Interactive Broadcasting: Solution for a DVB-T / WCDMA Hybrid Wireless Access

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Abstract - **The latest developments in the area of wireless systems are placing the accent on the interactive services related to mobile Internet services and digital TV services. In order to use the DVBT link for data transmissions as well as or digital TV programs, an uplink channel has to be defined for interactive services. A possible solution might be the use of a hybrid system DVB-T/UMTS, in which the uplink is ensured by the UMTS while the downlink might be shared between UMTS and DVB-T, increasing thus the capacity of the overall system. This paper presents a possible interconnection scenario, which takes benefit of the advantages of both systems in order to realize an improved, high capacity fully mobile communication link. The development of a simulator for the overall system is under development but partial solutions, obtained from the DVB-T system simulation are presented.**

Keywords – **Interactive broadcasting, DVB-T, UMTS, WCDMA**

I. INTRODUCTION

The Digital Switchover process, which implies switching from analogue type broadcasting systems to digital broadcasting ones (DAB, DVB), offers the possibility to introduce supplementary data services in the remaining bandwidth. Those systems can be used as flexible digital multimedia content-broadcasting platforms. They enable access not only to multiple TV and radio channels sources, but to data services as well, which, on their turn, can be a mixture of video, audio and text content. A second trend in broadcasting services is interactivity and personalization: the users should have many degrees of freedom, to choose the content and the form of the selected program, before or during the presentation, in an interactive manner.

In the same time the mobile networks evolved form narrowband telephone / audio services to complex multimedia services. The UMTS has been adopted as the global wireless multimedia network standard at the beginning of 2000.

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Due to its flexible system design, UMTS offers a large variety of services, with various data rates, from speech telephony and pure voice applications to high rate data applications such as web-browsing, as well as to interactive communication and entertainment services.

A new challenge might be the integration of all these new technologies, very different as applications and data processing algorithms in a hybrid system. The system might provide in this way more flexibility, new applications and a better quality of the existing services. For example, broadcasting technologies are ideal for the delivery of one-to-many services, such as video streaming. In exchange, the mobile telecommunication technologies offer good symmetrical bi-directional communication link as well as a complex billing systems, which might constitute a drawback of the broadcasting technologies lack.

II. DVB-T SYSTEM

DVB-T is the standard for Digital Television Terrestrial Broadcasting defined for Europe. The DVB family standards allows for digital video and audio broadcasting as well as transport of multimedia services. For terrestrial broadcasting the system was designed to operate within the existing UHF spectrum allocated for analogue television. The system was developed for 8MHz channels but it can be reconfigured to work on 7 or 6MHz channels as well.

The achievable data-rates of DVB-T range from 3.7 - 23.8 Mbit/s for a 6 MHz channel and from 4.9 - 31.7 Mbit/s for an 8 MHz channel. The maximum achievable data-rate depends on the channel quality expressed as the signal-to-noise ratio observed at the receiver. This trade-off between SNR and achievable data-rate gives broadcasters a great flexibility in the system design. For instance, a broadcaster can decide between wide-area coverage at medium data rate, that can operate at higher SNR's, or local-area coverage at high data-rate, which assumes low SNR's.

The DVB data broadcasting specification is designed to allow software downloads over satellite, cable or terrestrial links, to deliver Internet services over broadcast channels (using MPE encapsulation), and to provide interactive TV. The specification is based on a series of four profiles, each corresponding to an application area. The four application areas covered by the DVB data broadcasting specification are as follows [2]:

- *Data Piping* – This is the simplest, asynchronous, end-to-end delivery of data through DVB compliant broadcasting networks;

- *Data Streaming* –supports data broadcast services that require a streaming-oriented, end-to-end delivery of data in either an asynchronous, synchronous or synchronized way through DVB-compliant broadcast networks;
- *Multiprotocol Encapsulation* – supports data broadcast services that require the transmission of datagrams of communication protocols via DVB-compliant broadcast networks;
- *Data Carousels* –supports data broadcast services that require the periodic transmission of data modules through DVB-compliant broadcast networks.

III. UMTS

Third-generation mobile communication systems are characterized by offering:

- wideband multimedia services, which include both data and voice services;
- real-time as well as non real-time support;
- dynamic user bandwidth and services;
- IP connectivity from end to end.

The UMTS system can deliver high-speed data, Internet services and mobile multimedia as well as simple audio services to any fixed or mobile user. The system has been develop in such a way to maintain the compatibility with previous mobile systems (like second generation digital cellular systems, cordless telephones, etc.) providing also increased capacity, larger data ranges and supplementary services in order to make it more attractive.

UMTS provides an increased data rate capability, depending on the speed the user is moving: a rate of at least 144 kbit/s for full mobility applications in all environments is ensured, at least 384 kbit/s for limited mobility applications in macro and micro cellular environments and at least 1.92 Mbit/s for low mobility applications particularly in micro and pico cellular environments. The 1.92 Mbit/s rate may also be available for short range or packet radio applications in the macro cellular environment, depending on deployment strategies, radio network planning and spectrum availability.

The frequency bands allocated by ERC to terrestrial UMTS services are 1900-1980 MHz, 2010-2025 MHz and 2110-2170 MHz.

IV. SYSTEM ARCHITECTURE

The proposed system architecture, shown in figure 1, is composed by two main parts: the DVB-T system and UMTS system. The DVB-T system main components are:

- the DVB-T transmitter;
- the TS multiplexer - it multiplexes the transport streams coming from different sources: TV studios, IP /DVB-TS encapsulated streams;
- MPE encapsulation block – encapsulates others communications protocols into DVB-TS stream.

The system blocks that are specific to this architecture are the routing block and the mobile station. The routing block must be able to separate the IP traffic which will be transmitted over DVBT and the traffic transmitted over UMTS. The routing block rule should transmit the multicast traffic over the DVB-T (being addressed to multiple users). The remaining bandwidth will be shared for unicast traffic. The routing block should implement also a bandwidth management block which will decide the way the total bandwidth (the DVB-T remaining bandwidth and the UMTS bandwidth) will be distributed among users. The mobile station must have two wireless interfaces, one for DVB-T and the other UMTS. The mobile station could be a hand held device, a notebook or a computer attached to a mobile vehicle.

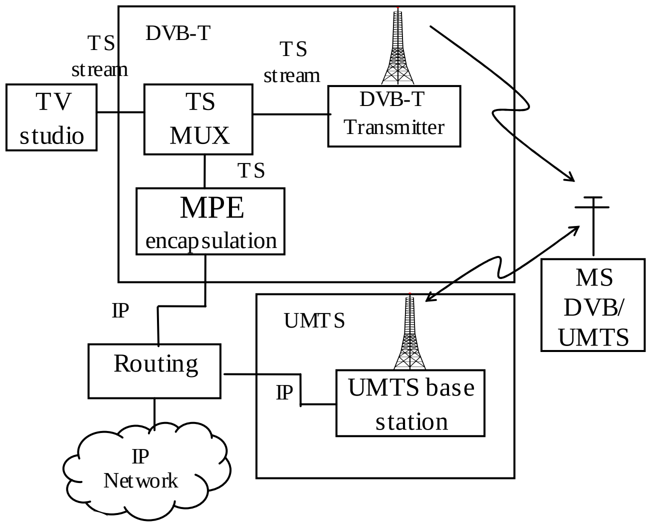

Fig. 1. DVB-T/UMTS system architecture

The architecture in figure 1 presents the way the DVB-T and UMTS are combined in order to realize an improved, high capacity, multimedia communication link. Another challenge for such a system is to deploy a fully mobile solution. It means that the user can move all over the coverage are and is able to have uninterrupted access to mobile services. For the UMTS system the global coverage problems is solved; the user cold have, from this point of view, a global access. For broadcasting services the availability is also global because, wile moving from one cell to another, the user could receive the programs without interruptions. The mobility aspects taken into account here refers the cases when the mobile switch from one UHF channel to another (figure 2) and when there is a transition from a DVB-T coverage area to a UMTS coverage area, which implies the reception of IP data to be switched from DVB-T to UMTS or opposite (figure 3).

In figure 3 the mobile moves from DVB-T to UMTS cell 2. In DVB-T cell it received an IP service via DVB-T downlink channel. In UMTS cell 2 there is no DVB-T coverage but it is via UMTS2 channel. So the traffic must be translated over UMTS2 channel.

In this respect, a traffic policy mechanism is required, which, in collaboration with the bandwidth management system, will route/direct the data traffic destined to a specific citizen, via the appropriate DVB-T stream (proper UHF channel within the same area or among different territories), in order to provide seamless access to the targeted services, besides enabling for any-time, any-where ubiquitous services distribution.

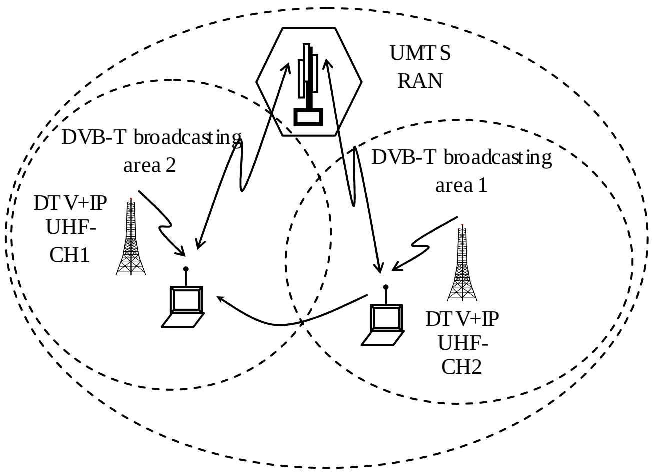

Fig. 2. Handover between different UHF DVB-T channels

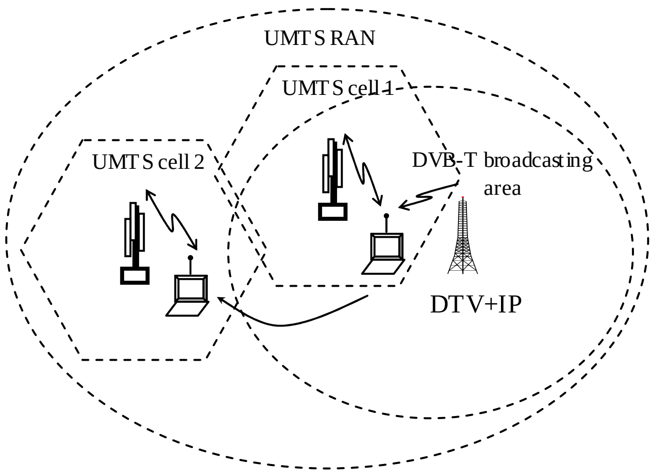

Fig. 3. Handover between DVB-T and UMTS

V. SYSTEM MOBILITY

A typical interactive broadcasting system has to deal with two types of mobility: the network layer mobility and data link layer mobility.

The network layer mobility implies that the mobile device can be found as an IP device when it moves. While moving it could travel across multiple IP networks (having different IP network addresses). It could be found in each network it crosses if it has an IP address belonging to that network. This implies that the mobile device must change its address while it moves from one network to another. Changing the IP address will cause the connection to be disrupted and lost.

The solution proposed for this kind of mobility is the Mobile IPv6. Mobile IP (RFC 2002), a standard proposed by a working group within the Internet Engineering Task Force, was designed to solve this problem by allowing the mobile node to use two IP addresses: a fixed home address and a care-of address that changes at each new point of attachment.

In Mobile IP, the *home address* is static and is used, for instance, to identify TCP connections. The *care-of address* changes at each new point of attachment; it indicates the network number and thus identifies the mobile node's point of attachment with respect to the network topology. The home address makes it appear that the mobile node is continually able to receive data on its *home network*, where Mobile IP requires the existence of a network node known as the *home agent*. Whenever the mobile node is not attached to its home network (and is therefore attached to what is termed a *foreign network*), the home agent gets all the packets destined for the mobile node and arranges to deliver them to the mobile node's current point of attachment.

When the mobile node moves, it *registers* its new care-of address at its home agent. The packets addressed the mobile user are sent to its home address firstly. It is the home agent task to forward the packets to the care of address. The further delivery requires that the packet be modified so that the care-of address appears as the destination IP address. This modification can be understood as a packet transformation or, more specifically, a *redirection*. When the packet arrives at the care-of address, the reverse transformation is applied so that the packet once again appears to have the mobile node's home address as the destination IP address.

For data link layer mobility we adopt the solution proposed by [4]. For seamless reception and uninterrupted access to the provided services i) the user must switch his DVB-T receiver device to the new UHF channel, and ii) the core infrastructure must redirect the IP traffic (targeted to him) from DVB-T cell 1 to the DVB-T cell 2 platform. In this respect, a handover policy mechanism is required for enabling efficient redirection of the IP traffic and fast transition from one UHF channel to another. The solution is based on a Location Aided DVB-T Handover (LADH) policy mechanism, capable of providing DVB-T mobility. The mobile transmits periodically information about its current location via UMTS. This information is processed by the LADH module and, if it decides that the mobile is about to enter another broadcast area, it will inform the Traffic Policy Manager (TPM) that the mobile user needs to switch to the new UHF channel. The TPM will transmit the control data (new UHF channel, communication parameters, etc) to the mobile user via DVB-T downlink channel. It will also reroute the traffic to the new DVB-T area. As a result the mobile user will switch to the new UHF channel

When switching from DVB-T to UMTS the LADH module will inform the mobile user that the broadcasted services will be lost. Also it will inform the TPM to reroute the IP data traffic (dedicated traffic) via UMTS, with a possibly decrease in QoS. The broadcasted services could be available at lower quality in UMTS also.

VI. SIMULATION RESULTS FOR DVB-T SYSTEM

The DVB-T transmitter and receiver system have been implemented in Simulink [8]. We didn’t include in our model The synchronization block was not included in the simulated model. Different system configurations was considered: 2k mode for OFDM signal with 3/4 code rate for the convolutional coder, 64 QAM modulation and ½ code rate, 16 QAM modulation and 8k mode with ½ code rate and 16 QAM modulation.

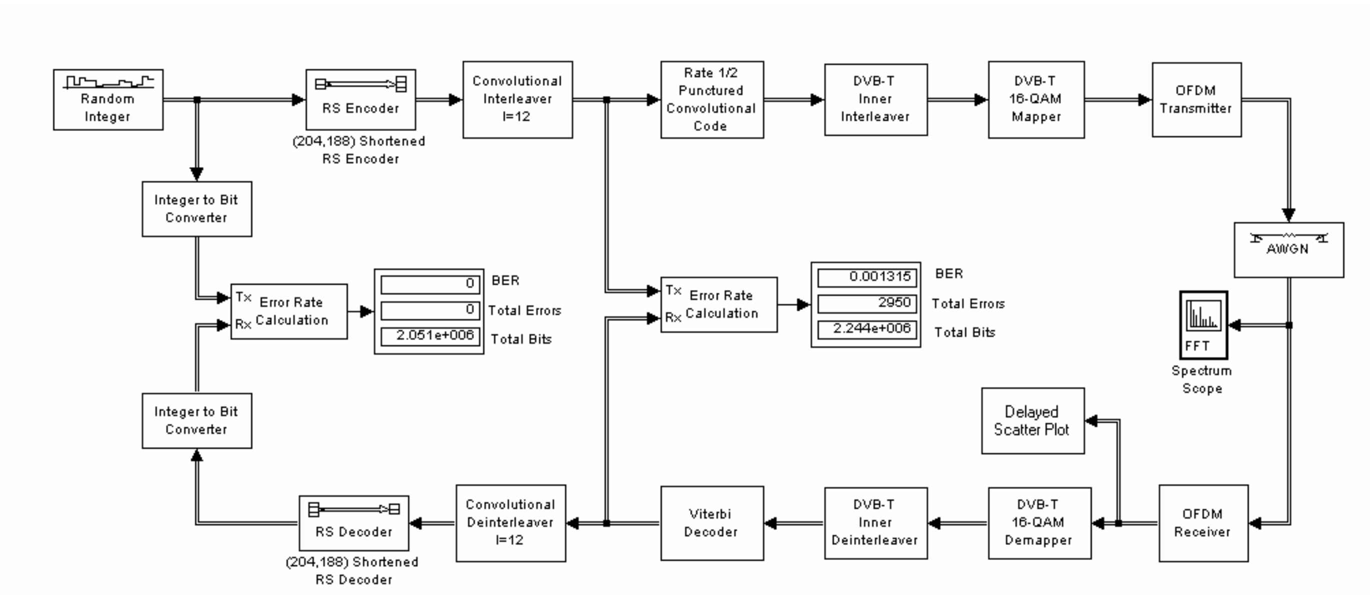

Figure 4 – DVB-T system simulink model

For radio transmission we used an AWGN channel model.

The simulation results are presented in figure 5 and figure 6. The BER is calculated after the Viterbi decoder

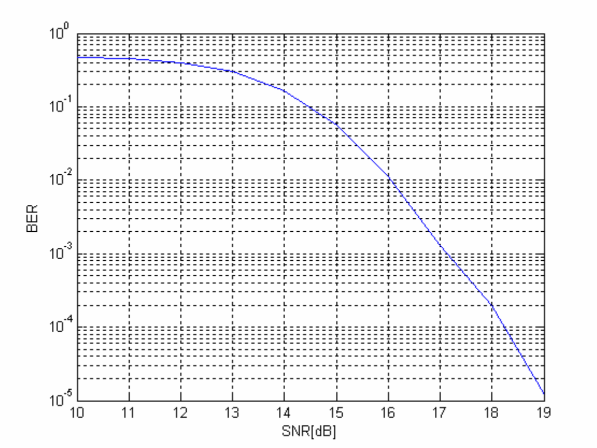

Figure 5 – BER for DVB-T (2k, 64QAM, 3/4)

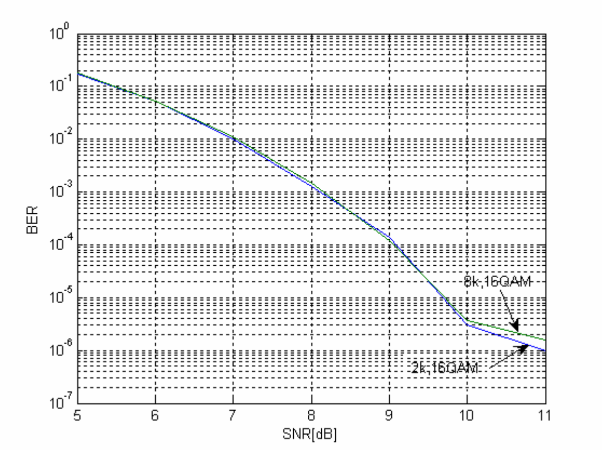

Figure 6 – BER for DVB-T (2k and 8k, 16QAM, 1/2)

VI. CONCLUSIONS

In this paper was presented an interactive broadcasting system solution based on DVB-T and UMTS hybrid access. The system architecture and the mobility aspects have been analyzed. Also some results obtained from DVB-T communication system simulations was highlighted. These simulations are part of an exhaustive set of simulations for the DVB-T system in order to have a better knowledge of its capacity and limitations, as well as to be able to verify their parameters in conjunction with an UMTS system.

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