Surveying Mobile Television

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Abstract**:** This paper will discuss the basic characteristics of standards for mobile television (Mobile IPTV, T-DMB, MediaFLO, ISDB-T, DVB-H), the basic differences at the technical level and finally present an overview of a proposed architecture for the deployment of mobile TV services combining difussion networks with ad hoc ones, which has been generated from projects developed in the experimental laboratory of interactive digital television at the University of Cauca.

Keywords**:** Mobile Television, Standards for mobile television, mobile IPTV, T-DMB, MediaFLO, ISDB-T, DVB-H**.**

1. Introduction

Services for mobile devices have evolved markedly over the last decade. Currently there are many benefits that can be made from a mobile, such as multimedia messaging, office automation, exchange of content via wireless communication, multimedia, games, radio, television, among others, that thanks to the support of multiple networks around to a mobile device: cellular network, local wireless networks (WiFi, Bluetooth), metropolitan area networks (WiMax) and own transport networks of specialized services standards (Mobile TV).

Moreover, thanks to the ability to integrate the IP protocol, it has been possible Internet integration of services previously operated independently (television, radio, mail, e-commerce, among others) on a single platform, taking into account above, with the spread of mobile Internet, a similar phenomenon is expected in terms of convergence of services in mobile environments, allowing access to multiple services anytime and anywhere from a handheld device.

One of the services is beginning to have success in Europe, is the Mobile TV, which has been considered the "killer application" in the near future [1], however it is important to note that this service will be successful, as it allows ease of convergence of services and provide an enjoyable experience for the user, or at least similar to that of conventional television.

The process of adapting a service management requires new standards, which should take into account the limitations of the new service environment. In the case of mobile TV, has identified several technologies and standards: Mobile IPTV, T-DMB, MediaFLO, ISDB-T, and DVB-H. Among these the most widespread standard is the DVB-H (Digital Video Broadcasting - Handheld), which has the support of multiple device makers and community development around the DVB standard (which is derived from this).

The importance of the DVB standard is in the wide acceptance it has in most European countries in the field of Digital TV and the work to be divested itself and its derivatives (DVB-H) in Colombia, after in August 2008 the National Commission for Television (NTV) will opt for the acceptance of this standard for the deployment of digital television across the Colombian territory. [2]

The following sections will discuss the basic characteristics of standard television, the basic differences at the technical level and finally present an overview of a proposed architecture for the deployment of mobile TV services, which has been generated from projects developed in the experimental laboratory of interactive digital television at the University of Cauca.

2. Mobile Wireless Communication Standard in Ad hoc Networks

Mobile networks are by excellence, wireless networks. That is the reason in this paper a section of wireless communication standard is included.

The right performance of ad hoc networks in mobile networks is natural, due to the conception, however, the natural performance of television networks is through broadcast; so, combine the broadcast network with ad hoc one is a challenger, that can be work adequately in the interactive services that are added to digital television. In the last part of this paper this mixture will be explain.

2.1 IRDA (Infrared Data Association)

Networks that exchange information via infrared technology. These networks are very restricted due to their short range, necessity of line view without obstacles, and low speed (up to 115 kbps). They are found mainly on laptops, PDAs, mobile phones and some printers. IrDA has a significant role to play in Wireless Personal Area Networks. Its key features (including short-range, narrow cone, dynamic ad hoc connectivity, rapid connection establishment, high data rates, low power, and low cost) make it an ideal technology for certain usage models. In other situations IrDA's ability to co-exist with, and complement Bluetooth solutions also make it an important player in this space.

2.2 Bluetooth [5]

The main features of this technology are its reliability, low power and low cost. The Bluetooth specification provides a uniform structure for a wide range of devices to connect and communicate.

Thanks to its wide acceptance, a Bluetooth device can connect to almost any compatible device that is in the vicinity, eliminating borders anywhere in the world.

Electronic devices equipped with Bluetooth technology can connect and communicate wirelessly via ad hoc networks called piconets short range. Each device can simultaneously connect up to eight within a single piconet. A device can belong to several piconets simultaneously. The piconets are established dynamically and automatically when Bluetooth

devices are in the same range. One of the main advantages of Bluetooth wireless technology is its ability to simultaneously manage both voice transmissions and data.
This allows users to enjoy a variety of innovative solutions, such as the use of handsfree call handling, printing and fax, or timing of applications including PDAs, computers and phones, among many others.

3. Television Standard

3.1 Mobile IPTV

Mobile IPTV is commonly known as Mobile TV over IP. This technology describes the services that allow receive video or television on mobile and portable devices through wireless internet connections. In other words, Mobile IPTV is the TV transmission system that has all the mobility features and the content is received over IP. The mobile IPTV service is based exclusively on video streaming for multimedia delivery from the service provider to the mobile devices. [5].

3.1.1 Protocols

While the streaming technology has been developed, some protocols were created exclusively for such applications. Some of them are designed to initialize and control the streaming session (RTCP, RTSP and SDP), another protocol was created to transfer data from the payload, and this is known as RTP. The Figure 1 shows how the TCP and UDP operate through the mobile network over IP. UDP protocol is used for audio and video streaming, while TCP and HTTP protocols are used to download files over Internet.

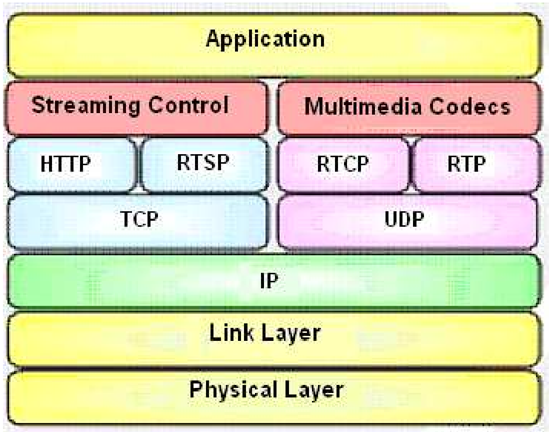

Figure 1. Protocol IP Stack

In the following section the protocols will be explained.

HTTP: Sends the complete information between the client application and the server. This protocol is on the application layer, and allows the remote reception of data. It is based on transactions and used the request-response scheme. Use this protocol for the streaming is inefficient due to this protocol Works over TCP protocol, which warranty the security in the package delivery to the destiny, traduce in redundancy of information. [6]
RTSP: Application layer protocol. Establishes and controls the synchronization time in the multimedia streaming send. This protocol is not used to deliver the play out. RTSP controls the network for multimedia services. Works correctly when is combined with RTP and RTCP protocols. RTSP is based on text, and its principal advantage is that works with user sessions keeping the Independence with other protocols in the transport layer. In the streaming services, these protocols allow pause, play, stop, forward and backward the video. [7]
RTP: This protocol was defined by the IETF and the ITU. RTP gives an end to end solution to the multimedia data transport in real time. RTP supports different transmissions as unicast and multicast. It is a transport protocol independent of the subjacent transport protocols and networks. When RTP is used for audio and video streaming over IP networks, the transference is made over UDP to warranty the information will be sent in real time. [8]
TCP: This protocol is used for sending the streaming play out. It is oriented to connection, this is, verifies the reception of every packaged sent; this generates an effectiveness reduction on the sending multimedia real time, besides; congest the network in case of a big lost of packages. [9]
UDP: This is a transport protocol not oriented to connection. UDP prefers the speed instead of reliability in the delivery of information. This is the principal reason that UDP is wide used in the world for multimedia real time transmissions. [9].

3.1.2 Advantages and Disadvantages

***a) Advantages** [7]*

With IPTV, a new interaction level between Internet, voice and video was established, this permit the creation of new kind of services. Data to be transmitted at high speed are sent by different channels, separating the transmission control and content. All these streams should be sent using the IP network. This separation ensures the quality of service and the effective send of multimedia packages.
A big amount of channels could be offered to the users, letting the users change the schedule and content through the return channel. This allows the creation of advanced services.

b) Disadvantages

Because it is based on the IP protocol has not been standardized or regulated.
Its characteristics depend on the transport network used.

3.1.3 Deploy Architecture

In the Figure 2 the deployment architecture of IPTV is shown.

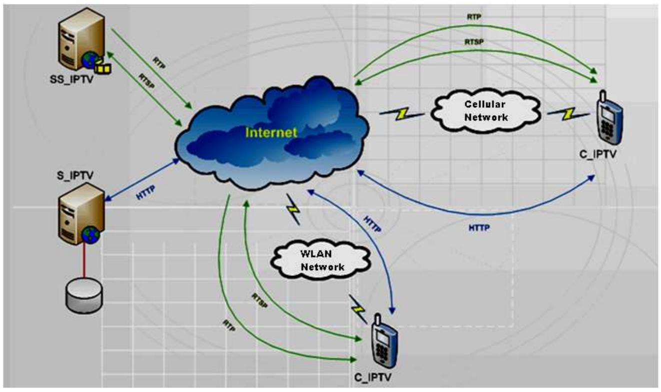

Figure 2. Deployment architecture of IPTV

IPTV has an Application Server (S_IPTV) and Content Server (SS_IPTV). SS_IPTV allows sending multimedia content to mobile devices using RTP protocol. SS_IPTV allows sending multimedia content to mobile devices (C_IPTV), while through S_IPTV is consumption of applications via HTTP. The mobile device must have the RTP protocol implementation. The IPTV service can be accessed via cellular network or via WLAN [10]. This architecture enables the convergence of streaming services to different types of devices, thanks to ad-hoc networks. Thus it is possible to access television content through WLAN or via the cellular network, maintaining the same transmission protocol.

3.2 T-DMB (Terrestrial Digital Multimedia Broadcast)

3.2.1 Technical features

T-DMB (Terrestrial Digital Multimedia Broadcast) standard is an evolution of Korean DAB (Digital Audio Broadcast) standard, which introduce some significant improvements to include multimedia services and become more robust the channel codification scheme. [1]

T-DMB is a standard designed from the beginning to receive the signal in mobile devices. Currently, it is deployed in South Korea, China, Hong Kong and Macao.[11]

The modulation is performed through DQPSK and transmission is performed using OFDM in the access channel. For the transmission of digital television signals, T-DMB uses the Third band and L-band of VHF, using channels 8 and 12 for TV broadcast. DMB uses 7 video channels, 13 audio channels and 9 channels of data. In the Third band uses the range frequency between 175 and 240 MHz, in the UHF band uses the range frequency between 791-796 MHz, and in the L band uses the range frequency between 1452-1478 MHz. [1][12]

T-DMB uses MPEG-4 AVC or ITU-T H.264 for video compression and MPEG-4 Bit-Sliced Arithmetic Coding (BSAC)/High Efficiency Advance Audio Coding (HE-AAC) for audio compression. The DMB system also defines the interactive data service functionality in order to provide additional information suitable for a display size and to prepare convergent services between broadcasting and telecommunications through MPEG-4 BIFS (Binary Format for Scene) compression. [1][12]

The audio, video and interactive data convergence is realized by MPEG-4 systems technology. Normally, multimedia and audio signals, and interactive data are synchronized individually by the MPEG-4 Synchronized layer (SL), then, they are multiplexed into a MPEG-2 transport stream (TS); after that, an error correction method is applied, generating the stream in ES147 stream (see Figure 3) [1][12]

T-DMB includes data transport protocols such as MOT (Multimedia Object Transfer), IP (Internet Protocol) Tunneling, and TDC (Transparent Data Channel), which are specified in the Eureka-147 DAB specification for the provision of various data services to send text, static image, moving picture, audio sequence, and the like. Moreover, the MOT protocol is designed to be suitable for the transmission of various multimedia objects so as to guarantee interoperability, although the manufactured heterogeneities of the transceiver and receiver or the heterogeneities of the data service and application exist. [13]

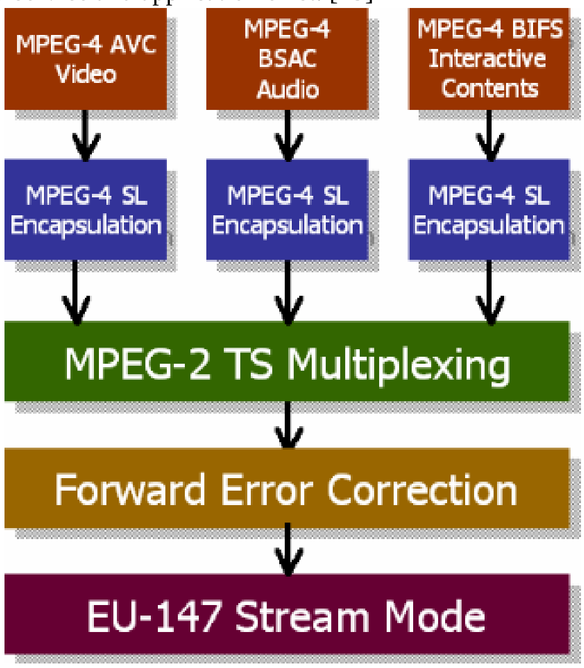

Figure 3. Protocol stack [13]

In the Table 1, a summary of the technical features of the T-DMB standard is showed. [1][12]

3.2.2 Advantages and Disadvantages

a) Advantages

- Low cost of implantation in countries where DAB standard is working for digital audio transmission.
- Frequencies used in Third and L band are secure.

b) Disadvantages

- The battery consume is not optimized.

Table 1. Technical Features T-DMB

Feature	Description
Frequency band used	• VHF • UHF (470-800MHz) • L Band (1452-1492 MHz)
Band width	• 1.5MHz
Modulation method	• DQPSK
Transmission Method	• OFDM
Channel Codification	• Convolutional Byte Interleaver • RS (Reed Solomon)
Multiplexation	• MPEG-4 SL • MPEG-2 TS
Video Codification	• MPEG-4 H.264
Audio Codification	• MPEG-1/2 Layer 2
Data Services	• MPEG-4 BIFS • PAD • NPAD • MOT • IP TUNNELING

3.2.3 Deploy Architecture

In the Figure 4 the deployment architecture of T-DMB is shown, in this architecture, 3 important components could be identified: Service provider, broadcasting system and DMB

receiver. [1]
The Ad-hoc network is included in the return channel, using a WAN-PAN Gateway that allows send to the Return Channel Server the events and responses of interactivity actions. This implementation is based on [15] and do not affect the broadcasting system.

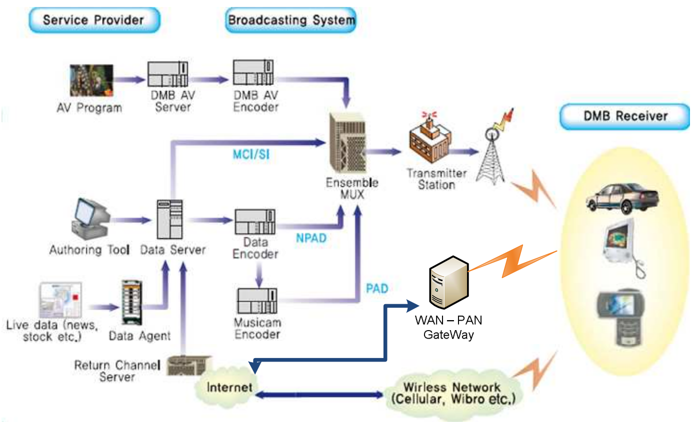

Figure 4. Deployment architecture of T-DMB

Service Provider: It is composed by 3 important servers:

- DMB Audio and Video Server: This server contains all the audio and video television programs that will be transmitted by the broadcasting system.
- Data Server: This server contains all de java application created with an authory tool, which will be executed by the middleware in the receiver. Also contain all the data services like news, life program, games, etc. This server receives the interaction of the user with the services.
- Return cannel server: This server manage the interaction of the users and establish a connection with the services through wireless networks with Internet Access.

Broadcasting System: It is composed by:

DMB Audio and Video Coder: Receives the DMB audio and video signals and codifies them in MPEG-4 format.

- Data Coder: Receives the interactive data from applications and services and codifies them in MPEG-4 format. Separates the audio data associated to the content from audio data not associated to the content.
- Music Coder: Receive the audio data associated to the content and codifies to MPEG-4 format.
- Multiplexer: Receive all the audio, video and data MPEG-4 streams and generates a MPEG-2 transport stream for the transmission.
- Transceiver Station: Sends the MPEG-2 transport streams by the broadcast cannel using DMB standard.

DMB Receiver: It is represented by the mobile terminals that receive and play the DMB signal. For the interactive applications or services that use the return channel, the device uses the cellular or wireless networks to access to the services.

3.3 MediaFLO (Media Forward Link Only)

It is the acronym of (Media Forward Link Only) which works in channels UHF (716-722MHz) and developed by the North American company Qualcomm for the United States. It is supported and standardized through FLO Forum and of the NTIA (National Telecommunications and Information Administration). It allows giving services of diffusion to mobile receivers using OFDM (Orthogonal Frequency Division Multiplexing), needing only three transceivers to cover a city of great size. Considering that MediaFLO operates in the band of the 700 MHz, is an important difficulty in the receiver, the proximity of frequencies with the cellular network. [16]

3.3.1 Technical features

This standard was designed from beginning to receive the television and audio signals on mobile devices to cover the deficiency of the American standard (ATSC) has. Actually, this standard is deployed on United States, United Kingdom.
The modulation is performed through QPSK, 16QAM, DQPSK, and use OFDM for the transmission. MediaFlo uses the range frequency 470 MHz-800 MHz from UHF band and the range of frequency 1452-1492 MHz from L band, getting a band width about 5, 6, 7 and 8 MHz. [16]
MediaFlo uses MPEG-4 AVC or ITU-T H.264 for video compression and MPEG-4 Advanced Audio Coding/High Efficiency Advance Audio Coding (AAC/HE-AAC) for audio compression. MediaFlo also defines the interactive data service functionality in order to provide additional information suitable for a display size; this interactive data services are offered using IP. [16]
In the Table 2, a summary of the technical features of the MediaFlo standard is shown.

3.3.2 Advantages and Disadvantages

***a) Advantages** [7]*

- Delivers national and regional programming within a one RF Channel.
- Allows interactivity functions and services consumption to users by means of cellular network.
- Includes IP data services, clipcasting and integration of interactive applications.
- Provides immediate access to real-time data extending the value of the mobile device to an "always on" lifestyle management tool.
- Economically delivers content to the masses with a minimal number of transceivers.

b) Disadvantages

- It is a proprietary system.

Table 2. Technical Features MediaFLO

Feature	Description
Frequency band used	• UHF (470-800MHz) • L Band (1452-1492 MHz)
Band width	• 6MHz • 7MHz • 8MHz
Modulation method	• QPSK,16QAM, DQPSK
Transmission Methode	• OFDM
Channel Codification	• Código convolutivo • RS (Reed Solomon)
Multiplexation	• FLO System
Video Codification	• Video MPEG-4
Audio Codification	• MPEG-4 AAC / HE-AAC
Data Services	• IP through cellular network

3.3.3 Deploy Architecture

In the Figure 5 the deployment architecture of MediaFlo is shown, in this architecture, 3 important components could be identified: National Operator Center (NOC), FLO Transmitters and FLO receiver.

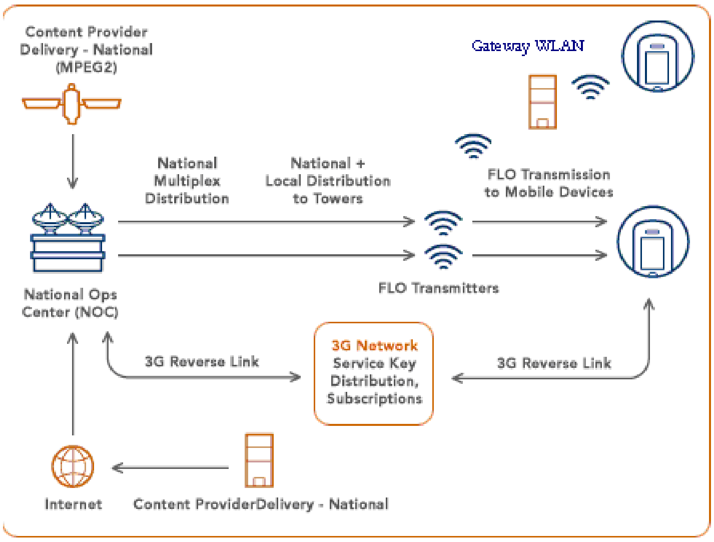

Figure 5. Deployment architecture of MediaFLO

National Operator Center: Receives the real time content from content providers like satellite network; and the non real time content from Internet. All these contents are reformatted into FLO Packet stream and is distributed over a single frequency network to the FLO transceivers.

FLO Transmitters: Receives the FLO packet stream and convert them into a FLO waveform which is radiated to mobile devices.

FLO Receiver: It is represented by a mobile device with FLO reception. Counts with access to 3G network to manage the interactivity with the content and services consumption.

This architecture enables the convergence of television services through Ad-hoc networks, thus allowing the contents of the broadcast can be received from WLAN networks (WLAN Gateway). This ensures the full access to mobile TV services

3.4 ISDB-T (Integrated Services Digital Broadcasting-Terrestrial)

3.4.1 Technical features

ISDB-T (Integrated Services Digital Broadcasting-Terrestrial) is the Japanese standard used for digital audio and television transmission. [16][17]

This standard was designed from beginning to receive the television and audio signals on mobile devices at the same time home television do it. Actually, this standard is deployed on Brazil (including an improvement to support MPEG-4 on the transmission), Peru, Chile, Paraguay, Argentina, Ecuador, Venezuela and Costa Rica. [11]

The modulation is performed through QPSK, 16QAM, DQPSK, and use OFDM segmented in 13 segments per channel for the transmission. Use the range frequency 470 MHz-800 MHz from UHF band, getting a band width about 6, 7 and 8 MHz. [16][17] Use MPEG-2 (ISO/IEC 13818-2) and H.264 for video compression and MPEG-2 AAC (ISO/IEC 13818-7) for audio compression. The data transmission is realized by BML (XHTML), ECMA Script. [16][17]

Normally, the multimedia and audio signals, and interactive data are individually synchronized though common interface for the MPEG-2 Transport Streams, these streams are multiplexed in one MPEG-2 transport stream, to which an error correction method is applied to be codified and sent over any medium (Satellite, Cable, Air or Mobile) [17]

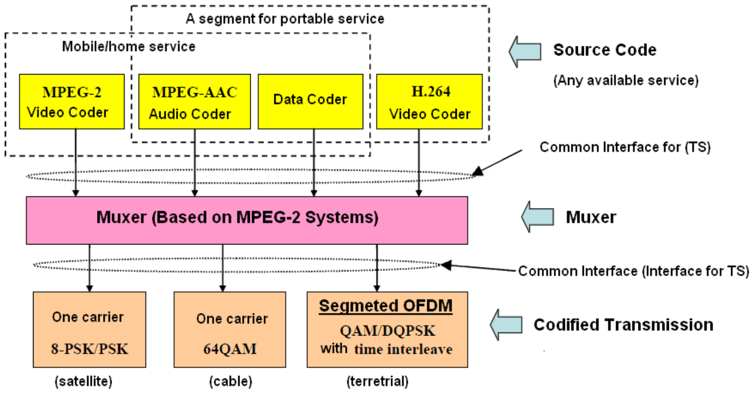

Figure 6. Structure of digital transmission system of ISDB-T

Summary of the technical features of the ISDB-T standard is shown [17][18].

Table 3. Technical Features ISDB-T

Feature	Description
Frequency band used	• UHF (470-800MHz)
Band width	• 6MHz : 3.7 – 23.2 Mbit/s • 7MHz : 4.3 – 27.1 Mbit/s • 8MHz : 4.9 – 31.0 Mbit/s
Modulation Method	• QPSK,16QAM,64QAM, DQPSK
Transmission Method	• OFDM segmented (13 segments per channel)
Channel Codification	• Convolute code • RS (Reed Solomon)
Multiplexation	• MPEG-2 Systems
Video Codification	• Video MPEG-2
Audio Codification	• MPEG-2 AAC
Data Services	• BML (XHTML), ECMA Script

3.4.2 Advantages and Disadvantages

a) Advantages [16][17]

- Better improvement of the frequency spectra; this is, in one channel is possible to offer multiple services, and it is not necessary an additional channel. All of this is call hierarchical transmission.
- ISDB-T generates saving in the transmission infrastructure, just one transceiver is used to offer services to fixed, mobile and portable devices.
- To reduce the energy consume, ISDB-T uses partial modulation, in which the 6 MHz signals are sent, and 432 KHz signals are received, getting a reduction of speed of 1/8 in the modulation.

3.4.3 Deploy Architecture

The deployment architecture of ISDB-T is shown, in this architecture, 3 important components could be identified:

Service provider, Broadcasting system and ISDB-T receiver.

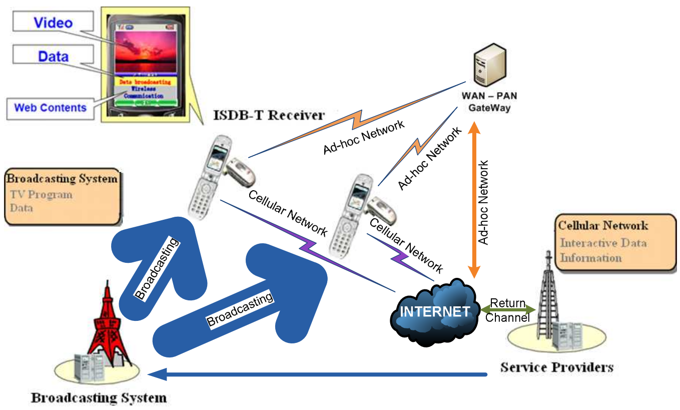

Figure 7. Deployment architecture of ISDB-T

Service Providers: This server contains all the interactive applications and services, which will be executed in the receiver. Also contain all the data services like news, life program, games, etc. This server keep the interaction of the user with the services through the return channel (wireless networks).
Broadcasting System: This system multiplexes the audio and video TV programs with the interactive data; and distributes to the users, through the broadcast channel, in MPEG-2 and sometimes, in MPEG-4 format.
ISDB-T Receiver: It is represented by the mobile terminals that receive and play the ISDB signals. For the interactive applications or services that use the return channel, the device uses the cellular or wireless networks to access to the services.
The Ad-hoc network is included in the return channel, using a WAN-PAN Gateway that allows send to the Service Provider the events and responses of interactivity actions. This implementation is based on [15] and do not affect the broadcasting system.

3.5 DVB-H (Digital Video Broadcasting for Handheld)

It is the acronym of (Digital Video Broadcasting). DVB-H is an open standard developed by DVB Forum, constitutes a diffusion platform based on IP for mobile and portable devices. It is a DVB-T adaptation to support limitations of mobile devices. Actually, is the accepted standard by the European Union and Nokia and Motorola are working in develop this technology. [19]

3.5.1 Technical features

Actually, this standard is deployed on European Union, Colombia and Uruguay [12]. That is the reason this paper contain a section to deep in DVB-H.
The modulation is performed through QPSK, 16QAM, 64QAM, and use OFDM for the transmission. Use the range frequency 174-240 Mhz from VHF, 470-862 Mhz from UHF, getting a band width about 6, 7 and 8 MHz. [19][20]
Use MPEG-2, MPEG 4 and H.264 for video compression and MPEG-2 AAC (ISO/IEC 13818-7) for audio compression. The data transmission is realized by IP. [19][20]
To reduce de power consume, DVB-H applies Time Slicing Technique, consisting in transmit the signals in burst allowing the receiver to go into sleep mode, waking up when the service is transmitted. [20]

Table 4. Technical Features DVB-H

Feature	Description
Frequency band used	• UHF (470-862 MHz) • VHF (174-240 MHz)
Band width	• 5MHz • 6MHz • 7MHz • 8MHz
Modulation Method	• QPSK,16QAM,64QAM
Transmission Method	• OFDM
Channel Codification	• Convolute code • RS (Reed Solomon)
Multiplexation	• MPEG-2/4 Systems
Video Codification	• Video MPEG-2 H.264
Audio Codification	• MPEG-2/4 AAC
Data Services	• IP

3.5.2 Advantages and Disadvantages

a) Advantages

- DVB-H can share spectrum (and investments) with DVB-T, using hierarchical modulation or multiplexation. DVB-H can work without any existent service would be disconnected.
- DVB-H uses time slicing to enhance the battery life by leaving the RF front end off 90% of the time. [21]
- DVB-H is an open standard, it is available to everyone to develop and deploy Mobile TV and Services.

b) Disadvantages

- DVB-H is an adaptation of DVB standard used in Europe for standard DTV transmission with a low power mode for battery-powered devices.
- Time to change a channel (Zapping time), about five seconds.

3.5.3 Deploy Architecture

The deployment architecture of DVB-H is shown, in this architecture [22], important components could be identified: Broadcast Service provider, Broadcast Network, DVB-H receiver, Internet Service Provider, Mediation Platform and Mobile Cellular Network.

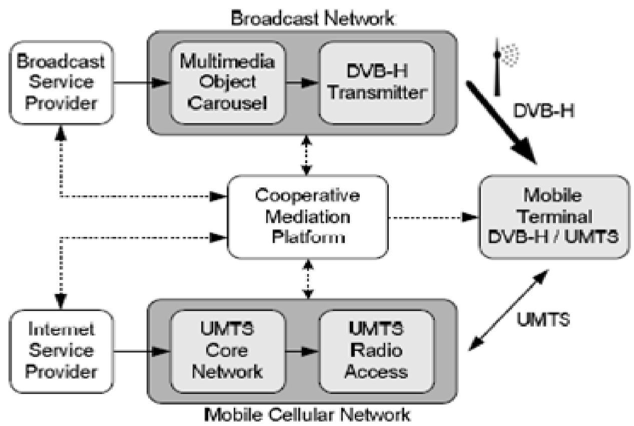

Figure 8. Deployment architecture of DVB-H

Broadcast Service Providers: This server contains all the broadcast content (TV programs) and all the data services associated to the content like news, life program, games, bibliography, etc.

Broadcast Network: This system multiplexes the audio and video TV programs with the interactive data and generates the object carousel. Also, generates the IP package to encapsulate the streams in DVB-H standard; and distributes to the users through the broadcast DVB-H channel in MPEG-2 and sometimes in MPEG-4 format.

DVB-H Receiver: It is represented by the mobile terminals that receive and play the DVB-H signals. For the interactive applications or services that use the return channel, the device uses the cellular or wireless networks to access to the services.

Internet Service Providers: This server contains all the interactive applications and services, which will be executed in the receiver and are not associated to the content. This server keep the interaction of the user with the services through the return channel (wireless networks).

Mediation Platform: This system synchronizes the interactive applications or services with the broadcast content. Determines if the interaction receive from the user requires a changes in the broadcast channel or establish the direct communication between the receiver and the interactive service.

Mobile Cellular Network: It represents the return channel used by the mobile devices to interact with the application and services.

This architecture based on mobile TV, does not guarantee full access to devices that do not support DVB-H standard. However, thanks to ad-hoc networks is possible to access television content for multiple devices. This last aspect is taken into account in the proposed architecture for mobile TV with DVB-H, presented at the end of this paper.

3.6 Digital Television in Colombia

On August 28th of 2008, Colombia chooses the digital television standard to be used in the country (DVB using MPEG-4 compression system). This decision was taken after several forums were making in different regions, the standards developers (United States, Europe, Brazil, Japan and China) were visited, working tests were performed and meticulous analysis was did to choose the standard that offers the betters conditions to Colombia. The country set as a maximum period of 10 years for transition from analogous to digital television. [23]

DVB standard was chosen taking in count the technical tests, the socio-economic impact study, the uses, habits and preferences viewers study, and the cooperation and technology transference offered by the standard developer. [23]

The European standard presents the following features [23]:

- Interactive and multi-channel advantages.
- Better flexibility of the signal in various geographic areas.
- Lower estimated costs in implementation.
- STB cheaper, due to the European standard has been adopted for more countries than the others standards.
- The European Union presents a complete offer of International Cooperation.
- DVB has the option of the reception of signal on mobile and portable devices
- Better audio and video quality.
- Possibility of doing interactive developments.

Regulatory decisions taken by Colombia were [23]:

- Period of transition from analog to digital television system: maximum 10 years.
- Digital Terrestrial Television is free and the open television licensees must provide the same free content broadcasts in analog system, in mobile and digital television one
- It is forbidden to transfer to third parties for the operation of portions of the spectrum. Is assigned to each dealer privately operated national television, 6 MHZ.
- H.264 and MPEG-4 compression system is adopted, according to the recommendation of the ITU.
- In 2010, 25% of the Colombian population must have DTT (digital terrestrial television).

As for mobile TV, the national television commission has not yet specified any regulation about it, which is why the mobile operators have not yet gone on experimenting with the TV in this medium.

At this time, TIGO, is the only operator that is offering mobile TV through the 3.5 G network using IPTV, always that the users comply with the following requirements [24]:

- The user must have a 3.5G device in the list of allowed devices.
- The mobile device must have streaming video capabilities.
- The users must pay TV consumption of 1 day valued at US$ 2 (2010 price).

Channels that are available in TIGO services are: Cablenoticias, MTV, CNN, Discovery Channel, Discovery Kids and Nickelodeon.

4. Differences between the analyzed standards – Comparative Table

Comparison between the analyzed standards in more representative aspects is shown. This comparison is the result of a study realized by Borko and Syed in “Handbook of Mobile Broadcasting: DVB-H, DMB, ISDB-T, and MediaFLO” book [24] and extract this features directly from the respectively standard.

In the Figure 9, the range of frequencies used by the standards is shown [13]. Lets visualize in which frequency band each standard is work.

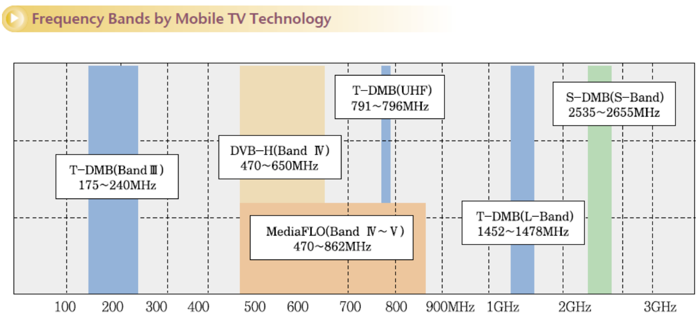

Figure 9. Band Frequency used by the standards

Table 5. Comparative Table

Feature	T-DMB	MediaFlo	ISDB-T	DVB-H
Frequency band	VHF	VHF UHF	UHF	VHF(174-240 Mhz) UHF(470-862 Mhz)
Channel bandwidth	1.56 MHz	5 MHz 6 MHz 7 MHz 8 MHz	6Mhz 7Mhz 8Mhz segmented in 432 KHZ	5 MHz 6 MHz 7 MHz 8 MHz
Spectral efficiency (bps/Hz)	0.2-1.2	0.47-1.87	Unkown	0.46-1.86
Modulation in transmission	OFDM	OFDM	OFDM segmented in 13 segments per channel	OFDM
Modulation	QPSK	QPSK 16QAM	DQPSK QPSK 16QAM 64QAM	QPSK, 16QAM, 64QAM
Average Channel Switching Time	~1.5 sec.	1.5 sec.	~1.5 sec.	~2.0 sec.
Video Watch Time with 850 mAhr Battery	~2 hours	Goal ~3.8 hours (at 360kbps)	Unknown	Goal ~4 hours Demo ~2 hours with 1600 mAhr battery
Channels Per Transceiver	3 channels, 1.5 MHz ~ 250kbps each	20 channels, 6 MHz ~ 300kbps each	13 channels, 6 MHz ~ 230kbps each	9 channels, 6 MHz ~ 300kpbs each
Channels per MHz	~2	>3	~2	1.5
Max Data Rate	Up to 1.4 Mbps	Up to 15 Mbps	416 Kbps, 280 Kbps, 1.78 Mbps	23.75 Mbps
Max distance to transceiver	Up to 90 Km	Up to 25 Km	Unknown	Up to 40 Km

After the information from table had been analyzed, the comparative conclusions are:

- The band frequencies used by the standards are VHF, UHF or a mix of them
- MediaFlo and DVB-H offer more bandwidth than the other standards, this permit improve the spectrum to distribute more programs and services.
- DVB-H and MediaFlo give the biggest data rate than the other standards
- DVB-H and MediaFlo systems can achieve better spectral efficiency than their competitors, having more possibilities to find available frequency channels in different broadcasting bands
- All the standards use OFD to transmission modulation, this strengthens the concept that is the better method to warranty the efficiency in the use of the frequency and reduce the interference between channels.

In the other aspects all the standards present similar behavior and performance, indicating that no one is better o worst than others, all the standards are good, each one has its own strengths and weaknesses and the use in determine country depends of the benefits, support and cooperation found by the commission assigned to take the decision.

5. Architecture for DVB-H Mobile TV

Considering the network-level convergence around a mobile, plus the need to provide full service coverage of television, mobile ad-hoc networks are an important input for mobile TV broadcasting on environment: WLAN and PAN (Personal Area Networks). This architecture takes into account the involvement of ad-hoc networking environments television to allow full access to the service. On the other hand, According to studies of usability and evaluation of standard DVB-H, referred by other authors, the main problems of the mobile TV can be summarized in the following aspects: The mobile television based on DVB-H only provides local interactivity [22], The time average to watch is of 10 minutes during the day [26], the time used in changing from a channel to another one is approximately 10 seconds [26], the access to the content multimedia through an interactive guide is troublesome, considering who can be spent great part of the time average of use of the device in the search of a content or cannel [26], mobile television does not offer a simple experience to the user like the conventional television, as far as the handling of simple controls [26], the television signal is unstable in regions with non-uniform relief [26], mobile TV is a personal and nonsocial fact [26].

From the previous thing it is possible to be deduced that it is necessary to adapt the architecture traditional of mobile television. It is important to raise an architecture that gives answer to some of the previous problems. This architecture has been designed from the projects in the experimental laboratory of digital television at the University of Cauca and have the following objectives:

- To guarantee full interactivity and convergence of additional services (chat, voting, forums, information of support to the content) by means of a return channel (cellular network).
- To facilitate the access to the contents multimedia, improving the form in which the jump becomes from a channel to another one (zapping). This process must become by means of a mechanism that avoids the jump from a channel to other to find content determined, which can be solved changing the traditional way of jump of channel by a finder of contents in the interface of the television system [27].
- To suppress the interactive guide promoting the premise

"a click to see" of the conventional television. This aspect can be solved or be replaced by a system of recommendations, which when entering the platform, present in screen, a set of channels according to the profile of the user [27].

- To offer tie information services with a television program. Ex: biographies, surveys, etc.; these are known like associated services.

The architecture presented in Figure 10, considers the previous aspects and is based on the architecture for 2.0 Mobile TV proposed in [22], from this some modifications related to personalization components and components for the semantic description of the contents were added. Additionally, this architecture takes into account ad-hoc mobile networks, allowing television content can be disseminated in networking WLAN and PAN, as WiFi and Bluetooth.

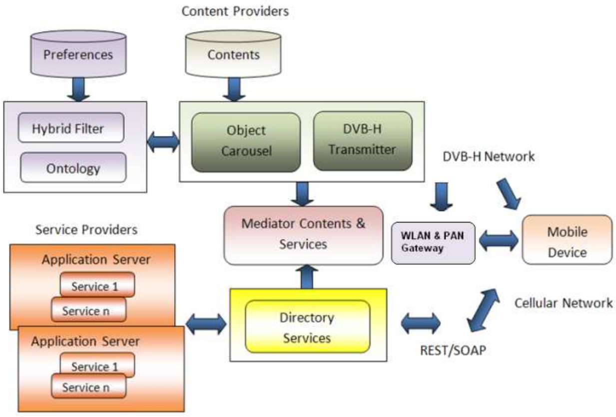

Figure 10. Deployment architecture of Mobile TV

In Figure 10, each one of the components of the Architecture of Reference is presented. It is important to emphasize that the transmission of the content television multimedia becomes through channel of broadcast or channel of diffusion, by means of standard DVB-H, whereas the consumption of the interactive services is realized through a return channel. Considering that a mobile device can accede to Internet by means of the cellular network, this becomes the best candidate to act like channel of interactivity. The consumption of services by cellular network becomes through protocol REST (Representational State Transfer), which is an implementation of Services Web that guarantees the efficient consumption of data, compared with protocol SOAP (Simple Object Access Protocol). Next each one of the components of the architecture is described.

WLAN & PAN Gateway: This module is a gateway through which it takes the TV signal and mapped to streaming on WLAN and PAN as WiFi and Bluetooth. Thus convergence can allow teams that do not support the DVB-H standard through adhoc networks.

Directory of Services: This module contains a catalogue with the services to unfold with the content multimedia. These services are indexed the directory and can be offered by diverse services providers, thus allowing characteristic of integration and composition. The indexed services can be of 2 types: associated or not to the content, in the first case they are unfolded at a certain moment within a television program, whereas in the second case they are independent to the content and they are available throughout the television program; within the not associated services they are: chat, forums, wikis and within the associates are: surveys, voting and information of support to the content. The directory of services is invoked from the mobile client through cellular network using the protocol of Services Web: REST.

Applications Server: It contains each one of the services pertaining to diverse dispersed suppliers through Internet, which are added the Directory of Services.

It contains each one of the services pertaining to diverse dispersed suppliers through Internet, which are added the Directory of Services. It contains each one of the services pertaining to diverse dispersed suppliers through Internet, which are added the Directory of Services. It contains each one of the services pertaining to diverse dispersed suppliers through Internet, which are added the Directory of Services. It contains each one of the services pertaining to diverse dispersed suppliers through Internet, which are added the Directory of Services. It contains each one of the services pertaining to diverse dispersed suppliers through Internet, which are added the Directory of Services. Final of formulary

Multimedia Objects Carousel: It is the unit, on which the suitable contents travel multimedia to the format of mobile television, which are obtained from the content provider; of equal way the carousel transports the interactive guide of television, which operates in this case of transparent way in the end user, due to expressed usability conditions. The interactive guide in the present architecture fulfills an intention different, which consists of registering tie contents and services in a television program; the registry of this information realizes the Mediator of Contents and Services through entrances XML.

DVB-H Transmitter: Within this unit the transmission of the content is realized packaging in the multimedia objects carousel (content and interactive guide), equipping to the content of the necessary characteristics of modulation demanded by the standard of mobile television: DVB-H.

Mediator of Contents & Services: This block is of extreme importance, since when equipping to the system of mobile television of bidirectional interactivity by means of a return channel (cellular network), it is necessary to synchronize this last one with the network of television DVB-H; this process of synchronization consists of tying services and contents through the interactive guide, in such a way that each content has available services in the television program.

Hybrid Filter and Ontology: Hybrid filters modules and ontology to handle the information of user preferences (contents, programs and thematic favorites) by means of XQL queries. According to the preferences and through network DVB-H, a series of contents or programs is recommended and presented to the user through a mobile browser. In mobile browser there is also a semantic search engine, which links the user preferences with available media, presenting at device's screen showing the search result according to the profile. Thus one looks for to improve the traditional form of channel jump to look for the contents or programs.

Content Repository and Preferences: The content repositories and preferences are stored multimedia content providers and user preferences. When a user enters the

mobile TV platform for the first time, must register their preferences or tastes in content, or thematic programs. When a user enters the mobile TV platform for the first time, must register their preferences or tastes in content, or thematic programs. This information is stored in the repository of preferences, and dynamically changes according to the contents that the user consumes and valued.
The components of ontology and the hybrid filter are responsible for recommending new contents from the updated preferences. Similarly in the process of semantic search of a specific content, the component of ontology classifies search results, taking into account user preferences, giving priority to the results related to the dynamic profile.
Mobile Device: The mobile device is responsible for presenting on-screen, the recommendations of content generated by the hybrid filter and ontology. Likewise, the mobile interface presents a search bar for channels or content, which lists in screen the contents or channels related to the item to look for and the user preferences. Additionally within the mobile interface shows the additional services associated or not to the content; associated services are part of the TV, while not associated services are located in a region of screen that will not interfere with the deployment of content.

6. Conclusions

- All technologies analyzed with the exception of mobile IPTV, make use of broadcast transmission mode. Therefore do not allow two-way interactivity.
- Ad-hoc networks enable convergence of television service, allowing devices that support the DVB-H standard to access television services on WLAN or PAN environments.
- All the existed technologies for digital television transmission require a return channel to allow the interactivity between the final user and the content or service presented on screen. This interactivity is realized through wireless or cellular networks, this mean, all the devices must have a data connection active to a right performance of the digital television and the access to interactive services.
- Including Ad-hoc networks in the return channel is a great idea that allows implement and use the remote interactive actions having low cost for TV users, however it requires government support and manufacturers collaboration to provide frameworks that allow manage this kind of connectivity and access to the TV features.
- All the analyzed standards use OFDM modulation to transmit the digital television streams to mobile devices. This mean, there is not a perceptible advantage between them in this aspect.
- Mobile Device requires an adequate receiver of digital television signals formatted into a specific standard, except mobile IPTV that requires the RTP protocol implementation and QoS manage in network.
- No standard is better or worse than another, all standards are good, each has its own strengths and weaknesses, and its use in a given country depends on the benefits, support and cooperation found by the commission assigned to make the decision.
- IPTV Mobile is the only system that allows the sending of multimedia content and services over a single network (cellular network), operating in unicast and multicast mode.
- Although DVB-H technologies is one of the most widespread has the problem of further delay in the channel change. This is revised in the proposed architecture.
- A good spectral efficiency is translated into a reduction in the quality of multimedia content.
- The most economical system to install on equipment and networks are T-DMB and Mobile IPTV (Based on the cellular network).
- The DVB-H standard is the most optimized battery in the mobile television service.
- One of the trends in mobile TV is to optimize the access time to media, based on viewer preferences.
- The architecture proposed in the last section attempts to solve the problems of the standard DVB-H related to channel change time and access time.

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