providing better robustness for mobile services. The number of sub-slices should be as large as possible.

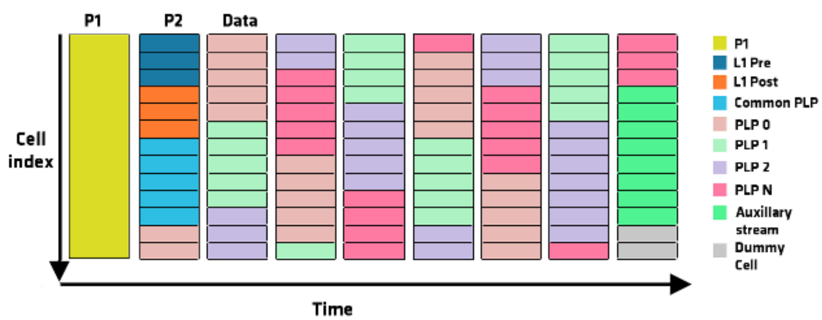

Figure 3: PLP type 2 with several sub-slices per T2 Frame

In M-PLP mode, the demodulator shall receive at the same time the common PLP and one data PLP to be able to build the MPEG-2 Transport Stream as it is received at the input of the PLP builder. The demodulator can be tuned to the desired PLP thanks to the information extracted from the SI tables or retrieved from the scanning. As the demodulator is supposed to read only one PLP at a given time there is no limitation in the receiver side on the number of supported PLP.

Some parameters are common to all PLP, such as central frequency, SFN/MISO, bandwidth, guard internal, FFT size or scattered pilot pattern. And some parameters are PLP specific such as constellation, code rate, FEC, TS bit rate and time interleaving depth.

In a regular DVB-T system only one MPTS can be broadcast per DVB-T channel. In a DVB-T2 system each PLP must contain consistent TS. So a simplified T2 system can be seen as several MPTS sharing the same channel without the need of multiplexing these MPTS together at the head-end.

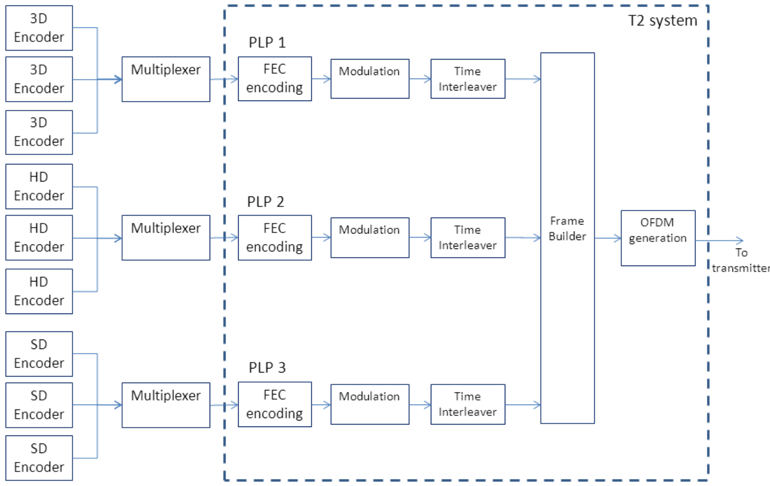

Figure 4: High level M-PLP T2 block diagram

MIGRATING TO DVB-T2 NETWORK

The DVB-T2 commercial requirements enforced the re-use of domestic receiving antenna installations as well as existing transmitter infrastructure. The resulting standard fulfills this requirement but mandates the update of equipment (modulators, de-modulators) or the insertion of new ones (T2 Gateway). Rolling-out DVB-T2 services has also an impact on the test and monitoring chain since new modulation parameters, protocols and services have been defined in the DVB-T2 standard.

From DVB-T to DVB-T2

Migrating to DVB-T2 architecture implies the insertion of the T2 Gateway at the head-end, the update of DVB-T modulators to DVB-T2 modulators, as well as the replacement of STB or iTV with the new DVB-T2 front-ends. The architecture remains the same for either Single PLP or M-PLP modes.

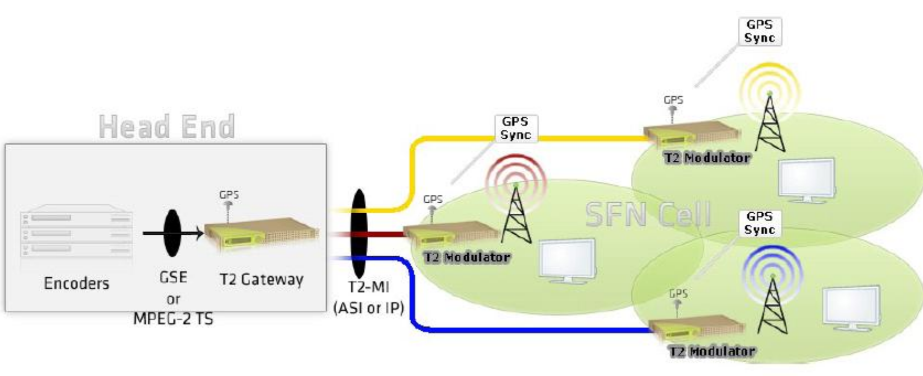

Figure 5: High level network architecture

DVB-T2 key network elements

The **T2 Gateway** aims at encapsulating the incoming MPEG-2 TS into baseband frames, inserting synchronization information for SFN broadcasting, controlling modulators configuration, scheduling the M-PLP broadcasting as well as the TFS allocation.

The **T2 Modulators** receive configuration from the T2 Gateway, perform the channel encoding by adding the forward error correction information, build the T2 frames, and modulate the signal prior to transmit it over the air. A DVB-T amplifier could be used to broadcast DVB-T2 by upgrading its DVB-T modulator by a DVB-T2 one.

The DVB-T2 standard has defined a new protocol interface the T2-MI (T2-Modulator Interface) to communicate between the T2 Gateway and the Modulators. The T2-MI packets carry the data encapsulated into BB Frames, provide for synchronization information when broadcasting over SFN and include all the signaling information for the transmission. All the PLP, TFS, SFN features are scheduled from the T2 Gateway and described within specific T2-MI packets.

DVB-T2 MULTI-PLP POSSIBLE BUSINESS MODELS

The PLP concept allows a wide range of business models. Operators can differentiate easily services on a PLP basis with an offering that varies in accordance with the robustness level.

QoS classes scenario: One possible scenario is the ability to use different modulation schemes to enable wide range of different QoS classes for each PLP. This scenario enable, for example, high data rate PLP for 3D/HD content reception by a rooftop antenna, a second PLP dedicated for indoor SD reception and a third PLP with high robustness for mobile TV or radio reception.

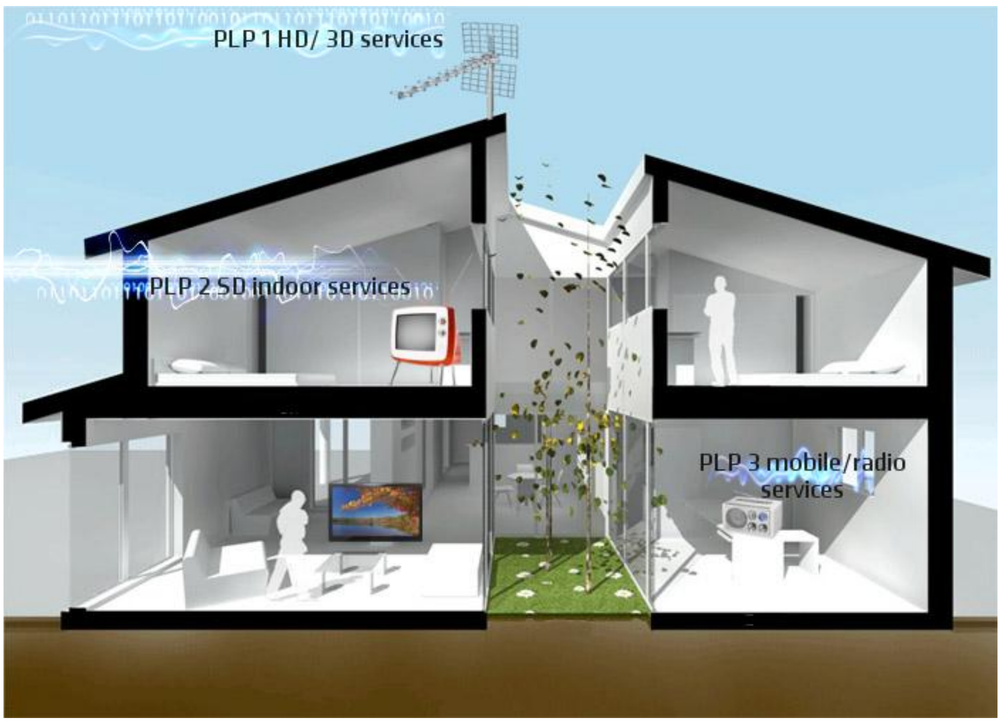

Figure 6: QoS classes scenario

In this scenario it's possible to achieve, for example, the configuration below.

Common parameters : 8 Mhz channel, FFT size 8K, pilot pattern PP1 and Guard Interval 1/4						
PLP	**Content**	**Reception**	**Modulation**	**Code rate**	**Bit rate**	**C/N**
1	HD/3D	Rooftop antenna	256 QAM	3/4	18.6 Mbps	23 dB
2	SD	Indoor antenna	16 QAM	3/5	4 Mbps	11 dB
3	Mobile/radio	Mobile reception	QPSK	1/2	0.5 Mbps	3 dB

This example shows 12 dB difference in C/N between the two first PLP to enable indoor coverage and additional gain of 8 dB for the third PLP to enable mobile reception. The time interleaver introduced by sub-slicing usage provides also additional robustness for mobile services reception.

This is just an example and various configurations are possible, but this scenario illustrates the different robustness and bitrate that can be achieved with M-PLP configuration in a single DVB-T2 channel.

<u>T2-Lite</u>: The T2-Lite profile is mostly a subset of the DVB-T2 standard. Two additional code rates were added to improve of mobile performance. T2-Lite is based on M-PLP where T2-Lite services can be transmitted in a specific PLP besides PLP with fixed services. The maximum data rates for a T2-Lite PLP shall not exceed 4 Mbps

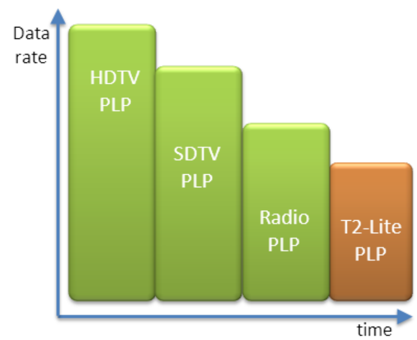

Figure 7: T2-Lite PLP frame structure

<u>Frequency sharing by several content providers</u>: In some countries, content providers have been allocated only for a part of a given frequency resource. In a DVB-T network the content providers have to re-multiplex the content all together in order to create a single MPTS. In this case content providers don't have the full control of the transmitted MPTS.

Using PLP capability, the allocation of the percentage of the bandwidth to each content provider can be managed at the PLP level to guarantee bandwidth allocation. This technique allows to make each operator independent from each other, by having them operating their own mux and choosing their own modulation parameters.

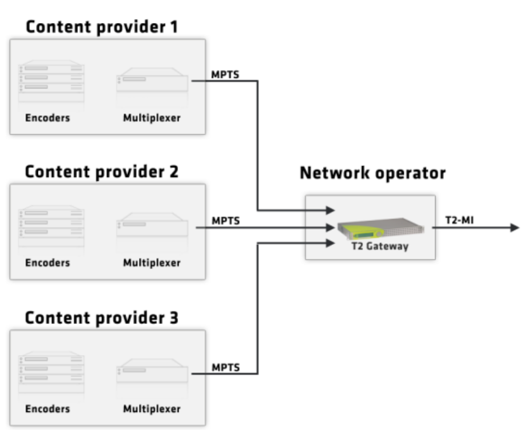

Figure 8: Frequency sharing scenario

REGIONAL TV SERVICES INSERTION

Regionalization aims at offering, in addition to national or common TV services, regional or local-specific content into a region that could be a city, a county or a country. Today out of the 1500 TV channels that are broadcast over a digital terrestrial network, 50% are local channels. Offering regional programming in DTT services is now considered mandatory.

Therefore, each region has to broadcast its own DVB-T2 multiplex composed of national and regional/local content. Regionalization can be operated through different kinds of architectures (national, regional, local) that vary depending on where the regional or local content is inserted.

Another key point to take into consideration is the necessity to guarantee the Single Frequency Network synchronization.

Centralized / National architecture

In a national architecture model, the national TV content is aggregated with regional TV content. Each region provides the content to the central head-end. Each regional DVB-T2 multiplex is created from national content multiplex and the regional TV services or regional multiplex as described below:

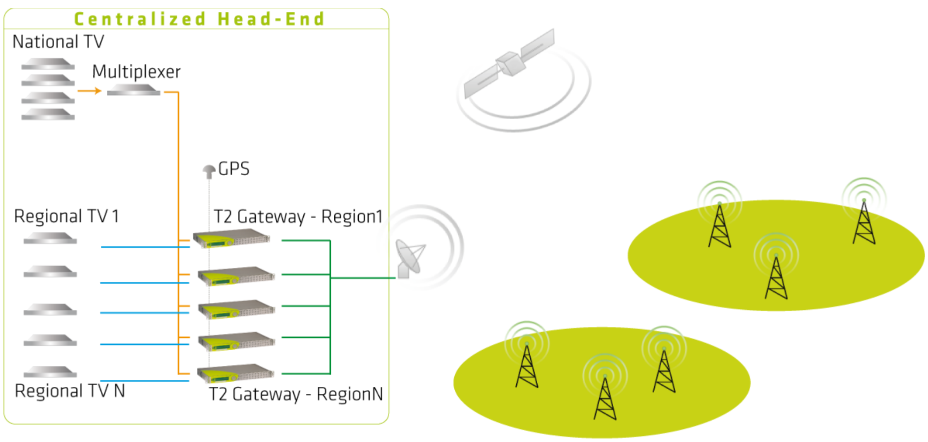

Figure 9: Centralized / National architecture scenario

In that case, for example, the T2 gateway creates the different regional DVB-T2 multiplex using M-PLP technology. Each T2 gateway has one PLP dedicated to national TV content and one or several other data PLPs dedicated to regional content. National TV content is retrieved from the national multiplexer. Regional TV content is directly retrieved from the regional encoders or regional multiplexers. Then, each regional DVB-T2 multiplex is carried towards the different regions from the centralized head-end. Although this architecture is quite straightforward, it is disadvantaged by having to duplicate the national content on the distribution network as many times as there are regions to address.

Regional architecture

In the regional architecture model, regionalization is performed within regional head-ends. Each regional head-end receives the national content from the central head-end, inserts locally the regional or local TV content, and then broadcasts the new DVB-T2 regional multiplex to all transmitters of the corresponding region. In this architecture, the regional T2 gateway outputs a T2-MI stream containing the national TV multiplex in one PLP and regional TV content in other PLPs.

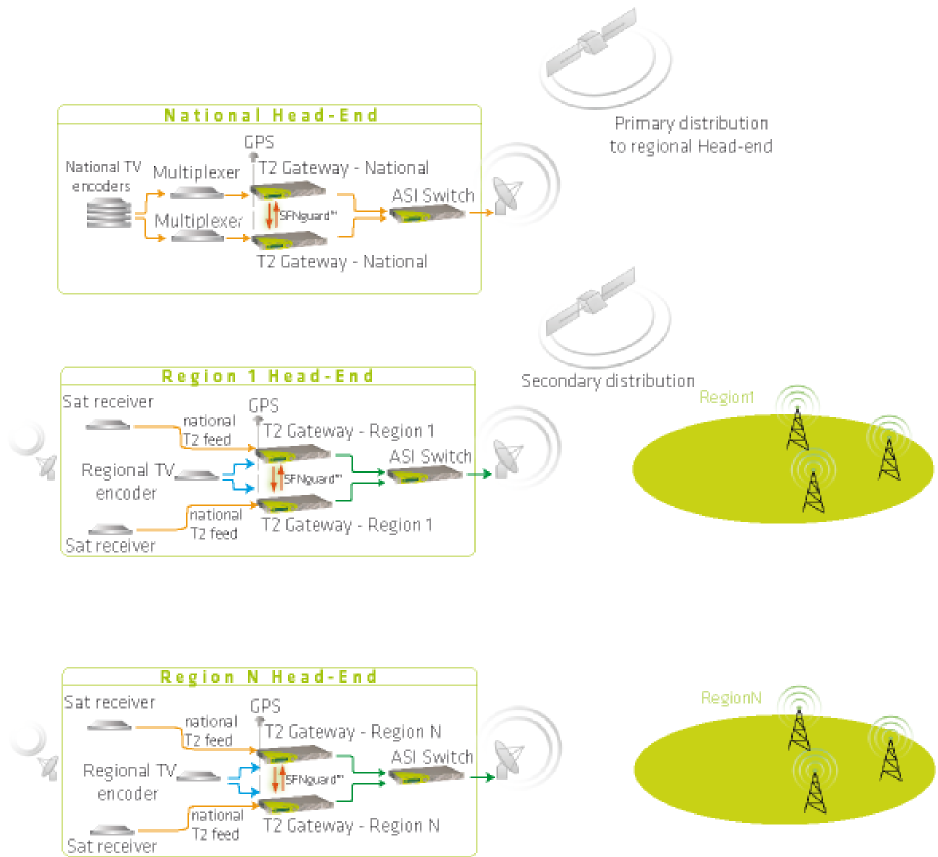

Figure 10: Regional architecture scenario

The main constraints of this architecture are the use of 2 distributions channels (from central Head End to Regional Head End, and from Regional Head End to transmitter sites) and the duplication of the national content in the secondary distribution link for each region.

Local architecture

In the local architecture model, the national T2 gateway generates national content in a specific PLP and generates other PLPs for content that will be replaced with regional content. The regional content is generated centrally, regionally or locally through a dedicated regional T2 gateway. In each transmitter site, a deterministic local T2 inserter gets from the distribution network the national T2-MI feed from the national T2 gateway and the regional T2-MI feed from the regional T2 gateway. The BaseBand frames (BB frames) data field of every T2-MI packet with a matching plp_id field (e.g. plp-id of the regional PLP), is then replaced from the national T2-MI feed with the regional T2-MI feed. Employing this deterministic method of PLP substitution ensures SFN preservation.

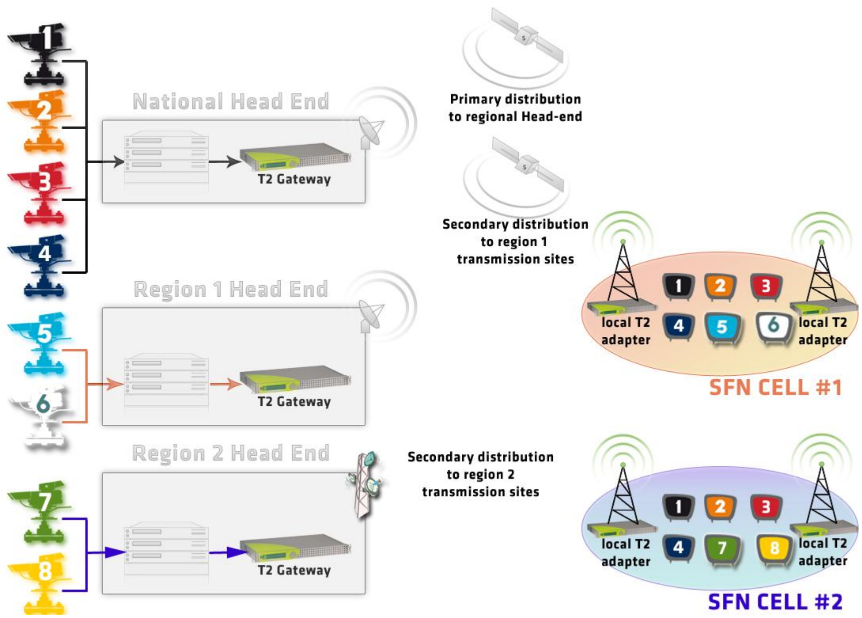

Figure 11 : Local architecture scenario

This architecture offers a great deal of advantages:

- Bandwidth saving: reduce the OPEX of the content delivery to the transmitter sites without duplicating the national content delivery
- SFN capable
- Standard-based solution: use of M-PLP technology
- Statistical multiplexing capable between regional or local TV services
- Local TV insertion capable
- Support centralized architecture if the regional contents are available in a central point
- Support distributed architecture if some regional Head-end has to be located in other places.

- Support heterogeneous distribution networks if microwave or IP distribution network is available in some regions
- Scalable architecture to enable seamless network extension

CONCLUSIONS

The second generation terrestrial network DVB-T2 extends DVB-T and provides more robustness, flexibility and efficiency in terms of bandwidth, network coverage and transmission power.

Several broadcasters are already using the power of DVB-T2 to launch new attractive services and today already 28 countries have adopted or deployed a DVB-T2-based network. Some trials in Germany and Singapore already demonstrate the benefits of M-PLP usage. Moreover the roll-out of the first commercial M-PLP network is already under deployment in Africa.

M-PLP provides maximum flexibility, without any drawback or overhead. Network equipment is available and deployed. There is also no additional complexity in the network compared to single PLP deployment. DVB-T2 chipsets are already M-PLP compliant and end-user receivers are now available without extra-cost for the support of M-PLP. Thanks to the ongoing deployments one can assume that the new receivers on the market will all support M-PLP as a standard feature.

The M-PLP feature of DVB-T2 opens to a wide range of new business models (such as different QoS classes, regionalization, bandwidth sharing) that broadcasters can take advantage to monetize the spectrum.

Likewise any DTTV deployment, regional services insertion is a key point for DTTV service success; with the Multiple PLP technology, DVB-T2 offers different ways to carry out this local channel insertion in a nation-wide rollout, in a much more efficient and flexible way than any other Digital TV standard. The National, Regional and Local architectures presented in this paper have their own advantages and disadvantages, which depend on several factors, such as country geography, distribution network topology and cost, service type and so on. If broadcasters have to assess the pros and cons of each one depending on their own constraints before choosing the right option, it is a matter of fact that DVB-T2 provides them with much more cost effective options than any other Digital TV standard.

References

1. ETSI EN 302 755 V1.3.1 "Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)"

2. DVB BlueBook A136 "Modulator Interface (T2-MI) for a second generation digital terrestrial television broadcasting system (DVB-T2)"