

A Review on Terrestrial Multimedia Communication using OFDM Technology

Shweta Shah, Upena Dalal

Abstract—The development of wireless communication technologies has changed our living style in global level. After the international success of mobile telephony standards, the location and time independent voice connection has become a default method in daily telecommunications. As for today, highly advanced multimedia messaging plays a key role in value added service handling. Along with evolving data services, the need for more complex applications can be seen, including the mobile usage of broadcast technologies. Here performance of a system design for terrestrial multimedia content is examined with emphasis on mobile reception. This review paper has accommodated the understanding of physical layer role and the flavour of terrestrial channel effects on the terrestrial multimedia transmission using OFDM keeping DVB-H as benchmark standard.

Keywords—Digital Video Broadcast-Handhelds, Multimedia, OFDM, Physical Layer

I. INTRODUCTION

MOBILE TV is a method that provides the users with high channel capacity and interactivity 'on the road'.

It brings totally new aspects on the personal information handling, whether it is about leisure time with entertaining TV program clips or complicated business solutions. This interactive mobile multimedia is one of the key ideas of the next steps of multimedia era. Handheld broadcast component provided with Digital Video Broadcasting - Handheld (DVB-H) is a useful addition to the conventional cellular radio networks serving the users with point-to-point connections. Terrestrial broadcasting has brought entertainment and media information to mass audiences around the world for nearly a century. The adoption of multimedia requires a robust infrastructure that can supplement multimedia applications, regardless of whether the endpoint is a traditional PC or a mobile device. Bandwidth is an important infrastructure component because of the "real time" nature of many multimedia services. Various test marketing trials and limited deployments indicate that people enjoy watching TV broadcasts on mobile phones, which is made possible by using technology compliant with one of four Mobile TV broadcasting standards: DVB-H, DMB, ISDB-T, and MediaFLO. Of the four competing MobileTV standards, DVB-H appears to be the most popular. DVB-H is part of the DVB-IP Datacast (DVB-IPDC) set of technologies designed to deliver any type of content to mobile devices over IP when broadcast network output is reformatted for

Mobile TV reception. Fig1 shows the simplified technology for multimedia delivery.

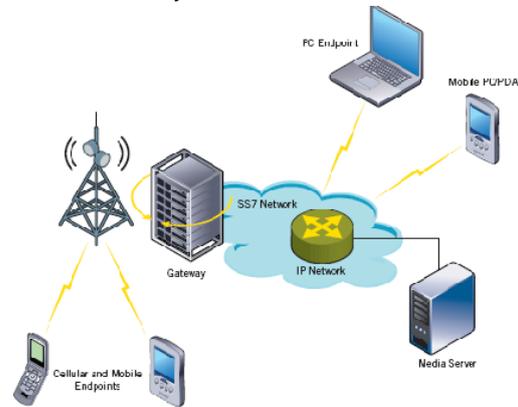


Fig. 1 Simplified technology for multimedia delivery

II. PHYSICAL LAYER

The system is defined as the functional block of equipment performing the adaptation of the baseband TV signals from the output of the MPEG-2 transport multiplexer, to the terrestrial channel characteristics. Fig2 gives general physical layer DVB block diagram keeping DVB-H as benchmark standard.

A. Transport Stream: Source Input

In order to cope with various wireless conditions, the MPEG - 2 defines two basic tools known as the Program Stream (PS) and the Transport Stream (TS). The PS focus on short distances delivery systems and have a very low error rate. The TS is used over error - prone systems such as local area networks. The TS packets are short and fixed in size (188-byte packet), in order to minimize consequences of packets loss and to be able to cope with network congestion.

B. Scrambler/Descrambler

In order to ensure the energy dispersal of binary data, a scrambler is used to randomize the input stream as shown in Fig.3. The aim of this operation is to achieve a flat power-density spectrum. The scrambler is a 16-bit Pseudo Random Binary Sequence (PRBS) with generator polynomial, $1+X^{14}+X^{15}$. The PRBS register is re-initialized at the start of every group of 8 MPEG - 2 TS packets.

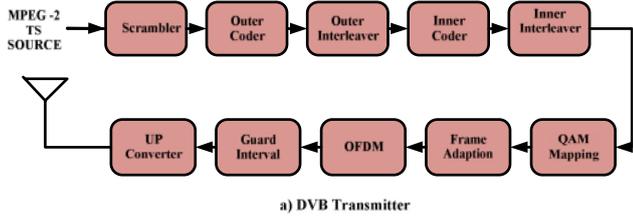
C. Outer Coder and Outer Interleaver

The outer coding and interleaving shall be performed on the input packet structure (see Fig4a). Reed-Solomon (RS) encoder is used as outer coder to generate 16-byte parity block

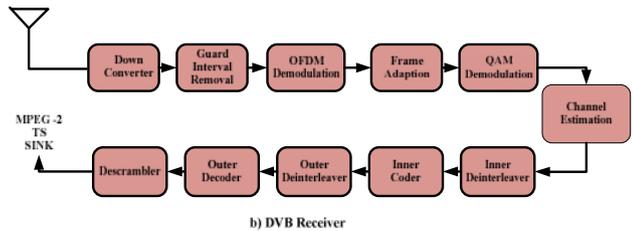
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for each randomized transport packet (188-byte) fed by the scramble.



a) DVB Transmitter



b) DVB Receiver

Fig. 2 Simplified Technology for Multimedia Delivery

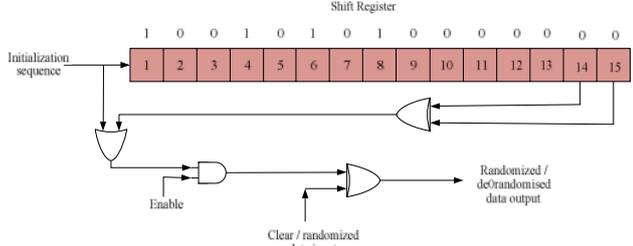
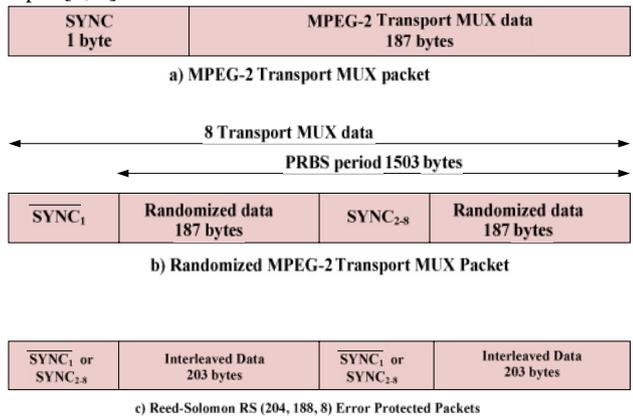
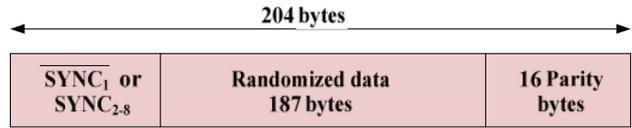


Fig. 3 Scrambler/Descrambler Schematic Diagram

In essence, 51 null bytes are intentionally added to the input randomized transport packet such that RS (255, 239, t = 8) mother code can be used. Reed-Solomon RS (204,188, t = 8) shortened code, derived from the original systematic RS (255,239, t = 8) code, shall be applied to each randomized transport packet (188 byte) of Fig4b to generate an error protected packet (see Fig4c). The null bytes are discarded after the coding procedure leading to an RS codeword of N = 204 including the 16-byte parity block appended at the end of each input [1, 9].



c) Reed-Solomon RS (204, 188, 8) Error Protected Packets



d) Data Structure after Outer Interleaver

SYNC₁: Non randomized Complemented sync byte
SYNC₂₋₈: Non Randomized sync byte, n=2, 3, ..., 8

Fig. 4 Outer Coding and Interleaving Process

D. Inner Coding

In DVB system, a mother convolutional code of rate 1/2 with 64 states is used to create a range of punctured convolutional codes. The generator polynomials of the mother convolutional codes are $G1 = X + X1 + X2 + X3$ for X output stream, and $G2 = X + X2 + X3 + X5$ for Y output stream. With mother code of rate 1/2, the input bit stream is doubled by the convolutional coder and the output is reduced by using puncturing method to provide an appropriate punctured rate such as 2/3, 3/4, 5/6, and 7/8 [1].

E. Inner Interleaver

The inner interleaver is a group of joined blocks of demultiplexer (demux), bit-interleaver, and symbol interleaver. The inner interleaver provides optimum performance at a given complexity and memory size and also, based on the modulation mapping technique the number of substreams for demux is decided. It divides input data into that many substreams and then processed by a separate bit-interleaver. The purpose of the symbol interleaver is to map bit words from bit interleaver onto the active carriers as per mode of OFDM symbol.

F. Frame Adaptation, TPS and QAM Mapping

In an OFDM-based system, a group of complex symbols are modulating with frequency carriers of the equivalent length to create an OFDM symbol. In DVB, transmitted signal is organized in frames; a frame is composed of 68 OFDM symbols, and 4 frames constitute a super-frame. Besides carrying data, OFDM symbol also carries scattered pilots, continual pilots, and Transmission Parameter Signalling (TPS) carriers. The power of pilot carrier is 16/9 times stronger than data carrier, whereas TPS carrier is transmitted at normal power as a data carrier. While TPS carriers are used for signalling various transmission parameters, the pilot signals are used in frame adaptation. In order to provide synchronization to the DVB frame structure through various methods such as frame synchronization, frequency synchronization, time synchronization, and channel estimation. The DVB receiver must be synchronized and equalized such that the received signal can be decoded successfully and to gain access to the information held by the TPS pilots. All data carriers in an OFDM frame are modulated using QPSK, 16-QAM, 64-QAM, non-uniform 16-QAM, or non-uniform 64-QAM constellations.

G. OFDM Structure

OFDM is a proven technique for achieving high data rate whilst overcoming multipath fading in wireless communication [2, 3, and 4]. OFDM can be thought of as a hybrid of Multi Carrier Modulation (MCM) and Frequency Shift Keying (FSK) modulation. Carriers are spread across the complete channel, fully occupying it and hence using the bandwidth very efficiently. The OFDM receiver uses adaptive bit loading techniques based on a dynamic estimation of the channel response. The most important advantage of OFDM systems over single carrier systems is obtained when there is frequency-selective fading. The signal processing in the receiver is rather simple; multiplying each subcarrier by a complex transfer factor thereby equalizing the channel response compensates distortion of the signals [5]. It is not feasible for conventional single carrier transmission systems to use this method.

The OFDM signal consists of N orthogonal subcarriers modulated by N parallel data streams. Denoting the frequency and complex source symbol of the kth subcarrier as f_k and d_k, respectively, the baseband representation of an OFDM is

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} d_k e^{j2\pi f_k t} \quad 0 \leq t \leq NT \quad (1)$$

Where d_k is typical taken from a PSK or QAM symbol constellation and NT is the duration of the OFDM symbol. The subcarrier frequencies are equally spaced at f_k = k/NT. Therefore the OFDM symbol can be represented:

$$x[n] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} d_k W_N^{kn} \quad 0 \leq n \leq N-1 \quad (2)$$

where, $W_N = e^{j2\pi/N}$

The transmitted signal is organized in frames. Each frame has duration of T_F, and consists of 68 OFDM symbols. Four frames constitute one super-frame. Each symbol is constituted by a set of K = 6817 carriers in the 8K mode and K = 1705 carriers in the 2K mode and transmitted with a duration T_S. It is composed of two parts: a useful part with duration T_U and a guard interval with duration Δ. The guard interval consists in a cyclic continuation of the useful part, T_U, and is inserted before it. The symbols in an OFDM frame are numbered from 0 to 67. All symbols contain data and reference information. Since the OFDM signal comprises many separately-modulated carriers, each symbol can in turn be considered to be divided into cells, each corresponding to the modulation carried on one carrier during one symbol. In addition to the transmitted data an OFDM frame contains: Scattered pilot cells, Continual pilot carriers, TPS carriers. The pilots can be used for frame synchronization, frequency synchronization, time synchronization, channel estimation, transmission mode identification and can also be used to follow the phase noise.

The carriers are indexed by K ∈ [K_{min}; K_{max}] and determined by K_{min} = 0 and K_{max} = 1704 in 2K mode as shown in Fig5. For different modes the number of carriers will be different.

The spacing between adjacent carriers is 1/T_U while the spacing between carriers K_{min} and K_{max} are determined by (K-1)/T_U.

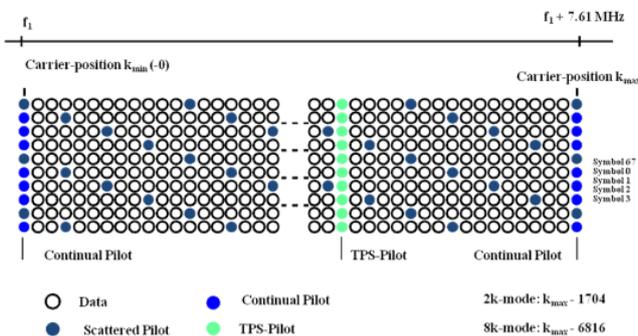


Fig. 5 Transmission Frame for the DVB-T signal [6]

Various cells within the OFDM frame are modulated with reference information whose transmitted value is known to the receiver. The information transmitted in these cells is scattered pilot or continual pilot cells. These pilots are transmitted with amplitude which is 1/0.75 larger than the amplitude of the other carriers in order to be particularly robust against transmission errors. Furthermore, TPS pilots are included. They inform the receiver about the actual operating parameters. The TPS carries are modulated by means of a Differential Binary Phase Shift Keying (DBPSK). Thus, one bit per carrier can be transmitted. Consequently, one OFDM frame contains a TPS block of 68 bits, namely, 1 initialization bit, 16 synchronization bits, 37 information bits, and 14 redundancy bits for error protection [1].

III. TERRESTRIAL SCENARIO FOR DVB-T/H

Due to the high data rate demand of DVB and the Intersymbol Interference (ISI) resulting from long channel delay spreads, multi carrier modulation schemes (like, OFDM) achieves acceptable performance then single carrier schemes. OFDM yields high bandwidth efficiency and reduces the effects of ISI by making the effective symbol period much larger than the channel delay spread. The loss of subchannel orthogonality due to residual ISI can be eliminated by adding a guard interval of length greater than the maximum delay spread of the channel. Besides stationary reception, portable and mobile reception of broadcast signals is also of interest, for example on buses, trains and automobiles. However, motion of the receiver causes channel time variations or Doppler spreading. Even a stationary receiver will experience some Doppler spreading if there is movement near the receiver antenna, and this must be accounted for in the system design. The Doppler shift due to receiver movement will apparent itself mainly through a loss in subchannel orthogonality, termed Inter Channel Interference (ICI). It can be shown that the overall discrete-time channel, consisting of the actual wideband fading channel and the OFDM multiplexer/demultiplexer, can be modelled as an equivalent

flat Rayleigh fading channel plus ICI. Use of such a model allows error rates to be determined analytically, which is desirable since error rates of 10^{-9} or less are very difficult to obtain by simulation. Acceptable performance for a DVB system cannot be ensured without fading compensation. In some research paper antenna diversity, trellis coded modulation, etc., schemes are discussed in terms to improve acceptable performance of DVB system for handheld devices [10]. However, the addition of ICI from receiver mobility requires the use of correlation-based combining, such as maximum ratio combining. Another technique that can be used to improve system robustness is *multiresolution modulation (MRM)*. MRM matches the transmission technique to the multiresolution nature of the source encoder, allowing reception of various levels of video quality dependent on channel conditions. This allows for polished degradation and increases the transmission region in which video of some quality can be received. If the time-varying impulse response of the channel can be tracked accurately, then it is possible to reduce ICI through equalization. Researchers have described several methods that used pilot tones to estimate the channel response and then performed linear equalization before the demultiplexing FFT. These methods require enough bandwidth to be allocated to the pilot tone so that it can be isolated at the receiver through filtering. For the highly frequency selective channel consideration, the number of pilot tones required to provide significant ICI suppression would result in a prohibitively large capacity penalty. Another channel estimation technique is to insert a training sequence into the transmit sequence [7]. This would provide knowledge of the channel impulse response at a particular time, but would not track the variations. Adaptive tracking of the channel response is also not possible because the transmitted sequence is the IFFT of the symbol sequence, whose elements are not constrained to be within an alphabet of reasonable size. Even if the channel can be tracked accurately, the equalizer will still introduce both noise enrichment and increased complication. At least two reviews are required for every paper submitted. For conference-related papers, the decision to accept or reject a paper is made by the conference editors and publications committee; the recommendations of the referees are advisory only. Undecipherable English is a valid reason for rejection. Authors of rejected papers may revise and resubmit them to the WASET as regular papers, whereupon they will be reviewed by two new referees.

IV. CONCLUSION

There are continuous research efforts going in the field of DVB for mobile. T. Jokela [13] has concluded that in fast mobile reception conditions the robustness of the signalling can be achieved by including time diversity which is not present in the DVB-T2. There are other technologies also which provides mobile TV services like DMB-T, MediaFLO, etc. Comparison of DVB-H vs. DMB-T is mention in table 1 [11, 14]. Intersymbol Interference in OFDM technology is

another effect to look after for better system performance. It shown in [12] that in a multipath environment, a delayed and attenuated copy of an OFDM symbol adds to every sub symbol within the OFDM symbol a rotated and attenuated version of itself. In a multipath environment, or in SFN broadcasting mode, intersymbol interference in OFDM causes serious impairments at the receiver if not compensated by adaptive channel estimation. Also it discussed that a guard interval does not protect against intersymbol interference, but it is indispensable in order to guarantee that the OFDM communication is not affected by intersymbol interference. Table 2 shows the comparison DVB-H and DVB-T.

TABLE I
COMPARISON OF DVB-H VS DMB-T

| Parameters | DVB-H | DMB-T |
|--------------------------|----------------------------|----------------------------------|
| Frequency | Band-III (174-240MHz) | Band-IV/V (470-862MHz) |
| Bandwidth | 1.536 MHz | 5/6/7/8 MHz |
| Modulation | DQPSK | QPSK / 16QAM / 64QAM |
| Tx power | Lower | Higher |
| Installation Cost | Cheaper | Expensive |
| Capacity | 4 times more than DMB-T | Good |
| Future Expansion | With less investment | Good for less no. of services |
| Specifications | Fully specified | Research is going on |

TABLE II
COMPARISON OF DVB-H AND DVB-T [15]

| | DVB-T | DVB-H |
|-----------------------|-------------------------------------|--------------------------------|
| Data Rate | 4-5 Mbps | 128-384 Kbps |
| Display | Large and medium TV screen | Small (mobile phone) screen |
| Antenna | Roof top, Desktop or Car Antenna | Internal |
| Power Supply | Fixed, Continuous | Battery powered, Limited |
| Reception Mode | Fixed, Indoor portable | Mobile Handheld |

DVB-H uses shared network with DVB-T with some additions and technology improvement to support mobile devices. But still it has not reached to its best result to support user requirements in all respects. By applying more improved technology and methodology in research can improve the system to satisfy the user needs.

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