Performance Analysis of Time slicing in DVB-H

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Abstract

Digital Video Broadcasting for Handhelds (DVB-H) is the latest DVB standard from the DVB Group targeting handheld, battery powered devices such as mobile telephones, PDAs(Personal Digital Assistants), etc. DVB-H enables IP data services including low definition TV services to be received on battery powered handheld terminals.

Time Division Multiplexing (TDM) is the technology that is usually used in computer and telecommunication systems for resoursce allocation. Time slicing is based on TDM and is one of the characteristics of DVB-H. This paper presents a basic model for predicting the power saving achieved by the time slicing algorithm used in DVB-H followed by analysis of the performance of the algorithm based on simulations using Matlab and Opnet; The simulations required the writing of Matlab and Opnet code to model the effect of time slicing.

The model and simulations presented illustrate the significant power savings that can be achieved by time slicing.

1. Introduction

It is anticipated that mobile users would like to be able to receive at low cost large amounts of data delivered at hight speed. It is costly to use 3G mobile telecommunications technologies to support high-speed, high bit rate services. Broadcasting is a relatively inexpensive way of distributing lots of data at high speed. Recent technological advances have made the reception of digital broadcast services in mobility on handheld terminals possible. DVB-H is a standard specified by the DVB group specifically for the broadcast of IP data, including TV content, to handheld devices such as mobile phones and personal digital assistants that have particular requirements in terms of power consumption, screen-size and mobility [1].

TDM is a type of multiplexing technology that combines data streams by assigning each stream a different time slice in a set. TDM repeatedly transmits a fixed sequence of time slices over a single transmission channel.

Time slicing is the mechanism DVB-H uses to transmit data in periodic bursts with significantly higher instantaneous bit rates than the bit rates required if the data are transmitted continuously as in Digital Video Broadcasting Terrestrial (DVB-T) [2]. Time slicing enables a receiver to stay active only a fraction of the time while receiving bursts of a requested service saving battery power. It is claimed that a 90% power saving for the front-end can easily be achieved [3]. The high bit rate signals are buffered in the time slice memory of a DVB-H capable receiver. The time slicing structure is illustrated in Fig. 1.

There is no literature publically available describing the theoretical analysis and simulation of the DVB-H time slicing scheme at the writing of this paper.

This paper presents a basic model for predicting the power saving achieved by the time slicing algorithm used in DVB-H followed by analysis of the performance of the algorithm based on simulations using Matlab and Opnet; The simulations required the writing of Matlab and Opnet code to model the effect of time slicing.

The paper is organised as follows: In Section 2 the research background to and a theoretical analysis of the use of time-slicing in DVB-H are presented. Section 3 presents a simulation of the time slicing scheme for DVB-H and an analysis of the simulation results. The time slicing mode of DVB-H is compared with the continuous transmission mode of DVB-H. The conclusions drawn are presented in section 4.

2. Theoretical Analysis

TDM has long been used in telecommunications and computer systems for providing services to different users in different time slots over a common media. In broadcasting, continuous transmission has been the dominant transmission mode for a very long time.

Traditional continuous mode broadcast transmission is shown in Fig.2. In continuous transmission mode, several programs are transmitted in one transport stream with numerous receivers sharing one downstream channel. When a receiver is tuned to receive one of the programs it has to receive the other unwanted programs at the same time consuming a lot of battery power.

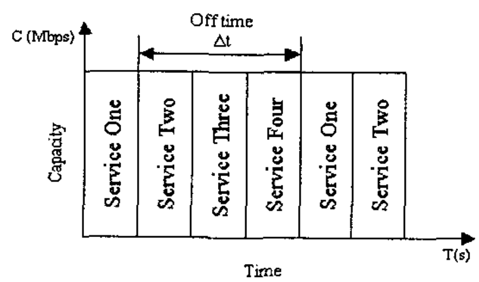

Fig. 1. Time slicing Structure

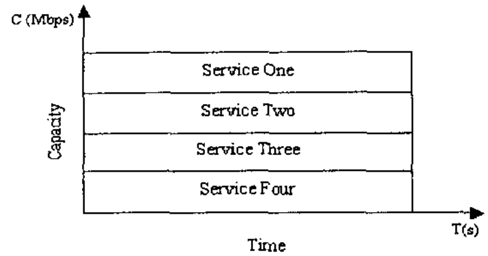

Fig. 2 Continual Transmission Structure

In time slicing mode, the service program streams are transmitted in different time slots with high instantaneous bit rates. The DVB-H receiver will receive its intended high bit rate service in one time slice and make the front end sleep during the other slices. This process is performed repeatedly. The high bit rate service received will be buffered in the receiver memory and played out continuously to provide the desired quality of service.

Suppose the receiver front-end consumes battery power E_i receiving the service in the *ith* time slice for t_i seconds, where t_i is the duration of the i time slice. We suppose there are n different services transmitted through the network and n is fixed. Then when the receiver is receiving a service from time slice m $(1 \le m \le n)$ for a transmission period T that is a multiple of $\sum_{i=1}^{n} t_i$, the battery power it consumes in time slicing mode is given as $E1$ in equation 1 and in continuous mode as $E2$ in equation 2 below.

$$E1 = TE_m / \sum_{i=1}^{n} t_i \quad (1)$$

$$E2 = T \sum_{i=1}^{n} E_i / \sum_{i=1}^{n} t_i \quad (2)$$

In this case, the total front-end battery power saved when using time slicing mode is shown as E_s in equation 3.

$$E_s = E2 - E1 = T(\sum_{i=1}^{n} E_i - E_m) / \sum_{i=1}^{n} t_i \quad (3)$$

It is easy to see that the more service streams that are transmitted in one channel, the more front-end battery power will be saved if the transmission mode is changed from continuous mode to time slicing mode.

In DVB-H networks, the handheld devices usually have small screen sizes. This makes it possible to use modest bit rates for decent video resolution. Using the H.264/AVC coding/decoding scheme, a 128 kbps bit rate can provide good video resolution on typical mobile phones [3].

It is anticipated that spectrum will be released for DVB-H services after the switch off of analogue broadcasting. At the moment, dedicated DVB-H networks will have up to 8 MHz bandwidth in UK [3]. In this case, a lot of different service streams will be incorporated inside one channel. In this situation, the time slicing transmission mode will definitely save a lot of battery power for DVB-H receivers.

Suppose

$$\sum_{i=1}^{n} E_i = 400\ mW \ [4]. \quad (4)$$

From (1) and (2) the following equation is obtained,

$$E1 = E_m E2 / \sum_{i=1}^{n} E_i \quad (5)$$

$$0 < E_m < 400\ mW \quad (6)$$

Suppose $p = E_m / \sum_{i=1}^{n} E_i$, then

$$0 < p < 1 \quad (7)$$

$$E1 = pE_2 \quad (8)$$

One DVB-H transport stream contains a lot of program channels. Each channel may consume different front-end power according to their different bit rates.

Using Monte Carlo simulation, under condition (4) the consumed battery power in time slicing mode and the saved battery power(%) are illustrated in Fig.3 and Fig.4 respectively.

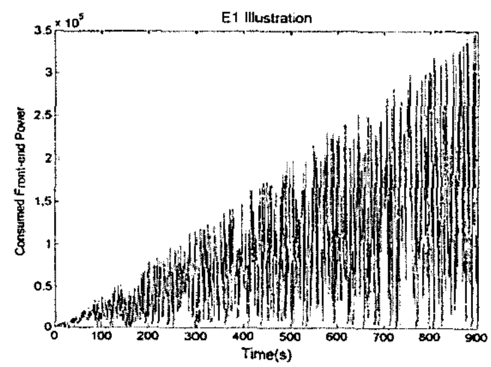

Fig.3 Consumed Front-end Power for Time Slicing

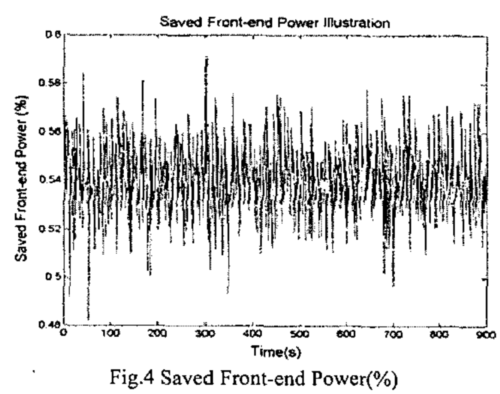

Fig.4 Saved Front-end Power(%)

From Fig.4, it is easy to see that about half of the front-end battery power consumption can be saved on average.

A DVB-H receiver is expected to usually be a single antenna terminal. As the DVB-H cell becomes smaller (up to several kilometres radius), handover between different cells will happen. When the receiver works in time slicing mode, it can measure the signal SNR value in the off burst time and eventually perform soft handover [5]. Thus the time slicing mode makes seamless soft handover possible for single antenna DVB-H reception.

3. Simulation And Results

No field test data on time slicing in DVB-H is available at the moment so simulation is used to illustrate the benefits of time slicing and analyse the performance of the time slicing scheme in DVB-H. The focus is on a performance comparison between time slicing and continuous transmission. Handover support in DVB-H using time slicing is not considered in this paper.

Two different network scenarios for DVB-H networks were set up in OPNET Modeler software [6]. One is continuous transmission mode shown in Fig. 5 and the other is time slicing transmission mode shown in Fig.6. A custom MAC node containing the time slicing algorithm was implemented in OPNET. UDP was used as the transport layer protocol. The CPU utilization statistics were used to approximate the power consumption characteristics of the receiver front-end. Although the CPU utilization statistics cannot accurately estimate the consumed front-end battery power, they can tell us roughly how much amount power saving can be achieved.

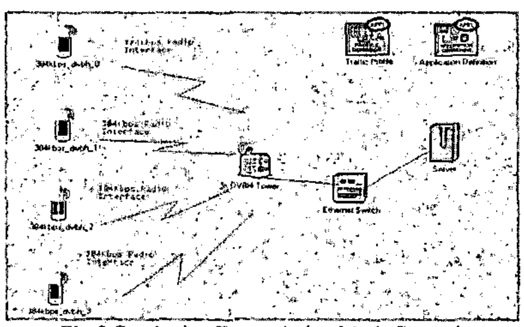

Fig.5 Continuing Transmission Mode Scenario

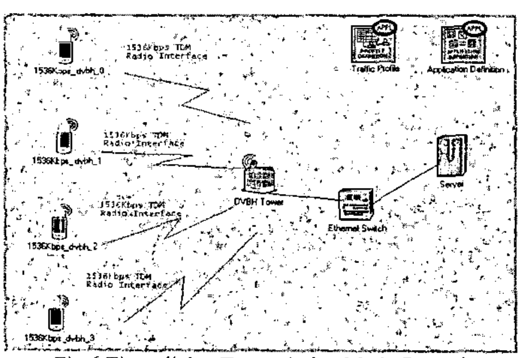

Fig.6 Time slicing Transmission Mode Scenario

384 kbps is the bit rate that can provide good quality of service to handheld PDAs [3]. Suppose there are four different services transmitted in both of the network scenarios and that each service stream has a 384 Kbps bit rate. The basic simulation parameters are chosen from DVB standards and are shown in Table 1.

Table 1. Basic Simulation Parameters

Transmission Mode	Continuation	Time-slice
Bit rate (Kbps)	384	1536
Transmission Frequency	606	606
Bandwidth (MHz)	5	5
Modulation	OFDM	OFDM
Application	Ftp Download	Ftp Download
Transmission Power(W)	100	100
Simulation Time (h)	1	1

In Fig.5, the transmission is in continuous transmission mode. Each receiver will receive an effective bit rate of 384 Kbps and the the other 1152 Kbps of unwanted traffic. Thus each receiver will receive 1536 Kbps in total of which three quarters is unwanted traffic.

In Fig.6, the transmission is in time slicing mode. In this situation, each receiver will receive 1536 Kbps burst traffic. The DVB-H transmission station transmits the four different service streams using Time Division Multiplexing (TDM). The same ftp download datacast [7] application is implemented in the two different network scenarios to compare the performance of the two transmission modes. The ftp application is a 5 Mbytes size file downloaded repeatedly. In order to mimic the time slicing mode, we divide the ftp application file into blocks, each of which can be transmitted in a single burst. The blocks are then transmitted successively in a particular time slot in a cycle. If the file is split into m blocks, the file is retransmtted every m cycles. After 1 hour's simulation duration, we get the simulation results shown in the following figures.

Fig.7 shows the receiver throughput. We can see that in time slicing mode the receiver receives much higher bit rate traffic at times that correspond to the relevant burst times, but receives much lower bit rates traffic the rest of the time which corresponds to the off burst time. The reason that the receiver is still receiving traffic in the off burst time in Fig. 7 is that in the simulation the receiver communicates with the service using signalling information. In reality, this will not happen and is included in the simulation because Opnet requires it for the simulation to be generated. This does not interfer with from the purpose of the simulation that is to show the order of magnitude of the power saving achieved by time slicing. While in continuous transmission mode the receiver receives low bit rate traffic continually.

Fig.8 shows the average radio receiver utilization. The receiver utilization characteristic is an indicator of how much of the effective bandwidth of the receiver is utilized during the period of the simulation. We can see that the time slicing mode makes much better utilization of the effective bandwidth of the receiver than the continuing transmission mode. The receiving efficiency in time-slicing mode is about 50% better on average than in the continuous transmission mode.

Fig.9 shows the average CPU utilization by the receiver. We see that the time slicing mode can save about 25% of CPU power in this case.

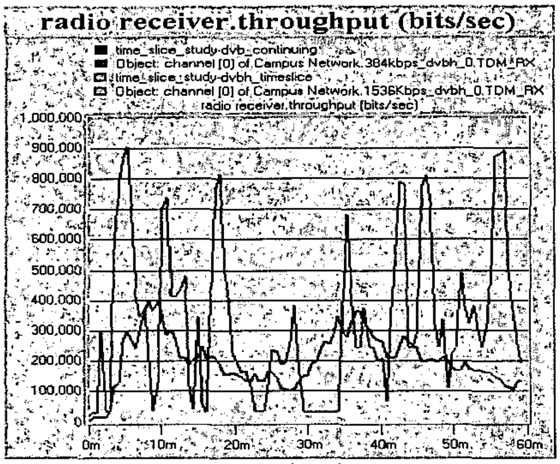

Fig.7 Radio Receiver Throughput

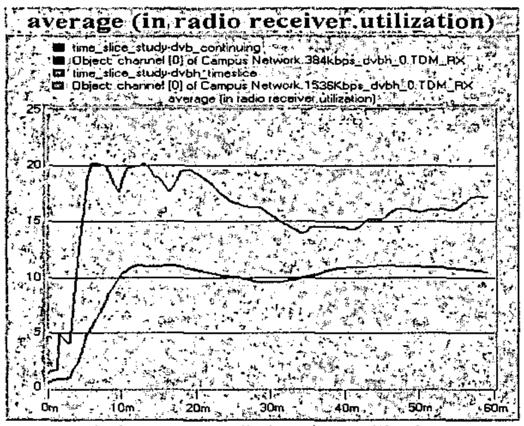

Fig.8 Average Radio Receiver Utilization

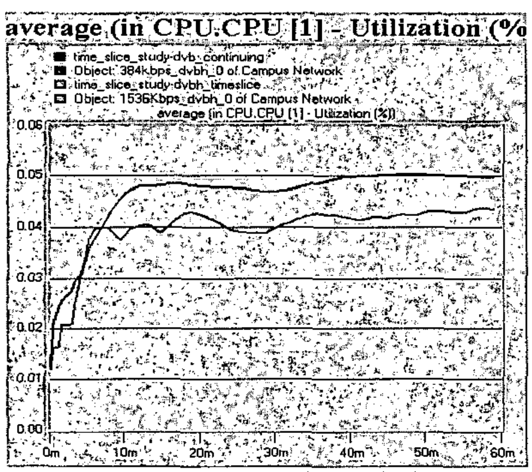

Fig.9 Average Receiver CPU Utilization

4. Conclusions

Broadcast services can give low cost connections from one transmitter to many receivers.

DVB-H is a low cost way to broadcast both low definition television programs and novel IP data services to portable and mobile devices with small integral antennas. With the switch off of analogue television broadcasting in the near future, digital broadcasting to mobile receivers will be a key player in the future wireless consumer market. It is estimated that 90% of the population in Finland will adopt a DVB-H device within the next 16 years [8] so the study of DVB-H is very important and urgent.

In light of the fact that mobile portable handheld devices could not until recently be used to receive lengthy good quality video simply because it consumed too much battery power the time slicing scheme is proposed to save battery power.

In this paper, a performance analysis through simulation of the time slicing scheme for DVB-H networks is reported. Although only 4 service programs are used in the simulation, the simulation reveals the much better performance of time slicing compared with traditional continuous transmission in terms of the power demands it places on the receiver.

Because DVB-H channels do not require as much bandwidth as traditional television channels, it is possible to broadcast many more channels within a multiplex reserved for DVB-H than within a multiplex reserved for DVB-T.

Further simulations, laboratory tests and field trials need to be done to prove the time slicing scheme and new algorithms need to be developed for transmission management.

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