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Service Development in a Multicast Hybrid Wireless Environment

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Abstract - this paper presents an architecture that tests the capabilities and potentialities of interworking between the DVB-T and WiMAX technologies in order to create an infrastructure that provides capabilities for multi-service development, using a single access physical infrastructure shared by multiple services. The present work describes the developed hybrid communications access network that use a regenerative DVB-T framework for enabling/ permitting/ promoting/ accepting different kind of providers to become co-equal users of the same infrastructure, through which they access (or provide) broadband connectivity to Internet for a large category of users. Based on this structure, a specific testbed has been implemented at University "Politehnica" of Bucharest using the interoperability capabilities of the 802.16d WMAN (WiMax) and DVB-T. This work presents the specific aspects of the testbed implemetation and a number of tools and applications developed and tested.

Keywords: interworking, multicast, WiMAX, DVB-T, 3G.

I. INTRODUCTION

Despite, the technological differences that naturally appears between the Telecommunications sector and the Digital Broadcasting one, a constant effort towards convergence has been made lately, not only at technological level, but also at service level. In this context, this paper propose an interworking approach that enhance the synergy between broadcasting and telecommunication sectors towards a more dynamic stage: the realization of a general environment which does not belong to any broadcaster or WiMAX/3G operator, but it can be used/exploited as a common infrastructure by operators and broadcasters having independent business plans and different users/clients, and by any spin-off businessman in the field of broadcasting/multicasting/networking. The architecture of such an environment has been developed at University "Politehnica" of Bucharest using the interoperability capabilities of the 802.16d WMAN (WiMAX) and DVB-T and serving as the SIUM project demonstrator.

The SIUM (Integrated System for Mobile Users) CEEX Project No. 80/2005. This project is focused on different aspects related to service and application development for mobile end-user. The project refers both to the development of an infrastructure for mobile communication systems based on the synergy between different mobile wireless technologies as well as to the development of applications dedicated to different end-users.

The present paper is related specifically to infrastructure development, insuring thus the synergy between different wireless technologies. Several mobile standards have been analyzed (DVB-T, WiMAX) in connection with an wired / wireless access technology to the final user. This structure can be generalized for a standard mobile data communication system, like GPRS or UMTS.

The hybrid communications access network provides a variety of heterogeneous services, with a large domain of rates, like MPEG-2 TV, IP TV sets, Internet access, e-mail access, multimedia services on demand and/or in multicast form, and creates a single broadband access physical infrastructure with multi-service capabilities, able to interconnect IP nodes. Following this introductory section, the rest of this paper is structured as follows: Section 2 presents the interworking architecture according to which a test-bed has been developed. Section 3 presents the mechanism implemented for IP multicast service wherein multicast data is transmitted through routers to user stations over a digital broadcast channel (DVB-T), depending on the available bandwidth over the broadcast channel. Section 4 provides a multicast transmission testing over DVB and presents available bandwidth results. Finally, Section 5 concludes the paper.

II. INTERWORKING ARHITECTURE

The overall architecture of the hybrid wireless access network developed within several research projects is presented in Figure 1. In accordance to this, a test platform have been developed and implemented within an experimental laboratory of Electronics, Telecommunications and Information Theory Faculty, University Politehnica of Bucharest.

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In order to simplify the tests and to evaluate better the hybrid network capabilities, an interworking architecture as a subset of the entire overall architecture, as it is presented in Fig. 2 and 3. It describes a DVB-T channel that uses the regenerative conception that comprises two core subsystems:
I) a Cell Main Node (CMN), and
II) a central broadcasting point (regenerative DVB-T).

Each CMN enables a number of users (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 (WLAN). The CMN gathers the IP traffic coming from all its users, and forwards it to the central broadcasting point (UHF transmission point visible by all CMNs) via dedicated point-to-multipoint links (WiMAX).

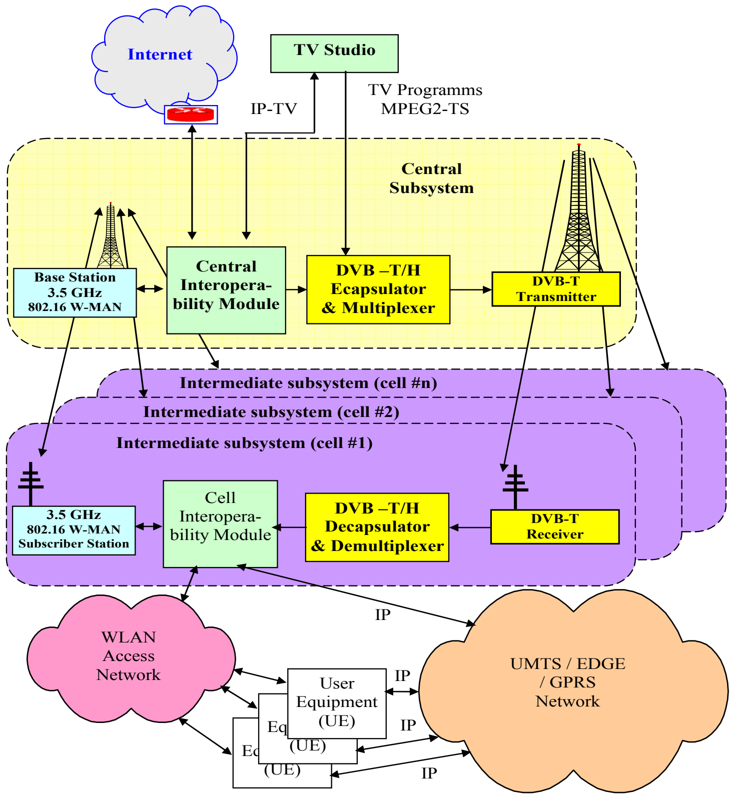

Fig. 1. Overall architecture of the hybrid wireless network

The IP traffic from all CMNs is received by the broadcasting point, where the multicast traffic is multiplexed into a single transport stream (IP-multiplex) along with digital TV programme(s), from the TV broadcaster(s), forming the final DVB-T "bouquet", and unicast which is transmitted via the WiMAX link. The regenerated/ combined traffic is 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.

The adopted cellular concept uses the DVB-T stream and WiMAX link 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 CMN). Users access the network through the appropriate CMN. In such a configuration, all citizens/providers are coequal 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 operators and broadcasters having independent business plans and different users/clients.

A). *Configuration of the regenerative DVB-T*

The configuration of the regenerative DVB-T (depicted in figure 2) is capable to:

a) receive the users IP traffic over WiMAX uplinks
b) receive any local digital TV programme (stemming from the TV studio broadcasters),
c) broadcast a common UHF downlink that carries the IP data targeting to all CMNs (located within the broadcasting area) and the digital TV programmes. In this context, and following the configuration depicted in figure 2, the multiplexing device is 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.

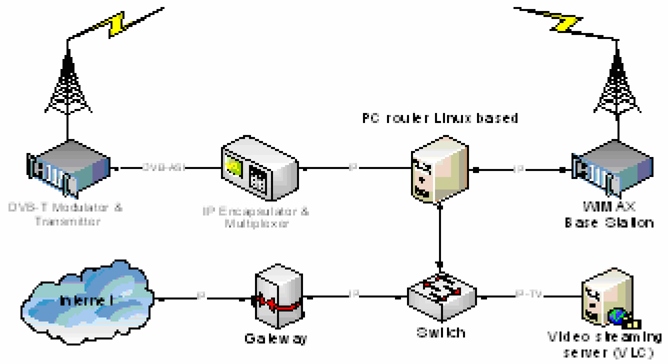

Fig. 2. Regenerative DVB-T and Core Network

B). *Cell Main Nodes Configuration (WLAN case)*

The overall configuration of a Cell Main Node (CMN) that uses the WLAN technology is depicted in figure 3. This part of the infrastructure is compliant with the IEEE 802.11x standard. Its physical layer is based on Spread Spectrum techniques, using either Direct Sequence or Frequency Hopping. Such a network will allow the realisation of point-to-multipoint communication between the CMN and the users. The WLAN network configuration follows a cellular architecture, as outlined in figure 3 (for a single cell).

The CMN comprise of a central processing node (PC router Linux based), which utilises 3 interfaces:

- A DVB-T compliant module (IPRICOT IPR T500) for gaining access to the common UHF channel (DVB-T downlink stream).
- One IEEE 802.11g WLAN (namely as “Access Point”) accommodating custom users, who require access to Internet and e-mail services and IP-TV and IP-Radio services.
- A IEEE 802.16d based interface for carrying the custom users traffic (of this CMN) to the regenerative DVB-T.

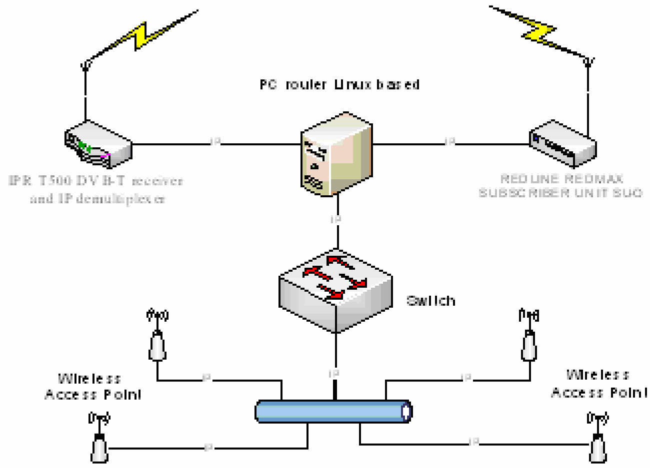

Figure 3. Cell Main Nodes Configuration and Access Network

III. MULTICAST TRAFFIC IN SIUM NETWORK

IP Multicast is a technology that allows one-to-many and many-to-many distribution of data on the Internet. A sender send their data to a multicast IP destination address, and receives express of interest in receiving traffic destined for such an address. The network manages to get the data from senders to receivers. If both the sender and receiver for a multicast group are on the same local broadcast subnet, then the routers do not need to be involved in the process, and communication can take place directly. If, however, the sender and receiver are on different subnets, then a multicast routing protocol needs to be involved in setting up multicast forwarding state on the tree between the sender and the receivers.

There are two different models for IP multicast:

- Any-Source Multicast (ASM), in which a receiver joins a multicast group, and receives traffic from any senders that send to that group.
- Source-Specific Multicast (SSM), in which a receiver explicitly joins to a (source, group) pairing.

Traditionally the IP multicast used the ASM model, but the problems that appeared in deploying inter-domain IP multicast led to the proposal of a much simpler SSM model. In the future, it is likely that ASM will continue to be used within intranets and enterprises, but SSM will be used when multicast is used inter-domain. The two models are compatible, and PIM-SM can be used as a multicast routing protocol for both. The main difference is that ASM only requires IGMPv2 or MLDv1, whereas SSM requires IGMPv3 or MLDv2 to permit the receivers to specify the address of the sending host.

In IPv4, multicast addresses are in the range 224.0.0.0 to 239.255.255.255 inclusive. Addresses within 224.0.0.0/24 are considered link-local and should not be forwarded between subnets. Addresses within 232.0.0.0/8 are reserved for SSM usage. Addresses in 239.0.0.0/8 are ASM addresses defined for varying sizes of limited scope.

In out test network the use of DVB-T access link is dedicated for multicast downlink traffic purposes. The IP multicast traffic from all CMNs is received by the regenerative DVB-T through the WiMAX interface, where the processing unit filters, regenerates, processes and multiplexes them into an MPEG-2 transport stream (IP multiplexes) along with digital TV programmes, towards forming one of the final DVB-T "bouquets". This regenerated/combined traffic carried by the specific MPEG-2 transport stream at a maximum of 30Mbps (following the DVB-T standard), is then routed/delivered to the appropriate DVB-T transmitter, in order to be broadcasted to the entire serving area via the corresponding UHF channel. Each user will be able to join multicast group received indirectly via the corresponding CMN, supplied to this RCMN via the DVB-T stream. For this reason, each RCMN receives all DVB-T broadcasts via a single UHF antenna, using, however as many DVB-T receivers as the DVB-T transmitted streams are. Such a configuration creates a unique broadband virtual and common IP backbone, which is provided by all DVB-T streams in UHF. Users access the provided services (video streaming) via the corresponding RCMN. In this respect, the DVB-T streams – provided and present at the entire overlapping broadcast are – interconnects all cells which are located within the serving area.

The regenerative DVB-T and CMNs are using Linux based PCs with to route multicast traffic from CMNs to the DVB-T encapsulator.

The developed system performances are entirely linked with the IP encapsulator performances. Thus, the reactivity and the performances of the system will have to be tested, checking the performance of the IP-to-MPEG2 encapsulation procedure following different conditions:

- IP input bit rate,
- complexity of the input digital TV stream,
- number of IP routes,
- number of IP PID.

IV. NETWORK TEST RESULTS

The network performances were tested both on WiMAX and DVB-T sections targeting several types of multimedia traffic.

A. *Uplink tests via WiMAX network section*

The service flow at the WiMAX base station was configured as in Figure 4.

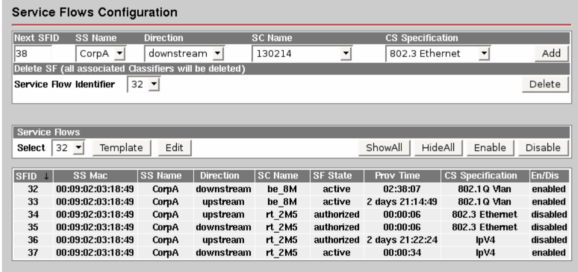

Figure 4 Service flows configuration at WiMAX base station

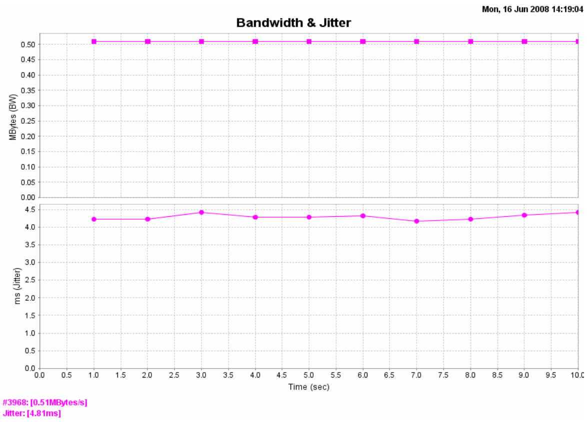

Fig. 6 Available bandwidth and jitter on WiMAX uplink connection using UDP protocol

The corresponding tests made on the WiMAX network section using UDP protocol on the uplink multicast connection presented in figure 5 reveals the results presented in figure 6.

These tests have shown that the available bandwidth is about 0.51 Mbps, results confirmed using TCP protocol. The jitter of 4.814 ms is acceptable for the usual applications.

B. *Downlink tests via DVB-T network section*

For the downlink multicast tests made via DVB-T network section the service flow settings were establish using the VLC application as in figure 7. The entire DVB-T network capacity of 20.5 Mbps were used for the VLC application (a typical example of paid IPTV multicast distribution in such hybrid wireless network configuration). The traffic route is presented in figure 8. The AMBER IP encapsulator and multiplexer (product of Thompson Broadcasting & Multimedia) is set to ensure the multicast traffic on the downlink connection (figure 9). The output traffic at the AMBER equipment is presented in figure 10.

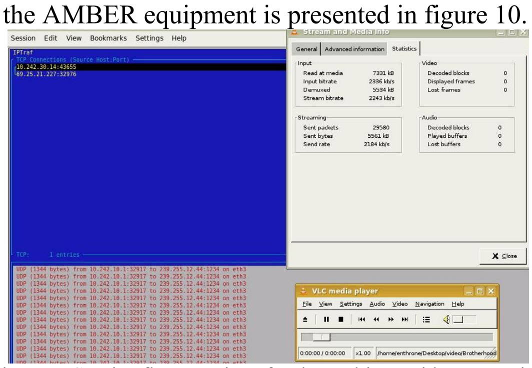

Figure 7 Service flows settings for the multicast video streaming with VLC from the server located in the core network

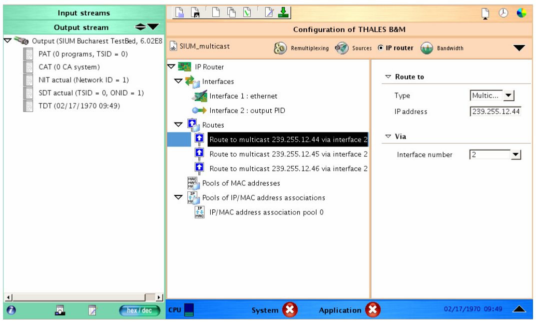

Figure 9 AMBER II settings for IP encapsulation

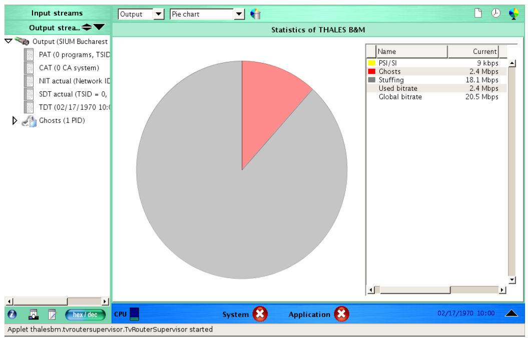

Figure 10 Output traffic of the IP Encapsulator/Re-Multiplexer

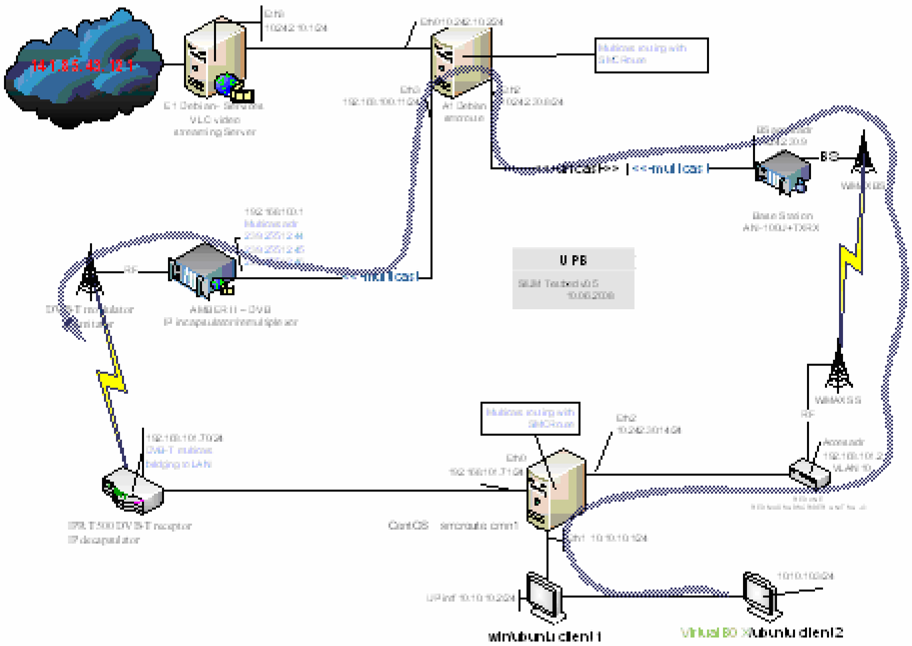

Figure 5 Uplink multicast test configuration for WiMAX section

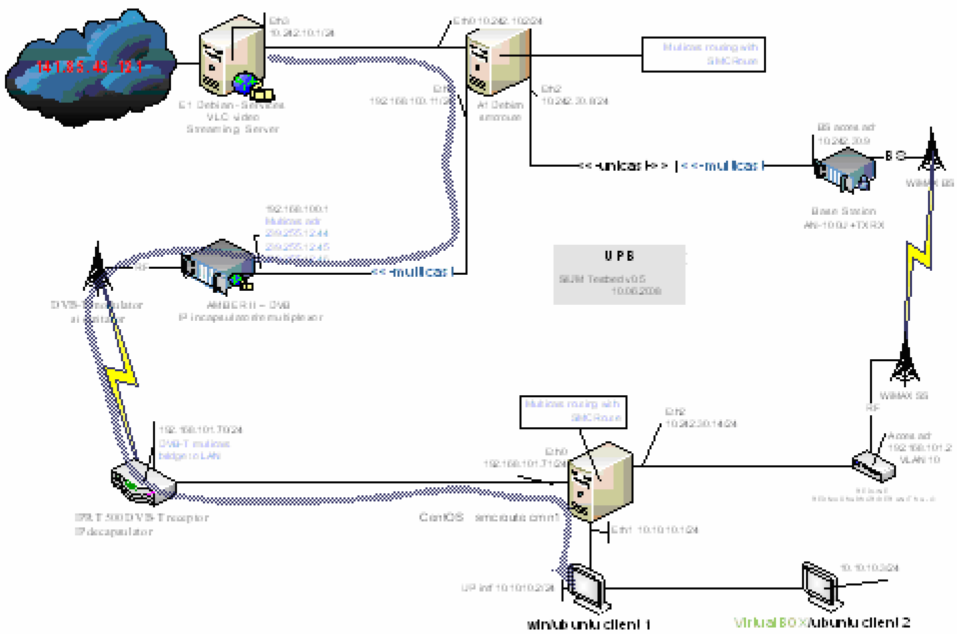

Figure 8 Downlink multicast test configuration for DVB-T section

The measurements with the DVB Dump test on the IPRICOT IPR DVB-T receiver and decapsulator (product of Thompson Broadcasting & Multimedia) have shown that all the data sent via DVB-T network section are received correctly and no data was lost.

Setting the DVB-T connection at a higher bandwidth capability (30 Mbps; i.e. lower capacity of error correction via DVB-T network section) and repeating the tests in a similar configuration reveals that the video traffic is acceptable in terms of performance, but some data packets are lost (figure 11).

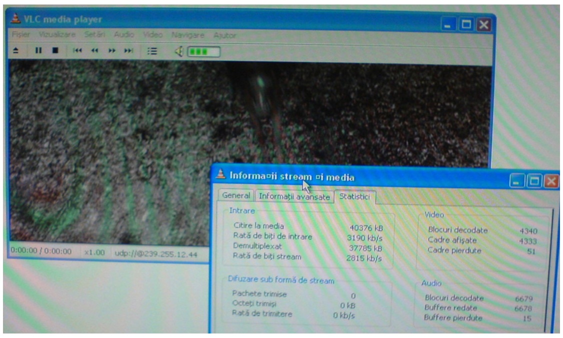

Figure 11 Received traffic in the target CMN and the client VLC application.

V. CONCLUSIONS

The tests made on the downlink multicast IP traffic routed via DVB-T interface and on uplink multicast IP traffic routed via WiMAX interface using the SIUM test platform shows that the proposed system is able to carry an important traffic via this particular access network and to increase the efficiency of the entire hybrid system in comparison with an homogeneous one using, for example, only the WiMax access technology.

All the ideas presented are very general from a network implementation point of view: the users can be connected via Ethernet, wireless LAN or IP-based cellular network. Also, the diversity of possible technical capabilities offers solutions to find different business models able to exploit the achievement of the solutions presented in the paper.
The system is still under development. It has to be actualized in order to include DVB-H and WiMAX 802.16e in order to keep it aligned with the technological development.

ACKNOWLEDGEMENTS

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