Seamless IP Traffic Diversion in a Hybrid Telecommunications / Broadcasting Network

George Gardikis
National Technical University of Athens, Mobile Radiocommunications Lab., Zografou, Athens, Greece.

Anastassios Kourtis
Institute of Informatics and Telecommunications, NCSR «DEMOKRITOS», Agia Paraskevi, Athens, Greece.

Philip Constantinou
National Technical University of Athens, Mobile Radiocommunications Lab., Zografou, Athens, Greece.

Abstract

This paper presents the implementation and testing of a consolidated network, which combines the interactivity of a low-cost and low-bandwidth widespread Internet access system with the capacity and the robustness of modern digital broadcasting platforms. The proposed system, which can result as cooperation between an Internet provider and a broadcaster, enhances traditional data service provision with high rate multimedia content.

I. INTRODUCTION

A lot of research activities nowadays are being focused in the effort to merge Broadcasting and Telecommunications worlds, which have traditionally occupied separate fields in terms of technology used (modulation schemes, multiple access methods…), applications, business models, spectrum, etc. Modern digital broadcasting is based on DVB (Digital Video Broadcasting) and DAB (Digital Audio Broadcasting) technologies, deals with "one-to-many" transmissions and is suitable for unidirectional distribution of audio/video/multimedia content. Conversely, telecommunications deal with "one-to-one" connections and are based on cellular (GSM, GPRS, UMTS), wired (PSTN, ISDN, xDSL) and broadband WLAN technologies. Typical applications are telephony, bi-directional exchange of data, and on-demand access to multimedia content. The communications channel is usually bi-directional (duplex), and has symmetry between upstream and downstream paths.

Despite their inherent differences, there are seen to be opportunities for co-operation between these two worlds. There are several ways in which the strengths and weaknesses of these two types of networks can be combined, in order to give significant service enhancements. A significant research and development effort is currently taking place, but no standard has been produced yet.

A number of scenarios have been considered for the co-operation between broadcasting and telecommunication systems. Much effort is devoted in the combination of UMTS and DVB-T networks [1], as they seem to be the most predominant in the wireless market. These scenarios range from the simple sharing of content, to the sharing of spectrum or to the coordinated use of both networks for a service[2]. In this respect, the possibility of combining and taking advantage of the joined resources of these two networks, in order to realize a consolidated network is examined in the IST SOQUET (System for management of quality of service in 3G networks - IST-2000-28521) project, funded by the EU.

However, as UMTS networks are not yet widely deployed, presently this concept can only be applied and tested in other types of telecommunications networks. This paper presents an telecommunications / broadcasting hybrid network, based on existing technologies, which can easily result as a cooperation between a digital terrestrial broadcaster and an Internet provider. This configuration makes use of the high downlink capacity of DVB-T (DVB Terrestrial) networks as part of communication sessions initiated via an ISDN (Integrated Services Digital Network) dial-up session. For low-bandwidth media services and for Internet access, ISDN network is used in both downlink and uplink channels. However, when an end-user requests broadband multimedia content stored in a local video server (e.g. video-on-demand), the downlink traffic, for that user, is automatically and seamlessly diverted to the DVB-T network, while keeping ISDN as the uplink channel. This traffic diversion may take place not only at the beginning, but also during a session, without causing any discontinuities in the provision of the service.

Through this architecture, a digital terrestrial television broadcaster is able not only to add interactivity to the TV service, but also to provide viewers with additional IP-based multimedia services. On the other hand, the Internet provider benefits from such a cooperation by widening the range of available services, without having the risk of overloading the network from additional traffic from external sources, as high-rate streaming emerges from a media server at the broadcaster's premises and is provided directly from the DVB-T downlink.

The technique described in this paper is not only applicable to ISDN, but to any other mobile or fixed

telecommunications network, like PSTN or GSM/GPRS. In this way, all these low-rate links can be enhanced with an additional high-speed downlink, when high bit rate multimedia services are requested.

II. OVERALL SYSTEM ARCHITECTURE

The architecture of the proposed network (Fig.1) is substantially an interactive DVB-T platform[3], where the return channel is implemented via the wired ISDN network. In this aspect, the wired networking infrastructure (ISDN) is able to provide bi-directional data services to end users at rates up to 128Kbps (BRI). Correspondingly, the DVB-T platform offers a high bit rate downlink channel that is able to provide high-quality digital television programs multiplexed with IP services. The end-user terminal -which can be either a standard PC or a stand-alone set-top box- is equipped with two types of interfaces: a DVB-T receiver and a connection to the ISDN network termination unit.

In order to be integrated into the overall network, the Internet service provider system does not need to be modified (a simplified typical configuration is shown in Fig. 1). A dedicated link (e.g. leased line) with strictly defined QoS parameters must exist to interconnect the broadcaster and the Internet provider. This IP link will feed the requests for multimedia content to the Media Server at the broadcaster's premises. The same link will also serve low-rate (up to a few Kbps) media streaming channels initiating from the Media Server to the end users.

At the broadcaster's site, the core of the DVB-T network consists mainly of an IP to DVB gateway, which performs special fragmentation and adaptation operations to encapsulate standard IP datagrams into DVB-compliant MPEG-2 transport packets. The gateway also serves as a statistical remultiplexer, which accepts live or pre-recorded digital TV programs as inputs and multiplexes them in real-time with the IP traffic, thus producing a constant bit-rate DVB bouquet at a rate up to 32 Mbps. This final multiplex (transport stream) is fed into a DVB-T modulator, which performs a 2-layer error-correction and interleaving process before modulating the baseband signal in a QPSK, 16-QAM or 64-QAM constellation utilizing the COFDM (Coded Orthogonal Frequency Division Multiplexing) scheme (8k mode). The COFDM signal is then up-converted to occupy a 8 MHz channel in the UHF band, and fed into a linear power amplifier which supplies an adequate power level for transmission. At the end user side, the DVB signal is received by a standard UHF antenna and fed into a DVB-T receiver card incorporated in the end-user's PC. This card is detected as an Ethernet interface by the operating system of the user's PC. It performs all receiving, decoding and demultiplexing processes. Furthermore it is able to decode a selected MPEG-2 TV program from the received bouquet and reproduce it on the PC's screen. Also, it extracts IP datagrams from the DVB transport stream and feeds them to the TCP/IP layer, in order to allow access to interactive multimedia services.

The innovative key module of the broadcaster platform is the Media Server, which provides the multimedia content to the users in streaming format. The Media Server incorporates a self-adjustable redirector software, running under Windows 2000 server operating system. This software module, written in C++, was developed for the needs of this paper and is able to monitor the outgoing IP traffic per user and control the direction of the streaming. This is achieved by modifying in real-time the server routing table, and by issuing commands to the IP/DVB Gateway utilizing a proprietary client-server protocol.

In this way, the Media Server can decide in real-time, taking in mind the traffic load per user, either to route the streaming data back to the Internet provider and via the ISDN line, or divert it to the IP/DVB Gateway and include it as encapsulated IP traffic inside the MPEG-2 multiplex. The users, whose IP data are redirected, receive the media stream from their DVB receiver card, which realizes a high bit rate downlink channel relieving ISDN from a large portion of IP traffic, and enabling the user to use it for simultaneous data access.

This redirection does not take place for low-rate streaming media (up to a few Kbps), which is sent back through the ISDN line. In this way, the DVB bouquet -whose bit rate is shared among all users- is not loaded with traffic which can be sent privately to each user via the ISDN interface.

According to the proposed scheme, the users initiate their connection through the ISDN interface, which initially handles all IP traffic (uplink and downlink). At frequent intervals, the monitoring software measures the outgoing traffic load at the interface of the Media Server. If this activity exceeds a certain threshold, IP traffic redirection is activated.

This IP traffic diversion performed by the Media Server takes place automatically in real-time and, in the configuration described above, is based on the bit rate of the outgoing stream. However, in more sophisticated implementations, this operation can depend on a wide range of criteria, including the type of service requested by the end user (whether it is real-time or not) or even a priority list, in which the end users are classified according to their QoS requirements. Furthermore, this IP traffic diversion is seamless and may occur during a session without loss of information or service interruption.

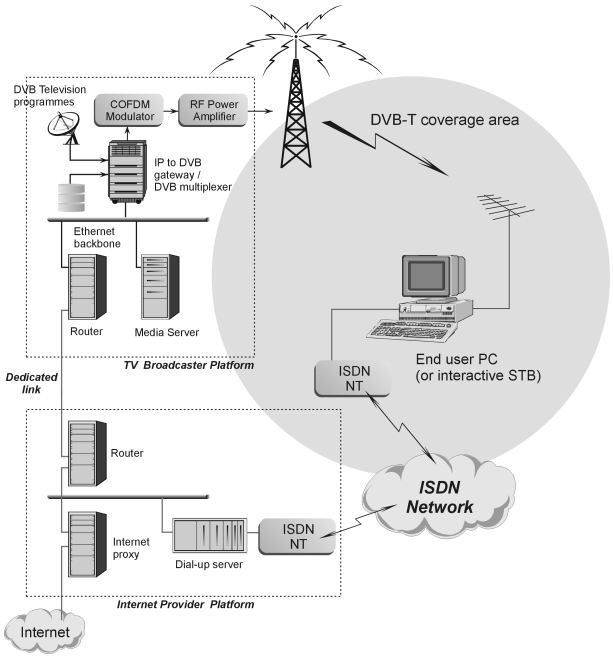

Fig. 1: Overall System Architecture

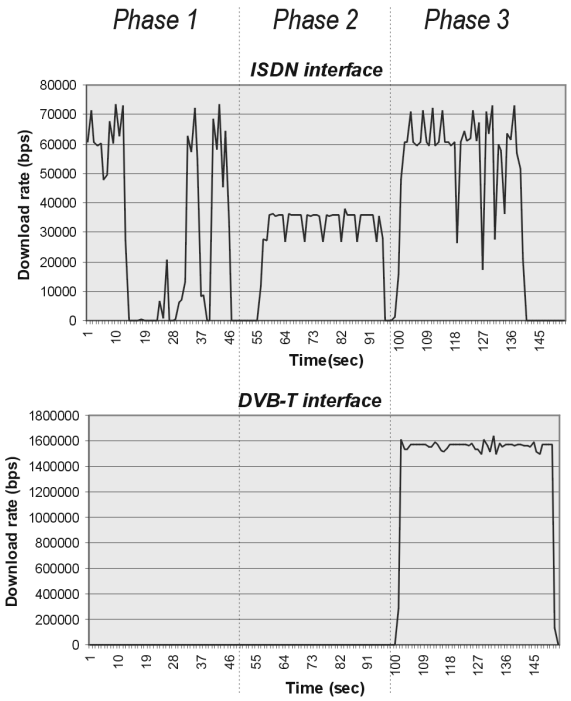

Fig. 2: Client interface load during the three-phase trial

III. PERFORMANCE MEASUREMENTS

In order to test the proposed platform under real operation conditions, a small-scale campus-wide prototype was implemented, with an end-user terminal located 200m away from the broadcaster antenna under line-of-sight conditions, equipped with a DVB-T network adapter and an RS-232 connection to an ISDN Network Terminal (NT) unit. The UHF transmitter operates at relatively low power levels (1W), utilizing wide-angle antennas. At user level, a low-gain standard UHF antenna is used for the DVB-T receiver.

At the service provider site, another ISDN NT provides the connection between the public network and an ISDN dial-up server. A proxy server is used for routing traffic to and from the Internet, and the dedicated line has been replaced by a direct Ethernet connection.

The adaptive redirector software is configured to keep the traffic sent back to the ISDN network always below a predefined limit (e.g. 40kbps). If this value is exceeded, stream traffic destined for the end user will be diverted through the IP-to-DVB gateway. The DVB multiplexer is configured to transmit a single digital television program along with the IP traffic destined to end-users as re-routed from the Media Server. The latter provides an audio/video streaming service based on Windows Media technologies. It contains stored audiovisual content at various bitrates ranging from 24Kbps (low-rate MP3) up to ~1.5Mbps (full-resolution Windows Media video).

The trial scenario was divided in three phases to illustrate the algorithm adopted. Fig.2 shows the downlink bit rate at the two interfaces of the end-user (ISDN and DVB-T).

Initially, (Phase 1) the end user performs a typical Web access to an external server, through Internet. This traffic is handled exclusively by the Internet service provider, so the downlink average throughput is constrained to 64Kbps (fig.2 upper graph), as only one out of the two ISDN channels is utilized.

During Phase 2, the user requests a 24-kbps audio file from the Media Server of the broadcaster. As the ISDN channel can sufficiently handle such a rate, the traffic is not diverted (fig.2 upper graph).

Finally, during Phase 3, the user requests a video clip encoded at a total of 1.6 Mbps. The Media Server senses the load increase, and blocks the data return back to the ISDN network. At the same time, it issues a command to the IP/DVB Gateway to include in the MPEG-2 multiplex the media stream destined for the particular user. Now, the user receives the broadband video stream at high bit rate (fig.2 lower graph). At the same time, the ISDN line can also be used for Internet access, as it is shown in the upper graph of Fig.2.

Although the proposed technique has been implemented and tested over ISDN return channel links, it can easily be applied in a hybrid system combining DVB-T with cellular (GPRS/UMTS) technologies. In the latter case, mobile users can be supported and furthermore the proposed technique significantly relieves the cell downlink by diverting bandwidth-demanding streams through an alternative route.

IV. CONCLUSION

This paper illustrated how two different technologies, belonging to the distinct fields of personal communications and digital broadcasting, can be combined to form a consolidated network. An innovative switching module was implemented to offer better QoS to end-users by efficiently and in real time distributing the network load between the two subsystems. A small-scale, but fully operational prototype was implemented, integrated into a consolidated network and thoroughly tested to show the performance and verify the proper operation of the proposed concept. Although demonstrated for DVB-T and ISDN, the proposed concept is also applicable to virtually all access networks.

V. REFERENCES

[1] Report No 1 from the DVB-UMTS Ad Hoc Group, "The Convergence of Broadcast & Telecomms Platforms", March 2001

[2] Report 14 from the UMTS Forum, "Support of Third Generation Services using UMTS in a Converging Network Environment", UMTS Forum, 2002

[3] G. Gardikis, G. Xilouris, E. Pallis, A. Kourtis, "An Interactive DVB-T Platform with Broadband LMDS Uplink", in Proceedings of IST Mobile and Wireless Telecommunications Summit, Thessaloniki, Greece, June 2002, pp. 288-291.