MOBILE3DTV

Characteristics of DVB-H typical errors

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Characteristics of DVB-H typical errors

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Abstract: The goal for this deliverable is to study real and simulated communication channels and different error traces for different channels to be used in simulation of transmitted video content.

Keywords: Error characteristics, simulation

Executive Summary

DVB-H is an extension of the European terrestrial digital TV standard, Digital Video Broadcast—Terrestrial (DVB-T), to reach handheld devices. However, there are several differences. DVB-H employs a discontinuous transmission technique based on time-slicing, where data is periodically sent in bursts. If one burst is lost, the video stream is interrupted until the next burst is received. The degradation in video quality due to these loses depends on the amount of IP data transmitted in the burst and the data rate of the video stream. This cycle is different for the transmission of monoscopic and stereoscopic video because of the data rate. In this report, the aim is to study how the quality degrades as a consequence of transmission losses and the effects of system parameters. We first give a brief overview of the DVB-H as a transmission system, and then talk about the real and simulated communication channels including the required hardware and software components. These tools enable us to study typical transmission errors and the effects of system parameters on these errors. Several examples are given in the document. We finalize the report by introducing ideas for more robust transmission over DVB-H.

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1. Introduction

Digital Video Broadcast - Handheld (DVB-H) is an extension of the European terrestrial digital TV standard, Digital Video Broadcast—Terrestrial (DVB-T) [1]. There are crucial differences under which these two standards operate: 1) Mobility is an additional requirement for DVB-H transmission. Access to services should be possible at all indoor/outdoor locations and while moving in a vehicle at high speed. This requires installation of new transmitters and repeaters. 2) More severe propagation conditions for DVB-H, due to the scenarios such as indoor usage or moving vehicles. 3) Seamless transition in signal reception from adjacent DVB-H cells. The handover between adjacent DVB-H radio cells shall not be perceived when moving over larger distances.

The additional constraints for DVB-H compared to its predecessor DVB-T impose new error characteristics of the channel and the respective handheld (terminal) devices. First of all, fast varying channels employing burst-type of transmission are very error-prone. This results in receiving only a part of the burst. The situation is worsened by the fact that antennas built into handheld devices have limited dimensions and cannot be pointed at the transmitter if the terminal is in motion. Also interference from GSM mobile radio signals transmitted and received within the same device can impede the reception. Furthermore, if additional transmitters and repeaters are not installed, DVB-H networks will initially provide only partial coverage of the service area. Hence, mobile terminals can miss the entire burst. As a result, accessing a downstream of several Mbit/s with handheld terminals is a very demanding task.

In the following sections, we first give a brief overview of the DVB-H as a transmission system, and then review the tools used for simulating the wireless channel errors and compare these with real error traces. We conclude the report by introducing ideas for more robust transmission over DVB-H.

2. DVB-H as a transmission system

In a DVB-H system (Figure 1 and Figure 2), the audiovisual content is passed to the link layer in Internet Protocol (IP) datagrams. The datagrams are encapsulated column-wise into an Multiprotocol Encapsulation – Forward Error Correction (MPE-FEC) frame, the size of which can be selected in a flexible manner. The encoding of the MPE-FEC frame using a Reed-Solomon (RS) code is performed row-wise, which results in an interleaving scheme referred to as virtual time interleaving [2]. By varying the amount of application data columns and RS data columns, different code rates can be achieved. For transmission, the MPE-FEC frame is divided into sections. An IP datagram forms the payload of an MPE section and an RS redundancy column forms the payload of an MPE-FEC section. The MPE sections are transmitted first, followed by the MPE-FEC sections. Both of them are transmitted in MPEG-2 transport stream (TS) format [2].

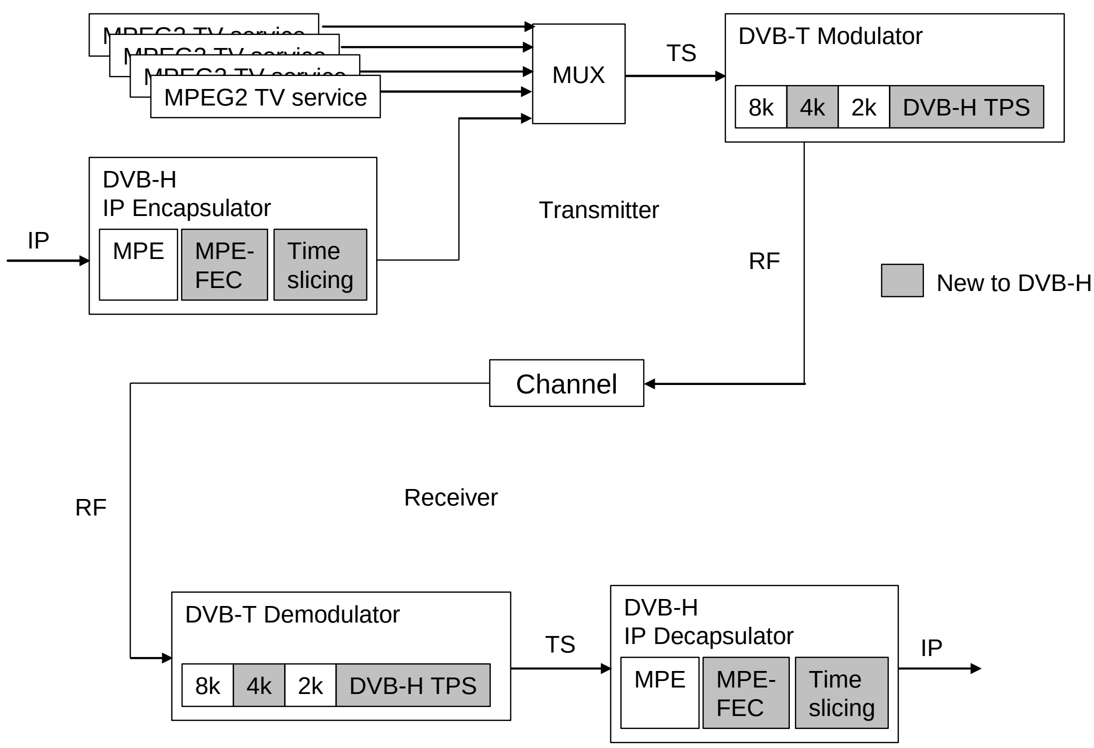

Figure 1. DVB-H link and physical layers

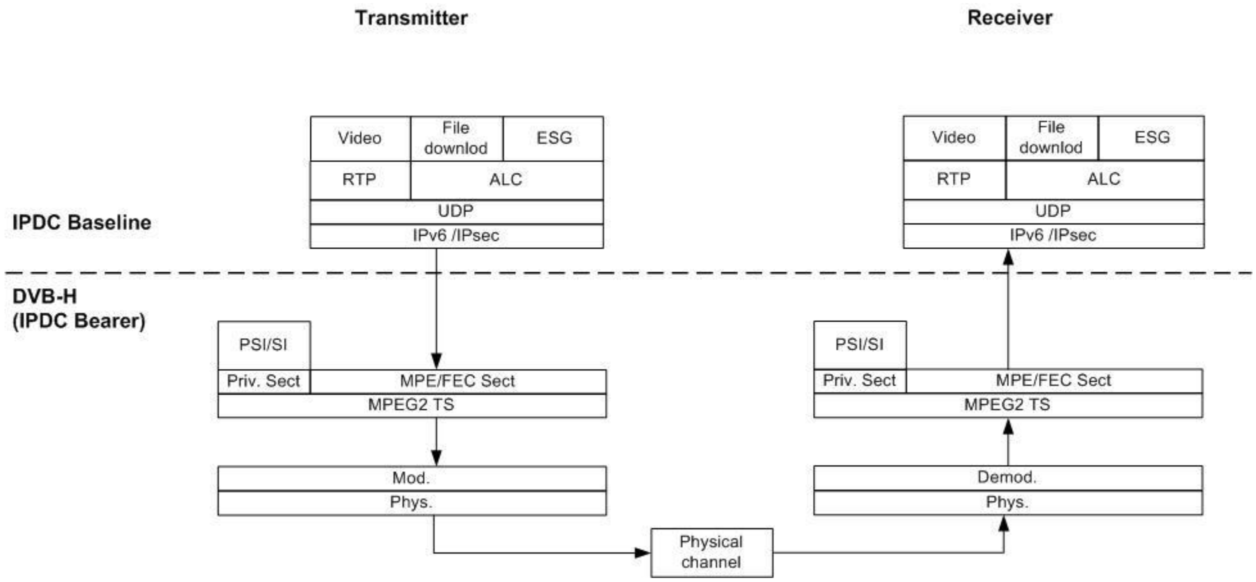

Figure 2. DVB-H protocol stack

Time-slicing is applied to enable power saving, so that one MPE-FEC frame is transmitted in one time-slice burst. The TS bit rate during the burst is significantly higher than the service bit rate and the receiver can turn off its radio parts between the bursts to save power. The frame size, transmission bit rate and off-time between bursts are parameters that affect the video bit rate, service switching time and power saving. In addition to the link layer, there are a set of physical layer parameters, such as modulation, code rate, guard interval length, OFDM mode as shown in Table 1. With such a large set of options, simulations are usually the most efficient way to find the optimal parameter combinations for robust transmission.

Parameter	**Options**	**Explanation**
Modulation	3	QPSK, 16QAM, 64QAM
FFT-size	3	2K, 4K, 8K
In-depth interleaver	2	On / Off (only for 2K and 4K)
Guard Interval	4	1/4, 1/8, 1/16, 1/32

Convolutional code rate	5	1/2, 2/3, 3/4, 5/6, 7/8
MPE-FEC code rate	6	1/2, 2/3, 3/4, 5/6, 7/8, 1 (= no FEC)
Burst size	4	256, 512, 768, 1024 rows
Burst bit rate	2	
Number of combinations	14400	

Table 1. DVB-H Parameters [11]

3. Simulating Wireless Errors

3.1. Real Error Traces

Obtaining accurate and various real error traces is important since link layer simulation models are derived based on the traces as well as the traces can be used directly for simulation. The real error traces can be obtained in two ways: Either by using a hardware channel simulator and noise generator or by directly recording field measurements. Experiments to obtain error traces by the two methods have been performed in previous projects [6]. For field measurements, an experimental system has been set up in Tampere University of Technology (TUT).

3.1.1. Traces from Previous Projects

The CELTIC-WINGTV project [6] has addressed TV services to handheld terminals. In this project, error traces have been generated using a hardware channel simulator provided by Nokia. Its setup is shown in Figure 3 [7]. It uses six-tap Typical Urban radio channel model (TU6), developed by the COST 207 project [8]..

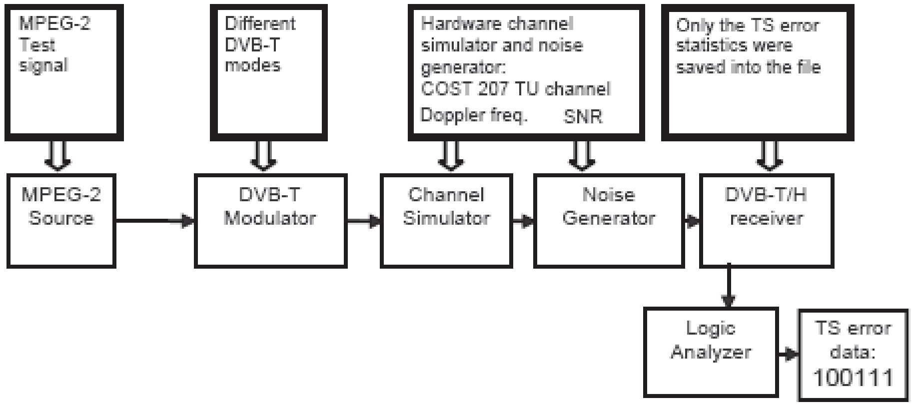

Figure 3. Measurement setup for obtaining TS packet error traces [7]

The TU6 model has proven inefficient for modelling some DVB-H use cases; particularly pedestrian use cases and has been extended by new models covering pedestrian indoor, pedestrian outdoor, vehicular urban and motorway use cases [9]. In Ref. [9], it is concluded that the use of MPE-FEC at the link layer is not needed in the pedestrian use cases.

Within the same project, it is also reported that DVB-H field measurement campaign has been performed in the city centre of the Hague (Netherlands) [10]. A DVB-H receiver and a GPS receiver were used to record synchronized reception information. In this case the measurements consisted of synchronized RSSI (Received Signal Strength Indicator), terminal position and speed, and MPEG-2 Transport Stream (TS) packet error information at the DVB-H physical layer (sampling interval 100 ms and measurement time 6 minutes). The receiver antenna was placed inside a vehicle. In Figure 4 and Figure 5, example field measurement results can be seen.

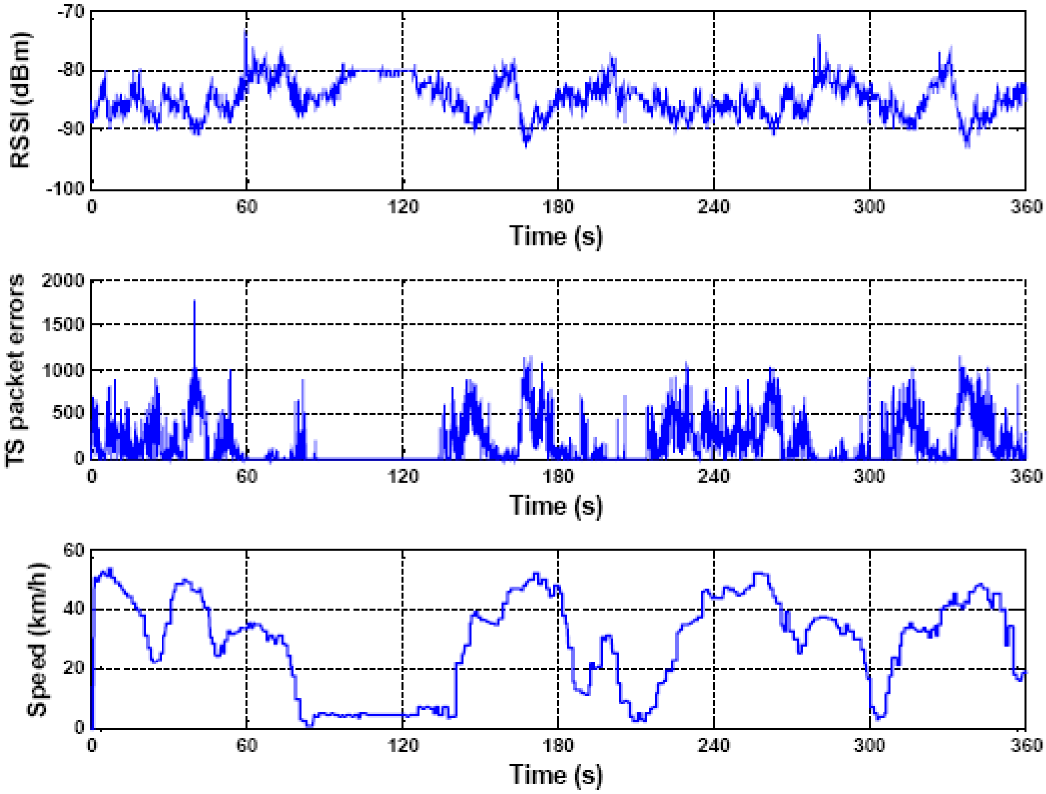

Figure 4. Example data of DVB-H field measurement [10]

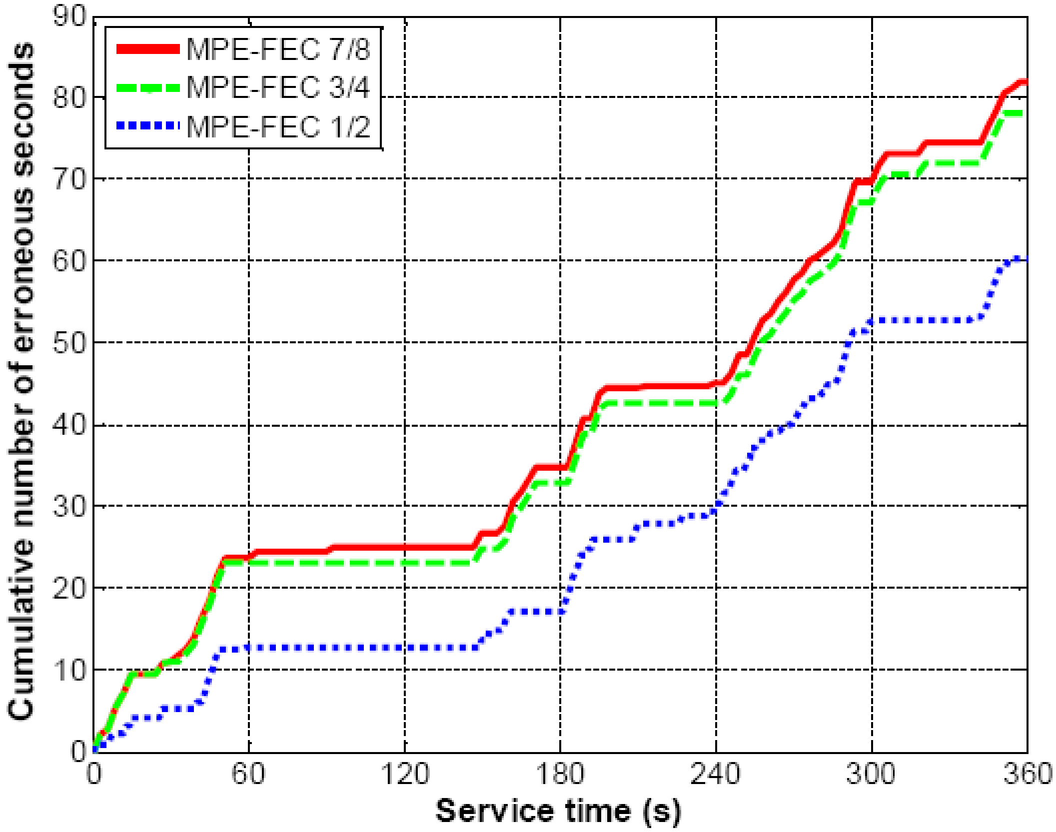

Figure 5. Cumulative number of erroneous seconds for a 256 kb/s streaming service across the measured trajectory with respect various MPE-FEC rates. [10]

3.1.2. DVB-H Test bed at TUT

Tampere University of Technology has built a fully-operational DVB-H broadcasting channel. By transmitting suitable test streams and recording them with a portable receiver, it is possible to collect real-life transmission error traces covering various different mobile use cases. Further, we provide a description of the broadcasting system and its use for recording real error traces.

The mobile TV broadcast test bed in TUT consists of real-time encoder, playout system, transmitter, antenna system and various receivers. The encoder is employed to create MPEG-4/H.264 coded A/V content for mobile devices. The playout server performs the DVB-H specific IP encapsulation and creates the MPEG-2 Transport Stream for broadcast transmission. The transmitter contains an exciter unit to form DVB signal, and two 50W power amplifiers. The system includes channel filters to guarantee clean signal for the emission. The antenna system is located on the roof 25 metres above the ground level. It consists of vertically polarized bi- and omni-directional antennas, which horizontal and vertical position can be adjusted to examine radio propagation effects with various antenna settings. The DVB-H system components are illustrated in

Figure 6.

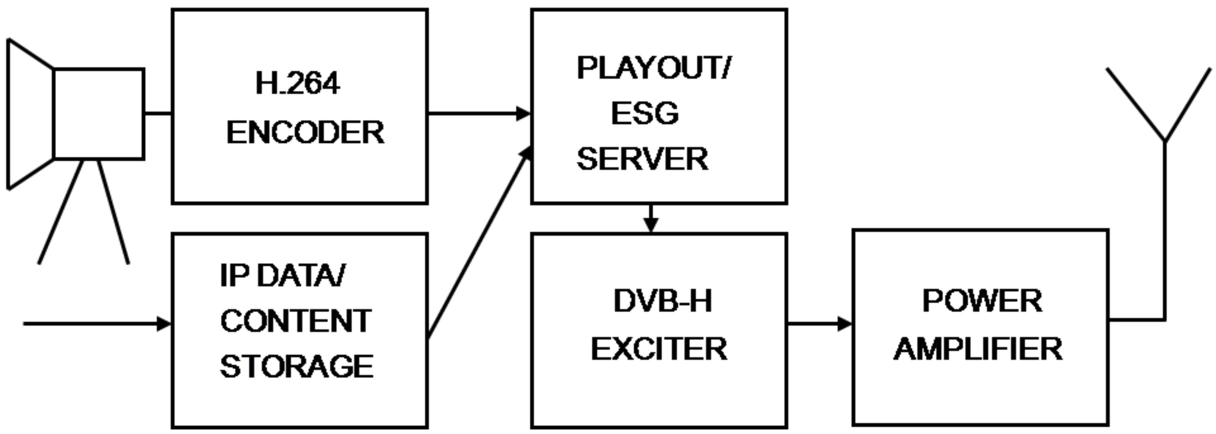

Figure 6. TUT DVB transmitter system components

For testing delivery and use of services, own development environment has been set up. It consists of Linux and Windows laptops equipped with PC card and USB stick DVB receivers. Commercial multimedia phones equipped with DVB-H receiver, Nokia N77 and N92, are used to verify the functionality of the conventional video backward compatible broadcasted services and to evaluate the quality of the reception by cognitive perception.

The playout system is used for generating the MPEG-2 Transport Stream which is fed to the transmitter. The TUT playout system is provided by Cardinal Information Systems Ltd, a company headquartered in Helsinki, Finland. The version is called 'Playout Compact for DVB-H'. The version name refers that the system is primarily meant for DVB-H broadcast, but the use of DVB-T streams is possible, too. The essential property of the server for DVB-H is content encapsulation in IP packets, which means that the playout system encapsulates the content IP/AV streams into Multi-Protocol Encapsulation (MPE) stream and then into the MPEG-2 Transport Stream packets. The playout system generates also other DVB-H features such as MPE-FEC and Time-Slicing.

The playout server provides five basic properties to fulfil the DVB usage scenarios:

- DVB Services

- IP Platforms for DVB-H
- IP source repository
- FLUTE carousel repository
- TS recording repository.

The DVB Services section lists all DVB-T/H services to be broadcasted, classified by the service provider and service type. For a service its component MPE streams can be assigned. With each service its IP/MAC Notification Table (INT) in the PSI/SI is declared.

In the IP Platforms all the IP/AV streams created for the DVB-H service content are divided into platforms. MPE streams with transport stream PIDs are defined for each platform and multicast addresses for encapsulated IP streams are selected for each MPE stream.

The IP source repository receives real-time IP sources and contains MPEG-4 files. These are used as the content of the DVB-H services. The sources are attached to services and platforms as desired for the playout and broadcast.

The FLUTE carousel repository contains file carousels for sending files through FLUTE protocol. These files may be image and application files or even XML files for self-created ESG content. The carousel is attached to a desired platform for sending the files.

The TS recording repository contains pre-recorded Transport Stream files, both DVB-T and DVB-H. One full TS dump can be played at a time, this eliminates the playout of all other services. It is also possible to record a TS dump of the services, which are running on the playout system.

The system creates PSI/SI tables based on the running playout configuration and makes possible modifications to the tables if needed. For instance, some receivers may require parameters, which are not included in the automatically created parameter set.

The system contains also an ESG server, which automatically creates the ESG data including some modification options, like scheduling of the services. The ESG server supports CBMS [16], OMA BCAST [17] and OAI [18] specifications and the desired ESG format can be selected.

If needed for testing or simulation purposes, the ESG server can be shut down and the self-created ESG data can be fed using the FLUTE carousel of the system or real-time IP source.

The exciter unit contains encoder, precorrector, modulator and synthesizer for the signal generation. It is equipped with operating and monitoring software installed on a PC, which is connected to the exciter through a serial interface. The software provides the full control of the exciter properties and transmission parameter modifications. The essential parameters are IFFT length of 2k, 4k and 8k mode; guard interval with values ¼, 1/8, 1/16 and 1/32; code rate with values ½, 2/3, ¾, 5/6 and 7/8; and modulation constellations QPSK, 16-QAM and 64-QAM. For the DVB-H signalling properties, Transmission Parameter Signalling (TPS) bits can be modified to signal if the DVB-H mode is on, whether the interleaver is native or in-depth, and the existence of time-slicing and MPE-FEC.

The playout/transmitter system described above can be used both for creating Transport Streams for simulations and for performing field trials. The transmitter system is used primarily for field measurements to compare the results of the simulations in respective real environments.

Based on the experiences in field trials, it should be noted that the results of the experiments may differ from the simulated ones because of the complexity of real environments. The reasons for possible differences will be analyzed when comparing the results.

3.2. Application Layer Simulation Environment

Application layer transmission simulations are performed using a software environment that comprises of programs for generating and decoding time-sliced, DVB-H compatible Transport Streams (Figure 7). This software system enables the conversion of any pre-recorded TS level error traces to IP packet level traces using the desired link layer error protection scheme, e.g. MPE-FEC code rates can be adapted. It is also possible to make real-time transmission simulations by feeding the encapsulator with IP packets containing actual A/V data instead of dummy packets.

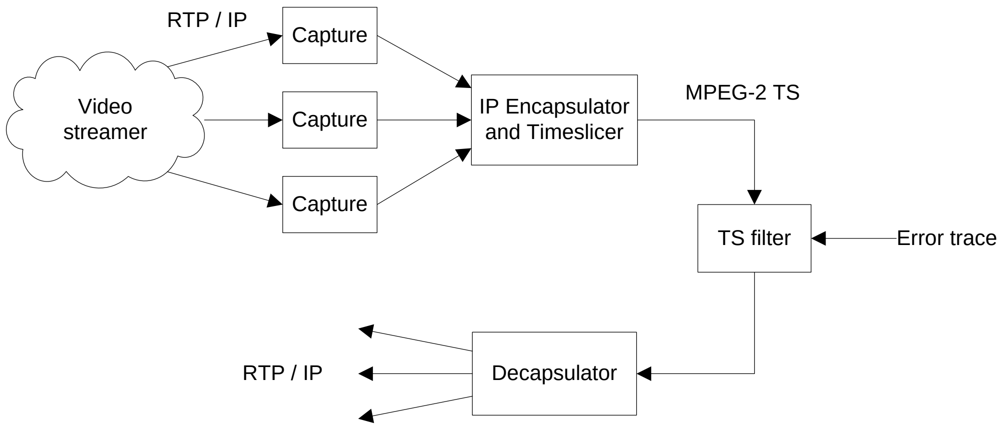

Figure 7 Software environment for simulations

3.3. Physical Channel Model

The output of physical layer modelling is the error pattern of transmitted bits, i.e. which bits are received correctly. Neither special hardware nor field measurements are required. Therefore it is simpler to obtain error traces by modelling compared to real error traces and there is no limitation on the length of error trace.

In FP6 SUIT project [1] the error characteristics of DVB-H have been investigated based on modelling the DVB-H physical layer and error traces are published [4]. Error traces include bit error and packet error patterns for Native 2k and 4k modes, 60 and 140 km/h velocities and {20,25,30,35,40,45} dB SNR values. The error traces have been generated using 64QAM-3/4, FFT size of 2048, speed of 60 kmph and 140 kmph [5].

Another physical layer simulator has been developed in [21]. It simulates various physical channel models by COST 207 [8], JTC [15] and Wing-TV [9]. The models are named according to environment: Typical Urban, Bad Urban, Rural Area and Hilly Terrain. These COST 207 models are widely used, for instance, in DVB-T network modelling. The mobile nature of DVB-H requires even more elaborated models. JTC and Wing-TV have defined models for mobile environment. These are Indoor Commercial and Outdoor Residential by JTC, and Portable Indoor (PI), Portable Outdoor (PO), Vehicular Urban and Motorway by Wing-TV. PI and PO channel models are accepted as part of DVB-H Implementation Guidelines [20]. All these models are Tapped Delay Line (TDL) models with Doppler spectrum, amplitude distribution, power and delay value specified for each tap.

3.4. Link layer simulation

A link layer simulator can be employed instead of measured error traces or a physical layer simulator. Link layer simulation has several advantages as indicated in [7]. The required memory and data storage capacity is reduced considerably compared to using measured error traces in simulations. Also, as finite-state models are generative by nature, they produce random, but statistically consistent output data. Moreover, the lengths of the output traces are not limited by the lengths of the original measurements used in evaluating model parameters. Comparing to physical layer simulation, link layer simulation is less complex since the physical layer simulator needs to simulate error of each bit and derive the corresponding link layer error trace. However, it should be noted that the aforementioned advantages are valid as long as the link layer simulator models the error patterns with adequate accuracy. The CELTIC-WINGTV project has addressed the link layer modelling for simulation [11]. We briefly review their results and comment on how they can be used for our goals.

3.4.1. Finite-state models for simulating link layer error performance

To model the channel, block error model is preferred to bit-level error model as it is not required to know the bit-level error behavior at IP or TS (Transport Stream) levels. Three finite-state Markov models are considered together with memoryless channel model. The Markov models are as follows: Two state Markov Model [12], Markov-based trace analysis algorithm (MTA) [13] and four state run length model [14]. Channel models are compared to measurement results. Criteria for assessing the packet channel models are TS Packet Error Rate (PER), Average Burst Error Length (ABEL), and Variance in Burst Error Length (VBEL).

Memoryless channel model: This model assumes that the TS packets experience independent and identical channel behavior.

Two state Markov Model: This model is proposed to better model the error bursts [12].

Markov-based trace analysis algorithm: This model [13] is a hierarchical two state Markov model that takes into account the need for time-variant finite-state model parameters. Finding the parameter values for this model is considerably more complicated than with the two state Markov model, and the PER and ABEL are not reproduced as accurately as with the simpler model, but the variance in burst error length is better reproduced than with the two state model.

Four state run length model: The principle of the four state run length model [14] is to directly estimate the good and bad state length distribution functions of measured error traces. Thus accurate function approximation is the main problem.

3.4.2. Modeling Results

Comparison of PER, ABEL and VBEL values for measurements and the models are shown in

Table 2. It has been shown in [11] that the VBEL parameter is a very important parameter to achieve closest MPE-FEC Frame Error Ratio (FER) with the measured data. It has been reported that the four state model having the closest VBEL match achieves very similar error statistics with the measured data and the FER values of the method and the measured data are close.

	PER	ABEL	VBEL
Measurements	0.029	14.187	1088
Memoryless model	0.029	1.028	0.0290
Two state model	0.029	14.251	185
MTA	0.031	16.079	483
Four state model	0.030	11.605	816

Table 2. Model output statistics comparison [11]

4. Conclusion

In this report, we have given a summary of the studies related to obtaining both real and simulated error traces for DVB-H. With a large set of DVB-H tuneable parameters, system simulations are usually the most efficient way to find the optimal parameter combinations for robust transmission. In the ideal case, simulations should agree perfectly with testbed measurements. However, there are issues which make this matching a nontrivial problem. The first issue is related with the variability of radio field which is changing in time and from place to place in non-line-of-sight conditions. Therefore, reliable confirmation of small differences, like 1dB improvement due to MPE-FEC settings, becomes a difficult task. The second issue is that receivers tend to be nonlinear and have thresholds of activity, near the thresholds their operation looks like unstable because signal levels change. A way of dealing with those problems is to collect statistically sufficient collection of data but this requires large number of measurements in the field which will be targeted within the project.

Based on the experiments on real physical channel with the TUT system, it has been observed that a combination of simpler parameters, e.g. QPSK, code rate ½, guard interval 1/8, results in better penetration through physical channel and better reception in demanding conditions. In this project, the physical channel experiments will be focused on the effects of MPE-FEC. Frame Error Rate (FER) and FER after MPE-FEC (MFER) will be measured with a DVB-H receiver (Dibcom) equipped with measurement software.

We will study other error protection mechanisms such as application-layer FEC by trading system capacity and streaming delay for improved user satisfaction also considering power consumption issues.

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Mobile 3DTV Content Delivery Optimization over DVB-H System

MOBILE3DTV

MOBILE3DTV - Mobile 3DTV Content Delivery Optimization over DVB-H System - is a three-year project which started in January 2008. The project is partly funded by the European Union 7th RTD Framework Programme in the context of the Information & Communication Technology (ICT) Cooperation Theme.

The main objective of MOBILE3DTV is to demonstrate the viability of the new technology of mobile 3DTV. The project develops a technology demonstration system for the creation and coding of 3D video content, its delivery over DVB-H and display on a mobile device, equipped with an auto-stereoscopic display.

The MOBILE3DTV consortium is formed by three universities, a public research institute and two SMEs from Finland, Germany, Turkey, and Bulgaria. Partners span diverse yet complementary expertise in the areas of 3D content creation and coding, error resilient transmission, user studies, visual quality enhancement and project management.

For further information about the project, please visit **www.mobile3dtv.eu**.

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MM Solutions Ltd.
Design of prototype terminal device
BULGARIA

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