

# Radio Broadcast Networks enable Broadband Internet Access for Mobile Users\*

Peter Sties, Wolfgang Kellerer  
Email: {Sties|Kellerer}@ei.tum.de  
Tel: +49 89 289 -23508/ -23505  
Fax: +49 89 289 -63508/ -63505  
Lehrstuhl für Kommunikationsnetze  
Munich University of Technology (TUM)  
Arcisstr. 21, 80290 Munich, Germany

## Abstract

*The ongoing propagation of Internet information services like WWW increases the desire for broadband multimedia information and communication services also for mobile users. Therefore wireless transmission media with high bandwidth for data services are needed. Currently used systems like GSM or even the future UMTS are lacking in bandwidth and flexibility for the effective provision of broadband data services. As a large part of the Internet traffic consists of frequent user access to only a few sources, broadcast radio networks could fill the bandwidth gap and enable broadband multimedia information services for a large number of mobile users. The new arising digital radio and television broadcast networks like DVB (Digital Video Broadcast) and DAB (Digital Audio Broadcast) seem to be well suited for our presented system concept as they provide sufficient bandwidth and the ability to integrate data casting into the program streams. Completed with an upstream interaction channel, e. g. via GSM, this system can be expanded to a fully interactive Internet access for mobile users.*

**Keywords:** Radio broadcast networks, Internet access, push services, TCP tunneling, DVB, DAB, GSM.

## 1 INTRODUCTION

As the Internet is growing faster and faster, it is becoming more and more popular. The Internet is moving from a research object of the universities to a commercialized service, which penetrates into every part of the daily life. The habitual use of new information and communication services will only be successful if the access to these services is easy and possible anywhere. The increasing mobility of users and the wish of the users to have access to

their well known services wherever they are, pushes the demand for mobile IP-based services.

Up to the present, GSM [1] is the only technology that enables mobile access to Internet services. As GSM has been developed mainly for voice services, its support for packet based services does not fit the need of mobile Internet services. The data rate (9,6 kbit/s) is far too low for modern multimedia services. Furthermore connectionless packet traffic is not possible yet. All data traffic has to be assigned to an explicit connection. This makes GSM ineffective for the wide penetration of mobile data services. Also upcoming packet switched services (cf. General Packet Radio Service GPRS) provide only limited bandwidth of a few ten kbit/s [2].

As data traffic will become more and more important in the mobile environment, new access possibilities have to be found. In this context, usually UMTS as the upcoming successor of GSM is mentioned. In UMTS, a data rate up to 384 kbit/s is planned for mobile terminals within city micro cells. Nevertheless, it is not clear, if UMTS will fulfil the requirements of mobile users in the next years [3]. Regarding the dramatic rise in bandwidth demand, it is doubtful, if 384 kbit/s will be enough for the upcoming new mobile multimedia services of the next years. Having the narrowness of radio frequencies in mind, new ways to provide mobile data services have to be considered that give the user the broadband data access he needs, by using the available bandwidth in an effective way without wasting resources.

### 1.1 Internet broadcast services

With the term Internet everyone associates a fully interactive network. When looking closer to the available services and their usage, one sees that services in the Internet differ a lot in their network

---

\* This work was supported by the Bayerische Forschungsförderung as part of the compound project Bayerischer Forschungsverbund Software Engineering (FORSOFT) in the project C2 "Service Engineering".

requirements. A substantial part of the Internet traffic consists of frequent user access to a few sources (e. g. information services like stock quotes or weather forecasts, or download of new software updates). Especially for mobile users, access to well known and common information sources like traffic reports and tourist information will become more and more important.

All these services do not need real individual interactive access to data. The broadcast of these data seems to be a more adapted way to provide mobile users with the mentioned services.

Also the more interactive services usually have very time dependent bandwidth requirements. For an effective use of resources, the access network should have the ability to share the bandwidth among a large number of users and to assign larger parts of the bandwidth flexible to individual users, dependent on the current demand.

These requirements seem to fit well to the features that common radio broadcast networks provide. In the last years, the development of new data services within the common radio broadcast networks suffered from the analogous technique that is still in use. But with the increasing digitalization of these networks, they become attractive for emerging mobile data services. These digital broadcast networks provide large bandwidth resources and could easily be used to provide new data services to a large number of mobile users.

This paper is structured as follows. In Section 2 we describe two digital broadcast systems: Digital Audio Broadcast (DAB) and Digital Video Broadcast (DVB) and we present our implementation of a data transmission system for DVB. To be able to include individual services within data broadcasting, we further describe system components for data push and TCP-tunneling in Section 3. The integration of an upstream channel into the system concept leads to interactive services. In Section 4 we present some example application scenarios and discuss the implication on traffic estimations. We conclude with a summary of our results.

## **2 IP BROADCAST OVER DIGITAL BROADCAST NETWORKS**

As already mentioned, Internet information services like the World Wide Web or distribution services, which e. g. enable software download, include content that is requested by a large number of Internet users at the same time. Therefore traditional broadcast networks without advancements already provide the possibility to access

Internet services. IP packets can be broadcasted continuously e. g. in repeated transmission cycles, over the radio channel and the users can access the information with suitable receivers.

### **2.1 Digital broadcast networks**

Currently two standards for wireless digital broadcast networks have to be considered for our concept. Terrestrial Digital Video Broadcasting (DVB-T) and Digital Audio Broadcasting (DAB) are both providing possibilities for data transmission over the radio channel to a large number of users. Furthermore, with the use of radio or TV broadcast networks for data casting the users do not need to purchase new equipment for mobile Internet access, since they may reuse their radio/TV receivers.

### **2.2 Digital Audio Broadcasting**

The DAB standard [4] specifies a system for the transmission of high quality audio via a digital radio channel. DAB is especially designed for mobile recipients. Beneath audio the transmission of data packets is an essential part of the DAB transport multiplex. One DAB transmission channel provides transmission rates of about 1 to 1.5 Mbit/s. This corresponds to 6 music programs. Bandwidth can be assigned dynamically to music programs or data services by dynamic bit rate management during transmission. In this way bandwidth that is not used during voice programs e. g. news, can be assigned to data services.

### **2.3 Digital Video Broadcasting**

DVB-T is the successor of the analogous terrestrial TV distribution networks [5]. DVB is based on the MPEG-2 transport stream for the transmission of video and synchronized audio. The information is therefore transported in packets of 188 bytes lengths, which contain a 4 bytes header and 184 bytes payload. Packet identifiers (PID) within the header mark packets that belong to the same program. DVB provides transmission rates of 5 to 38 Mbit/s per 8 MHz channel. Within DVB, it is possible to carry defined data containers in addition to the audio and video in the MPEG transport stream, as in DAB. The MPEG compression causes a variable data rate of each TV program because scenes with a lot of motion in the picture are encoded with a higher bit rate than scenes with less motion. To provide the fixed data rate for transmission, stuffing packets are inserted. These packets can be taken for the transmission of data

services without affecting the video programs in the channel.

For the system architecture that has been developed and implemented at our institute in cooperation with the company Rohde & Schwarz, we have chosen the DVB-T system standard for the transmission of information packets.

## 2.4 IP over DVB

Of the four mechanisms for data casting provided by the DVB standards [6] the „multiprotocol encapsulation“ seemed to be best suited for IP transmission over DVB. The data containers (called datagram sections) defined herein are optimized for carrying IP datagrams. Each data container does not only carry packet handling information like the section length in its header but it also contains 6 bytes for a MAC address.

For the transmission of IP packets over DVB-T within the MPEG transport stream, the IP packets are inserted in datagram sections which are then mapped into the 188 byte packets of the MPEG transport stream (Figure 1). For more information and some realization details concerning the prototype implementation refer to [7].

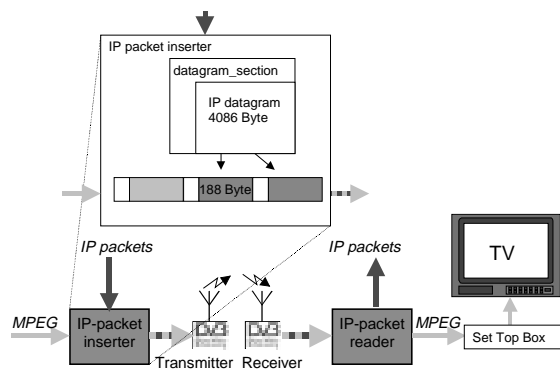


Figure 1: IP transmission over DVB-T

## 3 INDIVIDUAL INTERNET SERVICES

For personal services or services with individual selection of information, which is typical for the Internet, some further system elements are needed to satisfy the users' requirements. In the following we will present several steps that show concepts for the provision of an interactive access to Internet services.

### 3.1 Push services

When browsing for information, users are not willing to wait for the requested information to be received accidentally. To realize information

browsing for mobile users we have developed and realized a system for the access to the information of the World Wide Web over DVB-T, which is based on the IP packet transmission described in Section 2 of this paper. Since full interactivity is not possible with unidirectional channels like radio broadcast networks, we developed a concept for pushing HTML pages, which is based on the principle of a WWW proxy (Figure 2).

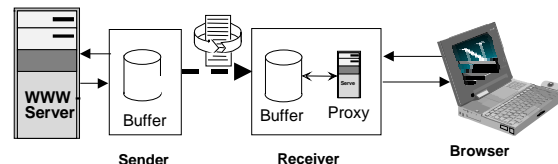


Figure 2: HTML push service

On the transmitter side, HTML pages are requested from the WWW and stored in a large information buffer. The selection of the pages depends on the business ideas of the push service content provider. The transmitter takes the packets from the buffer and transmits them over the broadcast medium. To ensure a proper reception of all pages the transmission is repeated cyclically.

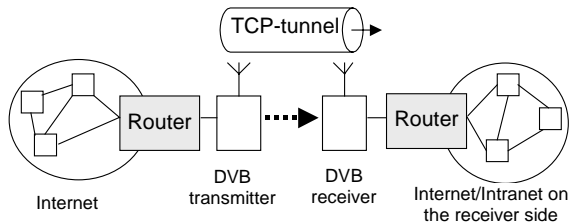
The mobile receiver stores all HTML pages in the receiver buffer. This buffer has also the feature to act like a WWW proxy. In this way, the mobile user can connect every WWW browser to the buffer to browse in the stored pool of HTML pages. The system has also been implemented in a prototype implementation at our institute [7].

### 3.2 TCP tunneling

In the last section we have shown one system realization for the unidirectional provision of IP based information services over broadcast networks. In order to realize a basic system for the provision of Internet services we have to look closer on the Internet protocol stack. As the Internet relies mostly on TCP/IP, we have to design our broadcast transmission system to provide TCP/IP access points on the transmitter as well as on the receiver side. In this way, the transmission channel is transparent to Internet applications.

Since the TCP protocol requires a return channel for the control of the data flow by acknowledgment messages, it can not be used on the unidirectional broadcast channel directly. Using an additional return-channel, e. g. via bi-directional networks like GSM, would be a solution. But using the return channel only for acknowledgments would be a very expensive and ineffective solution for information downstream oriented Internet services.

Based on the fact, that the digital broadcast transmission channel guarantees a reliable data transmission compared to the unreliable Internet, we have invented a solution called TCP-tunnel [8].



**Figure 3: TCP tunneling**

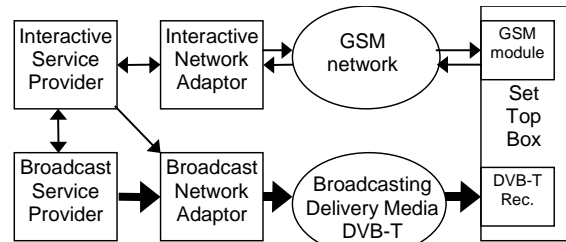
As you can see in Figure 3 the TCP connection is split into three parts: A TCP connection from an Internet node (client, server, router,...) to the tunnel-router on the transmitter side, a TCP tunnel connection over the uni-directional broadcast channel and a TCP connection from the tunnel router on the receiver side to Internet nodes on the receiver side. The router on the transmitter side terminates the TCP protocol by responding to all TCP messages and transmits all received TCP packets to the data transmitter. On the receiver side the TCP packets are routed to the addressed Internet node. The TCP connections to Internet nodes on the receiver side are terminated with appropriate responses.

### 3.3 Interaction channel

The system's transparency for TCP/IP connections allows to provide all Internet services that transport information downstream to the individual user. For full interactivity, which requires the upstream information transport from the user to dedicated Internet servers, an interaction channel has to be included in the system.

Since most Internet sessions are asymmetric concerning the bandwidth requirement for downstream and upstream direction, a combination of wireless broadcast networks and bi-directional wireless telecommunication networks like GSM brings a solution. This system concept is not only recommended and defined in the standardization of the digital radio broadcast networks (e. g. for DVB in [9]) but also recommended by the mobile communications community [3].

Figure 4, which is taken from the DVB standards, shows the principle system structure for complementing an unidirectional DVB-T broadcast channel with an interaction channel.



**Figure 4: Interaction channel model**

### 3.4 System architecture

The integration of all above described concepts leads to a component oriented system architecture for the provision of Internet access for mobile users. Figure 5 shows the overall system structure.

To support reusability and to be flexible in respect with the Internet applications to support, we have designed the system model in a component oriented way. The components may be exchanged to adapt the system to other application scenarios or different environment requirements, e. g. to have DAB instead of DVB.

## 4 APPLICATION SCENARIOS AND TRAFFIC ESTIMATIONS

The described system could serve as a platform for the realization of enhanced information and data casting services. In the following, we present some application scenarios to show the usability of the presented system concept. Focused on mobile users, we will emphasize our examples on automobile users. Other application fields are also imaginable.

As basic service for our system, the cyclic broadcast of information pages is considered. These pages could be common WWW pages from the Internet and contain for example general traffic service information, weather forecast, news services or tourist information. The range of these pages would be preselected by the service provider and then be cyclically transmitted to every user. Also software updates or updates of traffic routes for navigation systems could be included into the cyclic broadcast transmission.

Value added services could easily be included in this concept as premium rate services. For example actual stock quotes could be included in the transmission cycle. With the mean of encryption, these pages would only be accessible for users that have subscribed the appropriate premium rate service. Subscription could easily be done anytime on the way with the mobile phone

either with the use of a call center or by dialing through an oral menu.

User-individual and interactive services could be integrated with the use of the described upstream channel. All kinds of interactive services, e. g. WWW surfing, email, and FTP, are possible then.

Now, we want to focus on traffic estimations of the proposed services and their impact on the system performance. These calculations will be based on DVB-T as the broadcast transmission medium. As mentioned before, DVB-T could provide data rates from some few Mbit/s in stuffing packets within channels that are used for video streams, up to 38 Mbit/s if a whole channel is used for data broadcasting.

If you assume that an average information page, i. e. a WWW page, consists of about 30 kbytes of data [10] and that a DVB channel provides an average of 2.5 Mbit/s of stuffing packets, about 10 information pages per second could be transmitted. The cyclic transmission of the pages could be arranged in such a manner that pages, containing fast changing information, e. g. stock quotes, are transmitted more often than pages containing slow changing information, e. g. tourist information. If you esteem an average of 5 minutes for the retransmission of every page, about 3000 different pages could be provided to the user through the system by only using free bandwidth that is not used by the video streams.

Allocating more bandwidth exclusive to the data broadcasting system allows to enlarge the

number of different information pages in the system or to reduce the refreshing time accordingly. Using a cell structure of the DVB-T system enables the adaptation of the transmitted content to regional information claims.

For fully interactive Internet access for mobile users, more bandwidth will be required. Assuming a downstream rate of 384 kbit/s (cf. UMTS) per user and an average workload of 10%, every 38 Mbit/s DVB-T channel could serve about 1000 users at the same time. With the use of an appropriate cell structure, this scenario could scale for a large number of mobile users.

## 5 CONCLUSIONS

In our paper we have presented a system concept for the provision of an enhanced information service over digital radio broadcast networks. The described system concept allows the efficient use of available radio bandwidth for all kinds of mobile information services. The integration of a return channel allows fully interactive services like Internet access for a large number of mobile users. Simple data broadcast services could provide value added services within the existing radio broadcast networks.

It has been shown that the digital video broadcast technique (DVB) is well suited for the presented system concept. Some example application scenarios and appropriate traffic estimations have completed our paper.

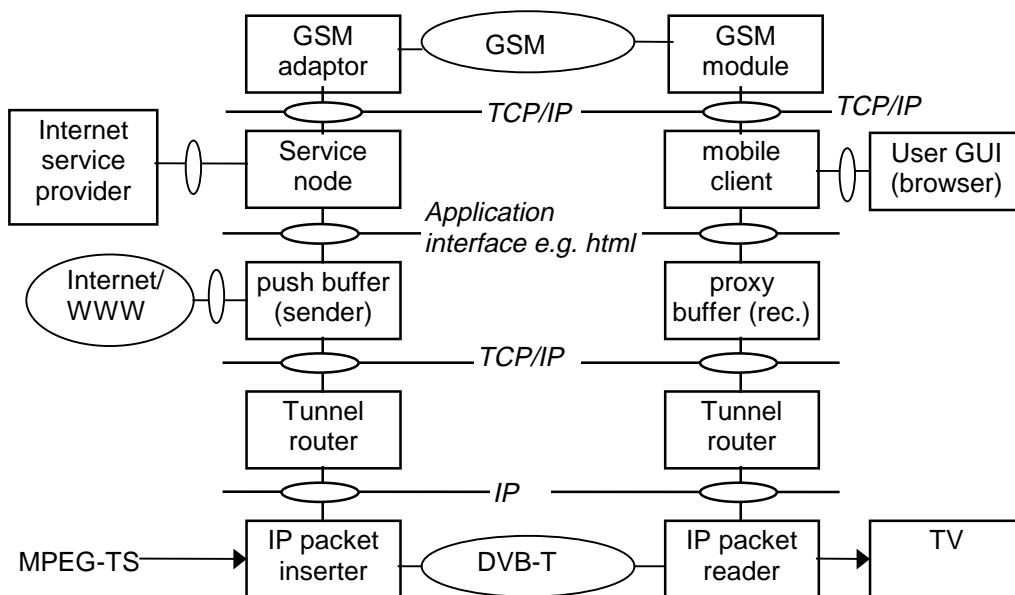


Figure 5: Overall system structure for mobile broadband multimedia Internet access

## 6 REFERENCES

- [1] J. Eberspächer, H.-J. Vögel. *GSM - Switching, Services and Protocols*. Chichester, J. Wiley & Sons, 1998.
- [2] Ch. Bettstetter. *Global Wireless Internet Access with GPRS*. In Proceedings of Eunice'99, September 1999.
- [3] *UMTS Technology Vision: Services for the End User*. In: Mobilennium the UMTS Forum Newsletter, No. 6, February 1999, p. 4.
- [4] European Telecommunication Standards Institute (ETSI). *Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers*. European Standard ETS 300 401, Mai 1997.
- [5] U. Reimers. *Digital Video Broadcasting: The International Standard for Digital HDTV*. Springer, 1997.
- [6] European Telecommunication Standards Institute (ETSI). *Digital Video Broadcasting (DVB) DVB specification for data broadcasting*. European Standard EN 301 192 v1.1.1, December 1997.
- [7] P. Sties, J. Eberspächer, W. Kellerer, B. Kreutzer, H. Reichel, G. Zurek-Terhardt. *Broadband Internet Access over Digital Video Broadcast (DVB)*. In Proceedings of European Conference on Networks & Optical Communications (NOC'99), Delft, June 1999.
- [8] W. Kellerer, P. Sties, G. Zurek-Terhardt. *System zur Datenübertragung von einem Anbieter zu einem Benutzer*. German Patent Office, AZ 199 10 023.
- [9] European Telecommunication Standards Institute (ETSI). *DVB; Interaction Channel through the Global System for Mobile communication (GSM)*. European Standard, Final Draft EN 301 195 v1.1.1, December 1998.
- [10] B. Mah. *An Empirical Model of HTTP Network Traffic*. Proceedings of IEEE Infocom'97.