Mobile Broadcasting Technologies: A Comparative Analysis

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Abstract - **This paper presents an overview of digital video broadcasting technologies in mobile networks, such as DVB-H, T-DMB and MediaFLO. Their virtues and limitations are discussed, and some recommendations are suggested for future development.**

Key words - **Broadcast, DVB-H, Digital television, MediaFLO, T-DMB**

I. Introduction

Mobile television involves bringing TV services to mobile phones. It emerged from the consumer requirements for a single device that would incorporate entertainment and communication. Currently, there are two main ways of delivering mobile TV. The first is via two-way cellular network and the second is through one-way dedicated broadcast network [1]. Streaming mobile television is an UMTS-supported service that is limited by the network capacity, the same as streaming via the Internet, while on the other hand the content is broadcasted over a large area neglecting the size of the audience [2]. Mobile reception of broadcasting services has recently attracted much attention worldwide. The standards that stand out are DVB-H, T-DMB and MediaFLO [3].

This paper discusses the main features of these standards, and gives certain comparisons regarding the performance of the diverse networks.

II. Systems overview

Many strict requirements should be met when planning a broadcasting mobile network [4]. The ability to change channels quickly is considered a key user requirement for all of the systems. Equally important is watch time, which was designed to be comparable to talk time, so as not to compromise the functionality of the mobile device. In addition to viewing high quality video and audio content and receiving IP data, the user may also have access to related interactive services, including the option to purchase a music album, ring tone, or to download a song featured in a music program. The user may also be able to purchase access to on-demand video programming, beyond the content featured on the electronic service guide [5].

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Digital Video Broadcasting - Handheld is a standard for terrestrial digital video broadcasting to handheld mobile terminals that was developed by the International DVB (Digital Video Broadcasting) Project and published by the ETSI (*European Telecommunications Standards Institute*) [4]. DVB-H is based on DVB-T standard for terrestrial digital television, and is adapted to the special requirements of mobile receivers [5].

One of the main DVB-H competitors is T-DMB (Terrestrial - Digital Multimedia Broadcasting) that was developed in South Korea and had its commercial start, before DVB-H, in 2006. Telecommunication Technology Association (TTA) of Korea and ETSI in Europe established a series of specifications for T-DMB video and data services [6]. The standard is an upgraded version of DAB (Digital Audio Broadcasting) in the source coding and channel coding areas and delivers mobile television services using the Eureka-147 DAB standard with additional error-correction. The DAB system is suitable for satellite, as well as hybrid/mixed terrestrial/satellite broadcasting, using a simple, nearly omni-directional receiving antenna [3].

The MediaFLO system, based on FLO technology, is an innovation of Qualcomm, supported by the FLO Forum and its industry members [7]. It was designed from the ground up specifically for the mobile environment. MediaFLO is able to deliver a rich variety of content choice to consumers while efficiently utilizing the spectrum. MediaFLO is a proprietary system, based on a proprietary physical layer, dedicated to multimedia broadcasting to mobile hand-held receivers. Proprietary codecs process real-time video content. IP protocol usage is restricted to non-real time contents [3].

III. Technical solutions and features

It is expected that the highest demand for broadcasting systems would be in densely populated areas with high level of human-generated noise, so the system has to offer efficient error correction solutions. The standards base upon currently highly popular multicarrier Orthogonal Frequency Division Multiplexing (OFDM). All solutions have the potential to find applications in Europe, depending on a availability of spectrum, cost of the distribution network and mobile terminals as well as the legacy of systems already in use [8]. One system may be preferable to another taking these issues in account.

The distinguishing features, which differentiate the various technologies, are in the details of how many OFDM carriers are used, in what bandwidth, with which modulation, using which error protection and power saving techniques. Currently, the broadcasters are seeking advice on which technology to embark and concentrate their resources on. In general, broadcast networks are perfectly suited for providing high bitrates simultaneously to a mass of users with high service reliability and excellent quality, at much less cost per user than via point-to-point telecom network.

IV. DATA LINK LAYER

A Power saving techniques

DVB-H system is based on the existing DVB-T standard for fixed and in-car reception of digital TV [4]. The main additional elements in the data link layer are time slicing and additional forward error correction (FEC) coding [8]. Time slicing is a Time Division Multiplex (TDM) variant, and is present in a similar way in MediaFLO [7]. Data is sent on much higher bitrate (i.e. ten times) than it would be necessary using conventional methods of transmission. The use of time slicing is mandatory in DVB-H. Time slicing reduces the average power in the receiver front-end significantly - up to about 90% - 95%, - and enables smooth and seamless frequency handover when the user leaves one service area in order to enter a new cell [4]. It enables the mobile terminal to switch some of its components off and thus save power. Between the two bursts, other services can utilize system capacity. Furthermore, while the receiver is inactive, it can scan the signal power level from nearby cells and decide the most appropriate moment for handover [9].

There are no effective power saving techniques in T-DMB (other than "micro-time-slicing", which is not an effective power-saving technique) [10]. T-DMB relies on the fact that it operates in a 1.5MHz channel bandwidth, rather than the 5, 6, 7 or 8MHz channel bandwidths that DVB-H operates in. The lower channel bandwidth for T-DMB means less data throughput, but should also mean less power. The target power consumption for the DVB-H tuner and front end was less than 100 mW, and current state-of-the-art is less than 40 mW. However, power consumption of the T-DMB system is about 150mW. That is almost four times higher than DVB-H consumption. In addition, the data throughput for DVB-H is 4 times higher than that of T-DMB [10].

FLO technology simultaneously optimizes power consumption, frequency diversity, and time diversity [7]. FLO has a unique capability that allows it to access a small fraction of the total transmitted signal without compromising either frequency or time diversity. OFDM carriers are divided into 8 regularly spaced groups, called interlaces [3]. In order to save power, the receiver is not obliged to demodulate whole OFDM symbols, but only those interlaces carrying data for the wanted stream. The mobile device accesses overhead information to determine at which time intervals a desired content stream is transmitted and its receiver circuitry powers up accordingly. FLO technology minimizes channel acquisition time. In most cases, it is less than two seconds [7].

B Error correction and coding techniques

In DVB-H, advanced Multi Protocol Encapsulation - Forward Error Correction (MPE-FEC) is used. As well as for MediaFLO and T-DMB error correction techniques, FEC for multiprotocol encapsulated data (MPE-FEC) gives an improvement in carrier-to-noise (C/N) performance, Doppler performance in mobile channels and improves tolerance to impulse interference [12]. Use of MPE-FEC is optional for DVB-H. DVB-H and T-DMB utilize Convolution coding and Viterbi decoding [7]. However, FLO has a more modern and efficient turbo code. All formats utilize a concatenated Reed Solomon code [7]. T-DMB and DVB-H use interleaving, a technique that displaces data flow over several bursts and thus enables high data recovery possibility if one of the bursts gets damaged while transmitted [11]. MediaFLO lacks this feature, which makes it more prone to errors.

The DVB-H MPE-FEC frame is a matrix-like structure with 255 columns and flexible row number, up to a 1024 rows [5]. Every position in the matrix carries one byte of information. Left part of MPE-FEC frame is Application data table and it carries IP datagrams as pictured in Fig. 1.

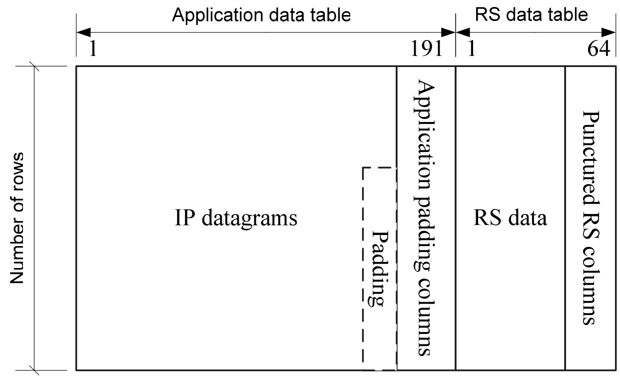

Fig. 1. MPE-FEC frame structure.

The remaining 64 columns are FEC parity information and are called RS data table. The IP data is carried in MPE sections in the standard DVB way, no matter if MPE-FEC is being used or not. This makes reception fully backwards compatible with MPE-FEC ignorant receivers [12].

DVB-H uses IP encapsulation over the MPEG-2 Transport Stream. The main idea is to accept any IP stream as an input and to encapsulate them into MPEG-2 transport streams, which are then transmitted by the DVB-T physical layer. DVB-H does not specify audio/video codecs, so all kind of streams can be transmitted using IP at the transport layer [3], [5]. Considering proprietary structure of some T-DMB and MediaFLO components, DVB-H flexibility comes forward as a great advantage [3], [7].

On the other hand, T-DMB is based on the physical layer of DAB. T-DMB MPEG-2 transport stream interface multiplexes video, audio, and auxiliary data [3]. However, it does not use IP encapsulation. T-DMB provides two mechanisms for transporting the data [3]. The Main Service Channel (MSC) is the multiplex of sub-channels that carry audio programs and is able to carry data in transparent Stream mode or in Packet mode. Stream mode is of particular interest for DMB, as it is used to carry video services. Optional Conditional Access scrambling is possible individually for each subchannel. The Fast Information Channel (FIC) mainly carries information about the MSC configuration and has a limited capacity (32 kb/s). T-DMB utilizes shortened Reed-Solomon codes and applies it to each 188-byte transport packet. Error protection against adverse propagation conditions is applied independently for each sub-channel as seen on Fig. 2, and it includes time interleaving [3].

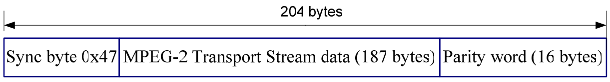

Fig. 2. Error protection for DAB MSC stream.

Sub-channels are multiplexed into Common Interleaved Frames by the MSC multiplexer. Then, they are multiplexed again with the data from the Fast Information Channel and then transmitted by the OFDM symbol and signal generator.

MediaFLO Channel is composed of Media Logical Channels (MLCs) [3]. A MLC may represent a single media service or several services grouped to form a program (i.e. video + audio + subtitles). Each MLC has its own coding rate and modulation and a receiver demodulates whole MLCs. FLO incorporates a turbo inner code and a Reed Solomon (RS) outer code. Each turbo code packet contains a Cyclic Redundancy Check (CRC). The RS code does not need to be calculated for data that was correctly received, which results in additional power savings [7]. FLO supports the use of layered modulation. A given application may divide a data stream into a base layer that all users can decode, and an enhancement layer that users with higher signal-to-noise can also decode. Due to the multicast-only nature of the FLO waveform, the majority of devices will receive both layers of the signal to deliver 30 fps video quality, with the base layer having superior coverage and equivalent total capacity mode. The base layer alone can deliver 15 fps video quality. The combined use of layered modulation and source coding allows for degradation of service and the ability to receive in locations or at speeds that could not otherwise have reception. Outer and inner coding is performed independently for the base and enhancement layer, providing adjustment to the relative thresholds of each layer and adjusts the ratio of bandwidths [7].

V. Physical layer

All systems use coded OFDM in the physical layer, and in theory, they should have similar transmission power requirements per video or audio service. More similarity could arise by the use of common IP-based protocol stack that would lead to simplified implementation in common chipsets and ultimately lower consumer costs [8]. The combined approach would enable significant cost cuts in the terms of common media formats, protocol layers and metadata sets, taking into account the need for scaling due to different transmission capacity capabilities. A key factor in the design of OFDM systems is the size of the transform: the number of separately modulated sub-carriers in each symbol, with available modes displayed in Table 1.

As for DVB-H, the 4K mode is architecturally compatible with existing DVB-T infrastructure, requiring only minor changes in the modulator and the demodulator [5]. In addition, TPS-bit signaling provides robust multiplex level signaling capability to the DVB-H transmission system. TPS-lock in a demodulator achieves with a very low C/N-value. It is also much faster to demodulate the information carried in the TPS than in the MPE-header [5]. Addition of a ‘in-depth’ symbol interleaver improves performance for impulse noise [5]. For DVB-H, mobile and portable reception, the most usable modulation scheme is 16 QAM with code rate of 1/2 or 2/3, which requires moderate C/N and provide sufficient transmission capacity for DVB-H services [5]. DVB-H performance in the case of impulse noise or Doppler effect vary according to the FFT mode chosen. Speeds higher than 100 km/h can be easily reached: 8K mode with CR=1/2 provides operation up to 86 km/h, which is enough in urban environment, while MPE FEC provides good behavior up to 120 km/h [3]. As C/N is rather moderate in such receiving conditions QPSK or 16 QAM modulations have to be used while 64 QAM used for broadcasting to stationery receivers must be avoided.

Table 1: Comparison of OFDM modes.

Parameter	2K mode	4K mode	8K mode
Active carriers	1705	3409	6817
Data carriers	1512	3024	6048
Elementary period	7/64	7/64	7/64
Useful symbol part	224 μs	448 μs	896 μs
Carrier spacing	4464 Hz	2232 Hz	1116 Hz
Spacing between carriers	7.61 MHz	7.61 MHz	7.61 MHz

The FLO physical layer uses the 4K mode (yielding a transform size of 4096 subcarriers), providing superior mobile performance compared to an 8K mode, while retaining a sufficiently long guard interval that is useful in fairly large SFN cells [7]. Robust performance maintains until more than 200 km/h. Beyond that, degradation is smooth, creating minimal impact to the overall performance [7].

Practical choice for T-DMB is encoding rate of 1/2 leading to a sufficient protection level, without sacrificing data rate [3]. Roughly, one Mb/s per multiplex is available, and 3 to 4 mobile TV programmes. T-DMB performance for mobile reception varies from urban reception, with typical speeds 50 km/h to 130 km/h, rural reception, on highways typical speed 130 km/h. and in-door reception that corresponds to fixed or very low speed conditions [3]. It does not support the conditional access scheme defined in ISO/IEC 13818-1. Moreover, the fact that T-DMB has fixed protocols for MPEG-4 makes it inferior to DVB-H, which employs IP protocol that adds more flexibility to future upgrades [11].

VI. Discussion

The fact that T-DMB is narrowband and DVB-H and MediaFLO are wideband means that the latter two have better frequency diversity, but worse sensitivity [11]. In case of DVB-H, this is compensated by better C/N performance [13]. DVB-H QPSK has 3dB advantage over T-DMB D-QPSK in Gaussian channel [11], [13], while

MediaFLO has below 1dB advantage over DVB-H [14]. DVB-H has the most advanced error coding, including MPE-FEC, which brings additional 2-3 dB advantage over the T-DMB [11]. MediaFLO operates on 700 MHz, T-DMB in VHF and L band while DVB-H utilizes VHF or UHF.

Data in Table 2 shows that T-DMB is practically limited to 1.06 Mb/s (1/4 Guard Interval, 1/2 Code Rate, RS-FEC), that is, three to four services via one T-DMB multiplex, while MediaFLO offers in theory from 3.76 Mb/s to 14.96 Mb/s depending on the channel bandwidth [7]. On the other hand, DVB-H offers from 2.49 Mb/s to 31.67 Mb/s in theory, though in practice the capacity is lower: from 3.32 Mb/s to 13.8 Mb/s (1/4GI for QPSK, 1/2 CR, MPE-FEC 2/3 - 1/8 GI 16 QAM, 3/4 CR, MPE-FEC 5/6) [11]. These data rates enable broadcasting from 10 to 50 different audio, video or data services. Scalability per multiplex is important as well when considering these bandwidths. T-DMB has fixed spectral efficiency of 0.62 bit/s/Hz in D-QPSK mode [3]. MediaFLO supports rates from 0.47 bit/s/Hz to 1.87 bit/s/Hz and up to 20 services per multiplex [7]. DVB-H in reality offers spectral efficiency from 0.415 bit/s/Hz to 1.73 bit/s/Hz [11].

TABLE 2: MAIN PHYSICAL LAYER OPTIONS.

Parameter	T-DMB	DVB-H	MediaFLO
Channel bandwidths	1.712 MHz	5, 6, 7, 8 MHz	5, 6, 7, 8 MHz
FFT sizes	2k, 1k, 0.5k, 0.25k	8k, 4k, 2k	4k
Inner modulations	Differential QPSK	QPSK, 16 & 64QAM	16QAM, QPSK
Protocol stack	Raw MPEG 4	IP layer	IP layer & proprietary p.
Theoretical data rate	1.06 - 2.3 Mb/s	2.49 - 31.6 Mb/s	3.76 -14.9 Mb/s
Practical data rate	1.06 Mb/s	3.32 - 13.8 Mb/s	?
Guard interval	246 µs, 62µs, 31 µs, 123 µs	1/4, 1/8, 1/16, 1/32	/

Audio services are based on AAC-LC or HE-AAC, while MediaFLO uses HE-AAC+ and HE-AAC+ V2 [3]. DVB-H and T-DMB video services are encoded using MPEG-4 H.264/AVC, a compression format twice efficient compared to MPEG-2 [15], [16]. T-DMB MPEG-2 transport stream layer multiplexes video, audio, and auxiliary data. MediaFLO does not use IP for real-time video broadcasting - IP is used only when it has a significant advantage in datacasting [3]. MediaFLO uses proprietary MPEG-2 transport stream which carries proprietary H.264 format, up to 30 fps, and is restricted to QVGA resolution. DVB-H resolution ranges from QCIF to CIF or QVGA, frame rate from 10 to 25 fps, and bit rate is in the range from 200 kb/s to 400 kb/s per user [5].

VII. CONCLUSION

T-DMB micro time slicing stands out as a significant disadvantage, compared to DVB-H and MediaFLO that utilize real time slicing resulting in better power saving results. Use of MediaFLO proprietary solutions can be taken in as a significant flaw when considering system flexibility. Despite certain unique features, T-DMB and MediaFLO lack the flexibility of DVB-H.

In summary, DVB-H will be the system of choice if the objective is to reach as many users as possible with a wide range of services at low transmission costs. DVB-H has the most balanced characteristics with support from more than 60 manufacturers. Moreover, efficient error protection and power saving technology are difficult to match by other standards. It is an expandable future-proof technology, which makes it a smarter investment option. On the other hand, final decision could depend on the availability of the spectrum or support for the domestically developed standard.

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