Digital Switchover: An alternative solution towards broadband access for all citizens

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Abstract. The paper anticipates that the actions to be taken concerning the Digital Switchover (transition form analogue to digital broadcasting – DSO) in UHF are of strategic importance for the European Member Countries and most candidate ones, as long as DSO arises as a possible and complementary solution towards the deployment of Broadband Access Infrastructures, especially in less favoured regions. Taking into account the networking potentialities of the new digital TV in UHF (Terrestrial Digital Video Broadcasting – DVB-T) and the broadband capabilities of the recent access technologies (i.e. WLAN, UMTS, etc.), the paper proposes a networking infrastructure that utilises the DVB-T stream in regenerative configurations for the realization of a common Ethernet backbone capable to interconnect all citizens within the broadcasting area. Citizens access this backbone via appropriate Distribution Nodes (DN), which make use of broadband access technologies. Such an approach enables for a multi-service capable environment (digital TV programmes, Interactive TV programmes, Internet access, e-mail, video/audio on demand, etc.), which is commonly shared among broadcasters, telecom operators and any active citizen who creates, manipulates and distributes his own content to the entire infrastructure (MPEG-21 approach).

1 Introduction

Despite the intrinsic technological differences between Telecommunications and Digital Broadcasting sectors, a notion of convergence has been recently achieved not only at technological level, but also at service level. This convergence was mainly empowered in European level by the work carried out in the field of 'Interactive Broadcasting', which was the subject of innovative work carried out by a number of

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Research and Development projects in the 5th European Framework Programme. The ultimate goal of these projects was to provide new affordable services to the users, fulfilling two observed tendencies: i) the personalisation of services, that cannot be offered by traditional one-to-many broadcasting networks, and ii) the consumption of bandwidth hungry multimedia services that cannot be offered by existing communication networks especially on the move. The objective of further development of the subject of Interactive Broadcasting was confronted by the European commission in a lately organised workshop that identified the technological and service issues which require further R&D including: i) video and audio delivery to mobile terminals, ii) traffic symmetry/asymmetry, iii) market prospects of the introduction of new services and applications, vi) regulatory and spectrum issues, and finally, and most predominant, the need of synergy (better than convergence) between broadcasters and telecom operators towards the introduction of the next generation networks (NGN).

In Sevilla European Council [1] Europe expressed its current interest for next generation networks by defining the actions-to-be-taken and by identifying the issues to be studied in depth (and in parallel) prior to the deployment of NGN. Two of these issues are (as they appear in the Sevilla document) the "**Digital Switchover**" (i.e. the transition from analogue to digital broadcasting), and the "**Broadband access for all citizens**".

Accomplishment of Europe's vision for the next generation networks requires, however, extensive study and in depth examination of the digital switchover and the broadband access for all issues. Currently, there is no clear point that such action have been taken, neither by the interesting sectors (broadcasting and telecommunication), nor by the political and governmental authorities [2], [3], [4]. Major barriers are the political authorities' unawareness about the potentialities and advantages of the new technologies, and the clashes between the broadcasting and telecommunication sectors in the market field.

Realising the networking capabilities of the new digital television in UHF (DVB-T), and the importance of broadband access technologies in the Information Society, this paper presents and draws-up the routes towards a successful deployment of NGN, by elaborating on the relation between "Digital Switchover" and the "Broadband Access for all" issues. It proposes the use of the DVB-T stream in regenerative configurations for the creation of a powerful backbone that interconnects distribution nodes within a city. As these distribution nodes (local networks) make use of broadband access technologies (i.e.WLAN, LMDS, MMDS, Optical) they enable all citizens to have broadband access to the entire network and to be interconnected. Such a configuration enables for multi-service capability, as the regenerative DVB-T creates a single access network physical infrastructure, shared by multiple services (i.e. TV programmes, interactive multimedia services, Internet applications, etc.).

Following this introductory section, the rest of this paper is structures as follows: Section 2, presents the overall architecture of the proposed infrastructure, Sections 3 and 4 describe its functional components (regenerative DVB-T and Cell Main Nodes), while Section 5 presents the principles of a real time dynamic bandwidth management system (DBMS), required for optimised spectrum usage. Finally, Section 6 concludes the paper.

2 Overall architecture

The overall architecture of such an infrastructure (see figure 1) comprises two core subsystems: I) a number of Cell Main Nodes (CMN), and II) a central broadcasting point (regenerative DVB-T). Each CMN enables a number of users/citizens (geographically neighbouring the CMN) to access IP services hosted by the network. The communication between the users and the corresponding CMN is achieved via broadband point-to-multipoint links (i.e. WLAN). The CMN gathers all IP traffic stemming from its users, and forwards it to the central broadcasting point (UHF transmission point visible by all CMNs) via dedicated point-to-point links (uplinks). IP traffic stemming from all CMNs is received by the broadcasting point, where a process unit filters, regenerates and multiplexes them into a single transport stream (IP-multiplex) along with digital TV programme(s), stemming from the TV broadcaster(s), forming the final DVB-T "bouquet". The regenerated/combined traffic is then broadcasted via the UHF channel at high data rates following the DVB-T standard. Each user receives the appropriate IP reply signals indirectly via the corresponding CMN, while receiving the digital TV programme directly via the UHF channel. In such configuration both reverse and forward IP data traffic are encapsulated into the common DVB-T stream, thus improving the flexibility and performance of the Network.

The cellular conception that is adopted utilises DVB-T stream in a backbone topology which interconnects all cells that are located within the broadcasting area. Thus, a unique virtual common Ethernet backbone is created, which is present at every cell (via its Cell Main Node). The IP traffic of this Ethernet is supplied by the DVB-T bit stream. Users access the network via the appropriate Cell Main Node.

In such configuration, all kind of citizens/providers are co-equal users of the same infrastructure via which they access (or provide) IP services. Such implementation can be used and exploited as common infrastructure by 3G and B3G operators and broadcasters having independent business plans and different users/clients.

Extension of this configuration will be achieved by using a regenerative satellite, in order to interconnect nodes and users around Europe (see figure 2).

Citizens, who utilise common PSTN/ISDN/xDSL lines access the common Ethernet backbone via an appropriate node (i.e. ISP node), who takes the responsibility to redirect data traffic targeted to them (IP reply signals stemming from any other user/citizen located within the same broadcasting area) to the UHF broadcasted Ethernet backbone. These citizens are the usual passive consumers of predefined content, accommodating best effort capabilities. This proposal is oriented to the active users/citizens that can provide and manipulate their own services to the entire Ethernet backbone (i.e. spin-off businessman, off line IP television multicasters, etc.).

The use of regenerative DVB-T configurations in conjunction with intermediate distribution nodes (cell main nodes - CMNs) that utilize broadband uplinks, constitutes a broadband access infrastructure capable to accommodate the active users/citizens, i.e. those who create, manipulate and distribute their own content to the entire network.

In this case, each CMN constitutes the 'physical interface' to the common Ethernet backbone of:

A service/content provider.

The users/citizens of a local network (intranet) who access the entire network indirectly via the appropriate CMN. This intranet may cover a part of the city (i.e. neighbourhood, outskirts, industrial zone, etc.) or comprise the LAN of a business centre that may be based on the IEEE 802.11x technology, for example.
The customers of a mobile network operator making use of 3G and B3G technology (i.e. UMTS).
Individual active users and implicit service providers, who access the common Ethernet backbone via the corresponding CMN in order to create, manipulate and provide their own content to the entire network (i.e. e-businessmen). (Also individual passive users, who request predefined content/services via common PSTN/ISDN/xDSL links and receive them via the UHF beam).

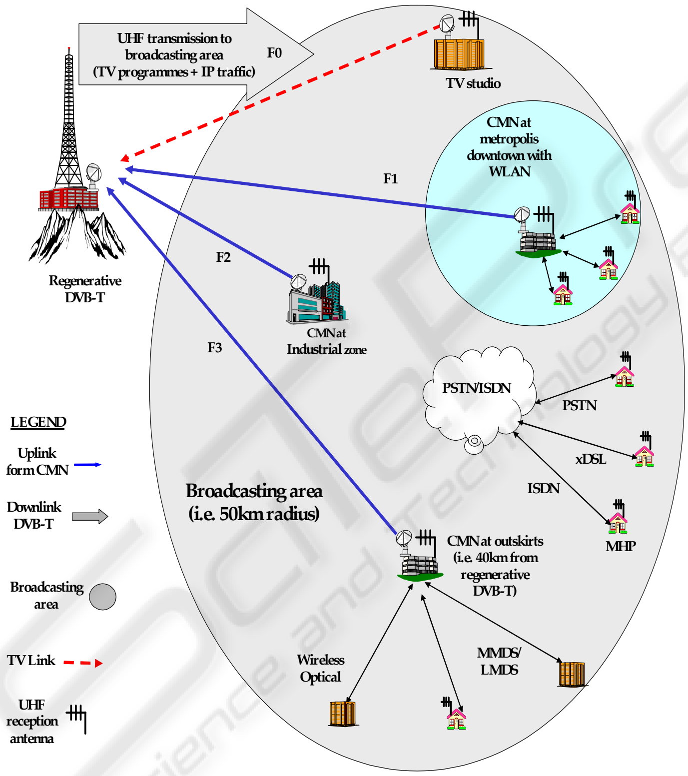

Fig. 1. Overview of the network configuration, where the common Ethernet backbone, access by both active and passive users/citizens, is present in the entire broadcasting area

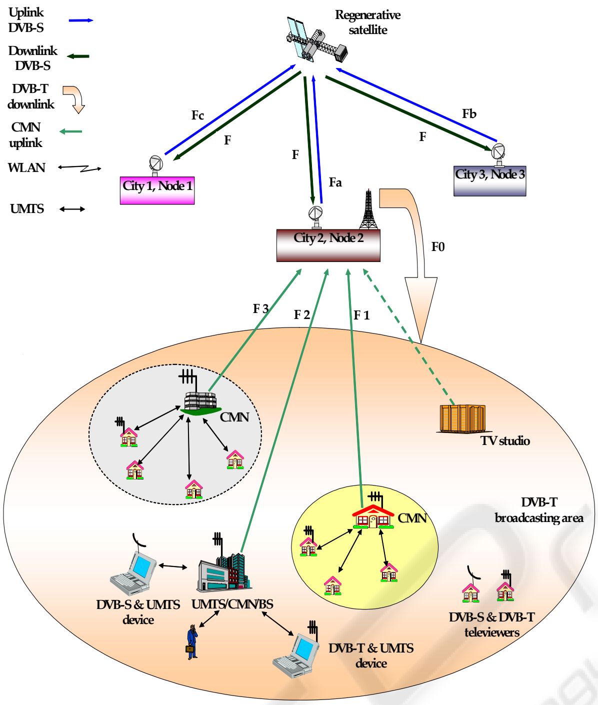

Fig. 2. Interconnecting nodes and citizens across Europe via the television stream

3 Configuration of the regenerative DVB-T

The proposed architecture of the regenerative DVB-T, which is depicted in figure 3, is capable to:

Receive the users/citizens IP traffic over terrestrial uplinks (via the appropriate CMN in the case of intra-metropolitan communication – see F1, F2, and F3 at figure 3).

Receive any local digital TV programme (stemming from the TV studio broadcasters).

Broadcast a common UHF downlink that carries the IP data targeting to all CMNs (located within the broadcasting area) and the digital TV programmes. Following the configuration depicted in figure 3, the multiplexing device must be able to receive any type of data (IP and/or digital TV programmes), to adapt any IP and MPEG-2 traffic into a common DVB-T transport stream (IP to MPEG-2 encapsulation), and finally to broadcast the common DVB-T stream following the DVB-T standard (COFDM scheme in the UHF band).

In the case that inter-metropolitan communication is required (communication and data exchange between users/citizens of different cities within Europe), the regenerative DVB-T must be able to i) receive the requests for IP services via the satellite downlink stemming from users/citizens located in another region, and any digital TV programme (stemming from the TV studio broadcasters either form the same country or from a distant one – via the DVB-S stream), and ii) transmit any IP and/or digital TV programmes, destined to other metropolitan area(s), to the satellite for cities interconnection (see figure 3).

4 Cell main nodes configuration (wlan case)

The overall configuration of the CMN that utilises WLAN technology is depicted in figure 4. This part of the infrastructure is compliant with the IEEE 802.11xx standard. Its physical layer is based on Spread Spectrum techniques, using either Direct Sequence or Frequency Hopping. Such a network will allow for the realisation of point-to-multipoint communication between the CMN and the citizens/users.

The WLAN network configuration follows a cellular architecture, as outlined in figure 4 (for a single cell). Such a configuration comprises an Access Point (AP) at the cell main node site, which maintains a full duplex communication with the Station Adapters (SA) at the citizen's/users' site. The output from each SA is in IP form, which can be transparently processed by the upper layers of the software of the end-user's terminal.

Each CMN enables a number of users (geographically neighbouring the CMN) to access IP services hosted by the network. The communication between users and the corresponding CMN is via broadband point-to-multipoint links. The CMN gathers all IP traffic stemming from its users, and forwards it to the central broadcasting point (UHF transmission point visible by all CMNs) via dedicated point-to-point links (uplinks). IP traffic stemming from all CMNs is received by the broadcasting point, where a process unit filters, regenerates and multiplexes them into a single transport stream (IP-plex) along with a digital TV programme (stemming from the TV broadcaster) forming the final DVB-T "bouquet". The regenerated/combined data traffic is then broadcasted to all CMNs via the UHF channel at high data rates following the DVB-T standard. Each user receives the appropriate IP reply signals indirectly via the corresponding CMN, while receiving the digital TV programme directly via the UHF channel.

Upon a user's request for inter-cell communication (i.e. between the specific user and any other content provider/user/server of the entire infrastructure), the AP and the IP backbone, as well as the router and the dynamic bandwidth management system (DBMS – see section 5) at the CMN, provides the necessary information (i.e. data requests, data acknowledgements) to the entire metropolitan network via the common downlink backbone (created at the regenerative DVB-T, see figure 3). The corresponding reply signals are received by a DVB-T compliant downlink adapter (in the CMN) via the common DVB-T stream (in the UHF band), and are forwarded to the appropriate user via the user's SA (see figure 4).

In this respect, the uplink of figure 4 may be named (according to the ordinary terminology) as the reverse path channel for the active user (carrying the data requests/acknowledgements), who requires access to services/content hosted by any provider within the entire network. The same physical link may be also named as the forward channel for an interactive user who accesses the services hosted by the active user.

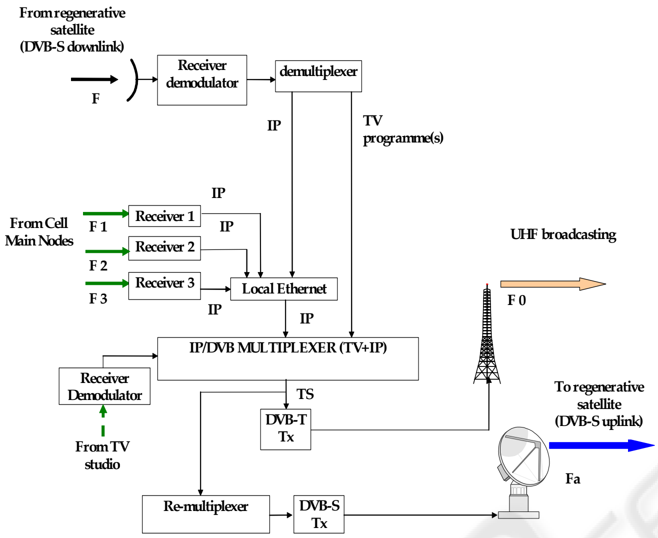

Fig. 3. Overall configuration of the regenerative DVB-T

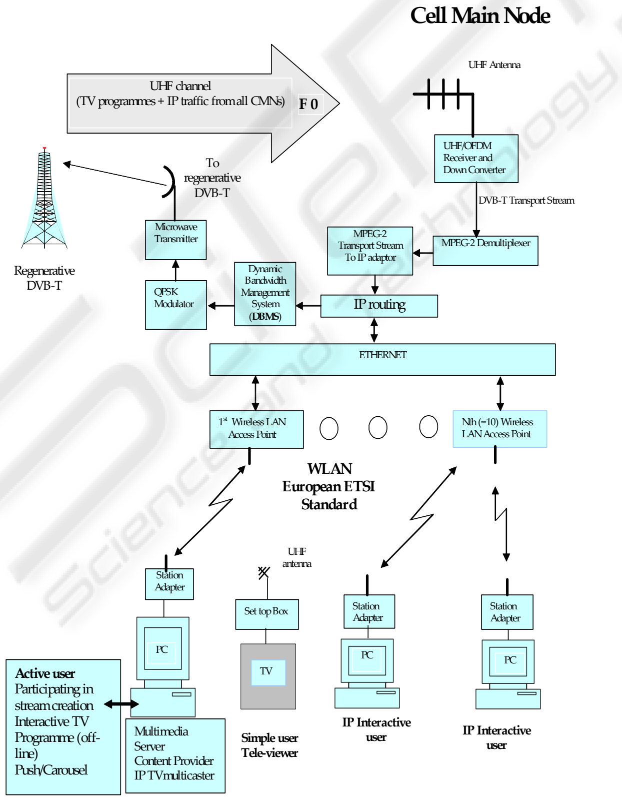

Fig. 4. Overall configuration of the CMN with WLAN

Both reverse and forward IP data traffic are encapsulated into the common DVB-T stream:
The 'Active user' and the 'IP interactive users' generate the IP traffic that is carried via the DVB-T stream to all broadcasting area.
Data IP traffic targeted to these users (and stemming from any other CMN within the broadcasting area) is supplied by the DVB-T stream to the local Ethernet, via the UHF channel.

5 Dynamic Bandwidth Management System

The proposed configuration enables for a multi-service capable platform, as long as the regenerative DVB-T creates a single access network physical infrastructure, shared by multiple services (i.e. TV programmes, interactive IP multimedia services, Internet applications, etc.). In such a configuration, a real time and dynamic management of the bandwidth is mandatory, in order to enhance the capability of DVB-T platform as a networking infrastructure and allow the provision of multiple kinds of services everywhere, anytime and over any type of network. The consequent adoption of this bandwidth-on-demand proposed capability, allows an optimised provision of heterogeneous types of traffic in respect to the available spectrum. Towards this, a real time Dynamic Bandwidth Management System is utilised, operating within the distribution node and managing the distribution of bit rate of IP traffic, in order to provide optimal allocation of the bandwidth available for the uplink. Referring to figure 5, the total bandwidth of the uplink (from the CMN to the regenerative DVB-T) of e.g. 7 Mbps is sliced into Virtual IP Channels and each channel into a number of services, whose bit rate can be variable and dynamically changed. Each service can be allocated one or more PIDs within the transport stream.

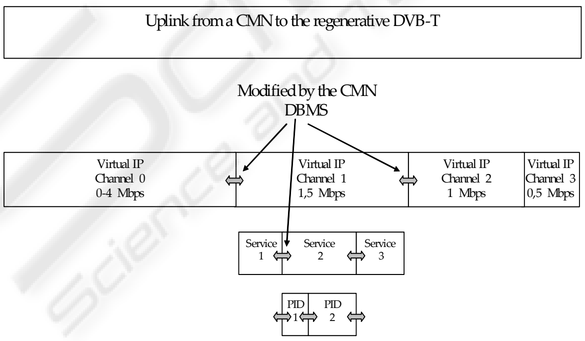

Fig. 5. Bandwidth slicing in a DVB-T transport stream

6 Conclusions

This paper presented an approach towards the realization of broadband access next generation networks (NGN), by taking into account the networking potentialities of the new digital TV in UHF (Terrestrial Digital Video Broadcasting – DVB) and the broadband capabilities of the recent access technologies. It described the overall architecture of a networking platform that makes use of regenerative DVB-T configurations for the realization of a common Ethernet backbone capable to interconnect all citizens within the broadcasting area, who access it via the appropriate distribution node over broadband links. Such an approach enables for a multi-service capable platform (digital TV programmes, Interactive TV programmes, Internet access, e-mail, video/audio on demand, etc.), which is commonly shared among broadcasters, telecom operators and any active citizen who creates, manipulates and distributes his own content to the entire infrastructure.

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