A DVB-H Testbed for Wireless Billboard Channel Simulation

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Abstract

This paper describes the design and implementation of a digital video broadcasting – handheld (DVB-H) physical-layer testbed simulator. The objective is to simulate the broadcasting of service advertisements' over the newly defined wireless billboard channels (WBCs). Initial performance evaluation results obtained from the testbed are provided and discussed.

1. Introduction

Wireless billboard channels (WBCs) [1] are new broadcast advertisement channels which will operate in a near-transparent non-intrusive manner providing mobile users with relevant data about wireless services they may wish to access. They were conceived as a key infrastructural component of the newly emerging ubiquitous consumer wireless world (UCWW) which will realize a consumer-centric business model (CBM) for mobile communications [2-3]. Their primary goal is to facilitate the advertisement, discovery and association (ADA) of wireless access network services and teleservices by mobile consumer users in the UCWW. While the concept and design have been driven by the needs of the UCWW environment, they can of course be employed effectively and beneficially in existing subscriber based wireless world, replacing the present unsolicited and intrusive SMS based advertisements.

WBCs are defined as simplex, unidirectional, narrowband and broadcast channels, which are solely used to 'push' (wireless) service advertisements simultaneously to a large number of mobile users (MUs). This is done as a background non-intrusive service with client applications on users handhelds extracting the advertised service details in accordance with user-composed profiles, i.e., garnering only that user-desired data and presenting it to the user at a time and ina manner of the user's choosing (according, that is, to the user's profile settings).

There are a number of carrier technologies suitable for WBCs, such as the digital audio broadcast (DAB), digital radio mondiale (DRM), digital video broadcast - handheld (DVB-H), multimedia broadcast / multicast service (MBMS), etc. The IP datacasting (IPDC) over DVB-H [4] is a new standard which enables distribution of digital content to mass audiences. As commercial DVB-H services have already been rolled out, the 'WBC over DVB-H' seems an attractive WBC solution. The DVB-H network operator(s) can combine the WBC service with other DVB-H services (e.g. TV) for sharing the same channel.

Following a brief introduction the structure of a 'WBC over DVB-H' physical-layer testbed simulator compliant, where appropriate, with the ETSI DVB-T standard (Section II), the main part of the paper sets out the core transmitter, channel and receiver elements of the simulator (Section III). Some performance evaluation results are presented in Section IV, followed by conclusions.

2. 'WBC over DVB-H' Physical-Layer Simulation Testbed

Based on the DVB-T ETSI-EN-300-744 standard [4], a 'WBC over DVB-H' physical-layer simulator, which will utilise a narrow band 64-kbps DVB-H sub-channel, has been designed and implemented in Matlab [5]. Figure 1 presents a block diagram schematic of the transmitter, channel and receiver components of this simulator.

Based on the number of carriers in one OFDM symbol, a DVB-H system may operate in three transmission modes, i.e., 2K mode, 4K mode, and 8K mode. Table 1 lists the parameters of these modes.

3. Testbed Design and Implementation

The main elements composing the 'WBC over DVB-H' simulator are a transmitter, a channel, and a receiver, with an error checking section which uses a transmit data loopback. The components are shown in schematic form in Figure 1 and their detail is set out in the following subsections.

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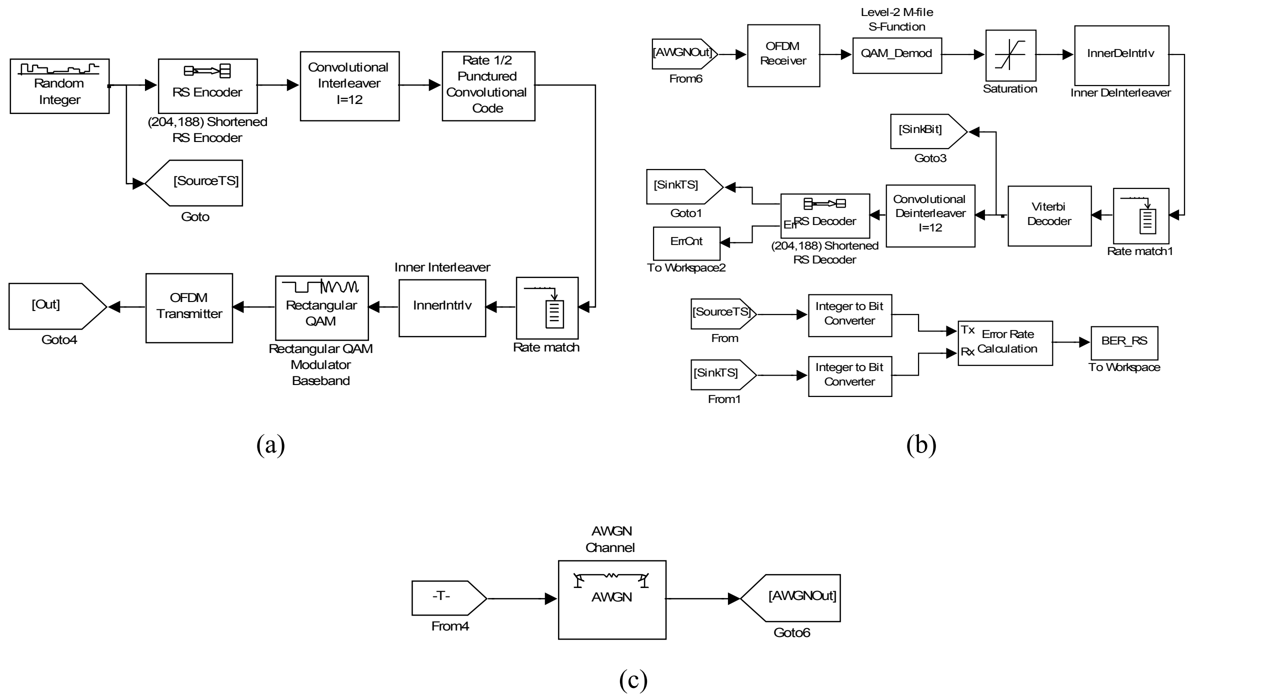


(a) (b) (c)

Figure 1: “WBC over DVB-H” Physical-Layer Simulation Testbed:

(a) Transmitter; (b) Receiver and error checking using transmit data loopback; (c) Channel;.

Table 1: The Parameters of DVB-H Transmission Modes

OFDM Parameters	2K	4K	8K
Number of carriers	2048	4096	8192
Number of modulated carriers (N_K)	1705	3409	6817
Number of useful carriers (N_{used})	1512	3024	6048
Duration of an OFDM symbol (in μs) (T_U)	224	448	896
Carriers spacing (in kHz)	4464	2232	1116
Maximum distance coverage (in km)	17	33	67

A. Transmitter

In the transmitter part the source data stream is encoded, interleaved, and modulated.

A.1 Source

As described in the DVB standard [4], the data being transmitted should be randomized. To simplify the design, a file of binary source data is first generated. This source data is logically subdivided into blocks of N_{TS} ‘transport stream’ (TS) packets. One block is transmitted per OFDM frame. Each TS packet consists of 188-bytes, i.e., equivalent to the DVB-H K-symbol messages where K is 188 and the symbols are bytes. These blocks of bytes, also denoted as source packet, $S_{packets}$, are the input blocks to the Reed-Solomon (RS) encoder.

$$S_{packet} = N_{TS} \times K \tag{1}$$

The N_{ts} is defined:

$$N_{TS} = SR \times [T_U \times (1 + cf)] \times N_{OFDM} / K \tag{2}$$

where SR is the WBC data broadcasting source rate; T_U is the duration of an OFDM symbol; *cf* is the expansion fraction arising from applying error protection coding (the cyclical prefix to encoder source block ratio); N_{OFDM} is the number of OFDM symbols per OFDM frame.

A.2 Encoders and Interleavers

In the *outer RS encoder module*, for every N_{TS} *K*-symbol message word, a Galois field array is created and then encoded using an *(N,K)* RS encoder. The output is N_{TS} *N*-symbol codewords (*N* = 204 bytes).

In the *outer interleaver module*, the above codewords are first *reshaped* to a 1 by $N_{TS} \times N$ array. The array is then permuted by shift registers with $I_{row} = 12$ and register length-step $N_{slope} = 204/12 = 17$.

In the *convolutional coder module*, the above output is encoded by a binary convolutional encoder with constraint length of 7. For this the Matlab function for converting convolutional code polynomials to trellis descriptions poly2trellis may be used, viz. here *poly2trellis(7,[177 133])*. The output is punctured by corresponding convolutional code rates CR (1/2, 2/3, 3/4, 5/6, or 7/8).

In the *inner interleaving module*, the above output is first padded to $(N_{used}/CR) x N_{OFDM}$ bits. N_{used} is the number of useful carriers and *CR* is the convolutional code rate.

A.3 Modulator

The output from the symbol interleaver section is modulated using either QPSK, 16-QAM or 64-QAM constellations. It includes symbol mapping and power normalization modules. After merging the pilot and NULL sub-carrier, the output is sent to an Inverse Discrete Fourier Transform (IDFT) algorithm to transform the signal from the frequency domain into the time domain. At the end, a cyclical prefix (CP) is added to the output and an OFDM frame is generated ready for broadcasting over the channel.

B. Channel

The Matlab communication block sets offers a variety of channel, e.g., 'additive white Gaussian noise (AWGN)' and Rayleigh channel models. Here we just use an AWGN channel. In functional form it is written: *OFDM_Out =awgn(OFDM_in, SNR).* It simply adds white Gaussian noise to the input *OFDM_in* so that the signal to noise ratio of the output OFDM_out is at 'SNR' in the functions argument. In the DVB-H physical-layer simulation testbed, the *OFDM_in* is a complex array, so that the *AWGN* function to add the appropriate complex noise is used.

C. Receiver

The receiver part of the simulator is used to extract the source data from the received signal. It runs in reverse mode to that of the transmitter, and includes two blocks - a demodulation block and a de-interleaving and decoding block. The demodulation block includes a *CP removing* module, an *OFDM demodulation* module, a *remove NULL sub-carrier* module, a *sub-carrier demapping* module, and a *channel estimation and decision* module.

The de-interleaving and decoding block includes an *inner de-interleaving* module, a *frame generating* module, an *convolutional decoder* module, an *outer de-interleaver* module, and an *outer RS decoder* module. The output is N_{TS} TS packets

4. Performance Evaluation

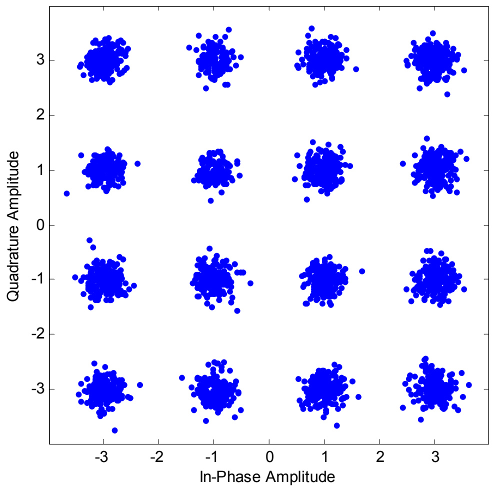
The parameters used for the DVB-H performance evaluation are: Mode, 4K; Modulation Type, 16 QAM; Convolutional code rate, 1/2; Guard interval, 1/4; RF, 700MHz; Bandwidth, 8MHz; Number of continual pilot carriers, 89; Number of TPS carriers, 34; Outer interleaver's parameters 12x17.

Figure 2 shows the discrete time scatter plot scope in the AWGN channel. When more noise is added, the signal constellation from the DVB-H receiver becomes distorted.

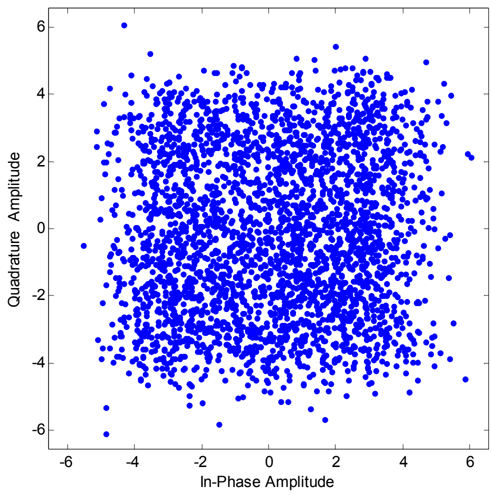
The byte error rate and the TS packet error rate (TSPER) are shown as functions of the signal-to-noise ratio (SNR) in Figure 3. The performance results suggest that the 4K mode can be employed successfully with the parameters values specified in Table 2, if the SNR ≥ 6.2 dB.

5. Conclusion

This paper has described the design and implementation of a physical-layer testbed for operational probing and testing of wireless billboard channels (WBCs) established over the digital video broadcasting - handheld (DVB-H) standard. The testbed can be used for performance evaluation and comparison of the three DVB-H transmission modes, e.g. for experimenting with different sets of operational parameters values in different communication scenarios.



(a)



(b)

Figure 2: The Discrete Time Scatter Plot Scope: (a) SNR=16 dB, (b) SNR=5 dB.

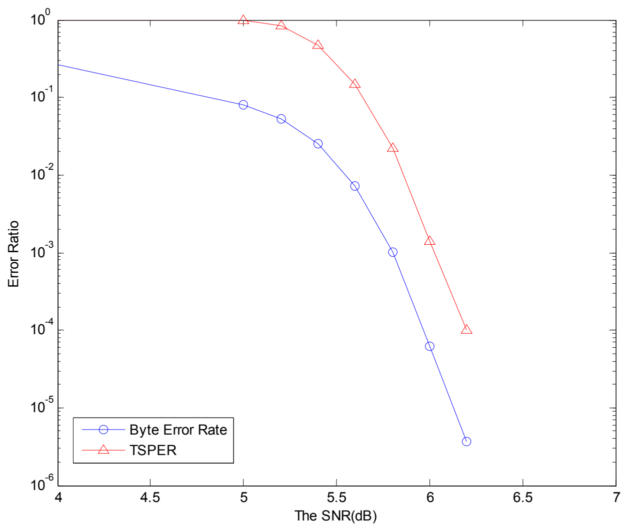


Figure 3: The Byte Error Rate and TSPER in the 'WBC over DVB-H' AWGN Channel

6. References

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