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INTEGRATING MOBILE MULTIMEDIA SERVICES INTO A BROADCAST SYSTEM; OPTIONS, CHOICES, AND WHAT YOU NEED TO KNOW

Name of Author: David Neff

Axcera, LLC, USA

ABSTRACT

Mobile TV technology allows television broadcasters to entertain, educate and inform viewers wherever they are, and broadcasters are understandably enthusiastic about the new business opportunities this service will enable. In order to make mobile TV service commercially viable, it is essential that the broadcast transmission network is designed and implemented to provide robust signal coverage to viewers. This paper will describe the options and choices to incorporate mobile TV transmission capabilities into traditional terrestrial digital TV transmission facilities, covering such areas as exciter conversion, multiplexing, single frequency networks (SFNs), power level and coverage considerations for mobile vs. fixed reception, and all aspects of the transmission network that are affected. While mobile TV service can be implemented by broadcasting from a single transmitter, the more demanding signal propagation requirements for reception by a portable receiver and for mobility may justify the implementation of a multi transmitter network, with transmitters operating at different power levels to optimize signal coverage. The paper will also discuss the concepts involved in planning ahead for migration from a single transmitter network to a multi-transmitter network.

DIGITAL TELEVISION STANDARDS

The majority of digital television systems are based on the MPEG-2 multiplexed data stream standard, and use the MPEG-2 video codec. The various digital television standards differ significantly in the video and audio format, and conversion of the MPEG stream to a TV broadcast signal. Implementation of mobile TV and mobile-multimedia services within these various standards also differs. The following is a description of the major digital televisions standards that support mobile TV services.

ATSC was developed by the Advanced Television Systems Committee and is the standard adopted in the United States, Canada, Mexico, South Korea, and Honduras. The terrestrial ATSC system uses 8-VSB modulation, a vestigial sideband technique. 8-VSB is an eight level amplitude modulation format. ATSC is not as inherently robust as other digital systems for multipath interference, however it is superior for impulse noise which is especially present on the VHF bands that remain in operation in the US. ATSC does not support hierarchical modulation. ATSC has introduced a mobile TV Candidate Standard branded ATSC M/H for “mobile/handheld” that is fully compatible with ATSC terrestrial service. As of this writing the Candidate Standard is scheduled for completion in May 2009.

Characteristics	
Modulation	8-VSB (Vestigial Side Band)
Inner Code	TCM 2/3
Outer Code	Reed Solomon (207,187,10)
Bandwidth	6MHz
Total Symbol rate	10,76 Mbauds
Data bit rate	19.39 Mbps

TABLE 1 – Characteristics of the ATSC standard (1)

DVB (Digital Video Broadcast) is used in most of the rest of the world. DVB-T, the terrestrial broadcast standard, was developed to provide format compatibility with direct broadcast satellite services in Europe using the DVB-S standard as well as the DVB-C standard for cable television. DVB-T uses coded orthogonal frequency division multiplexing (COFDM), which uses as many as 8000 independent carriers, each transmitting data at a comparatively low rate. This approach provides superior immunity from multipath interference. DVB also introduced DVB-H ("H" for "handheld"), which supports broadcasts for reception by portable and mobile devices.

Characteristics	
Multiplex	COFDM (2k and 8k)
Modulation	QPSK, 16QAM or 64QAM
Inner code	Convolutional 1/2, 2/3, 5/6, 7/8
Outer code	Reed Solomon (204,188,8)
Bandwidth	6MHz, 7MHz or 8MHz
Guard Time interval	1/4, 1/8, 1/16 and 1/32
Data bit rate (6MHz)	Min: 3.73Mbps - Max: 23.7Mbps

TABLE 2 – Characteristics of the DVB-T standard (2)

ISDB-T (Integrated Services Digital Broadcasting) was developed by the Association of Radio Industries and Businesses (ARIB) and is the digital standard in Japan. Brazil has adopted a modified version called SBTVD. ISDB-T operates in VHF and/or UHF bands, and uses COFDM modulation similar to DVB. In Japan, ISDB-T is implemented with the MPEG-2 video codec and in Brazil with the MPEG-4 codec. ISDB is very similar to DVB, however it is broken into 13 subchannels. Twelve are used for fixed TV, while the last serves either as a guard band, or for ISDB-H mobile terrestrial digital audio/video and data broadcasting service (e.g. the 1seg service in Japan).

Characteristics	
Multiplex	COFDM (2k, 4k and 8k)
Modulation	DQPSK, QPSK, 16QAM or 64QAM
Inner code	Convolutional 1/2, 2/3, 5/6, 7/8
Outer code	Reed Solomon (204,188,8)
Bandwidth	6MHz
Guard Time interval	1/4, 1/8, 1/16 and 1/32
Segments	13

Data bit rate per segment	Min: 280.8kbps - Max: 1.79Mbps

TABLE 3 – Characteristics of the ISDB-T standard (3 &4)

DTMB (Digital Terrestrial Multimedia Broadcast is the standard adopted in China including Hong Kong. DTMB is a hybrid system following the ADTB-T (Advanced Digital Television Broadcast-Terrestrial) standard for single carrier mode and the DMB-T/H standard (Digital Multimedia Broadcast-Terrestrial/Handheld) standard for multicarrier mode. Two multiplex schemes coexist in the DTMB standard, vestigial sideband (VSB) and time-domain synchronous OFDM. The standard does not restrict implementation to a specific video codec. The DTMB standard was developed to support both fixed and mobile TV service.

Characteristics	Single Carrier Mode	Multicarrier Mode
Multiplex	Vestigial Side Band (VSB)	Time-domain synchronous OFDM (TDS-OFDM)
Modulation	4QAM-NR, 4QAM, 16QAM, 32QAM	4QAM, 16QAM, 64QAM
Inner code	LDPC (Low Density Parity Check) (7493, 3048), (7493, 4572), (7493, 6096)	
Outer code	Reed Solomon (204,188,8)	
Code Rate	0.4(7488, 3008), 0.6(7488, 4512), 0.8(7488, 6016)	
Bandwidth	6MHz or 8MHz	
Guard Time interval	1/9, 1/7, or 1/4	
Data bit rate (6MHz)	Min: 4.81Mbps - Max: 21.96Mbps	

TABLE 4 – Characteristics of the DTMB standard (5)

MAJOR COMPONENTS OF A DIGITAL TELEVISION TRANSMISSION FACILITY

Figure 1 shows the functional components of the transmission facility signal flow of most digital television stations. While the quantity, quality and implementation of each might vary, the basic functionality remains the same.

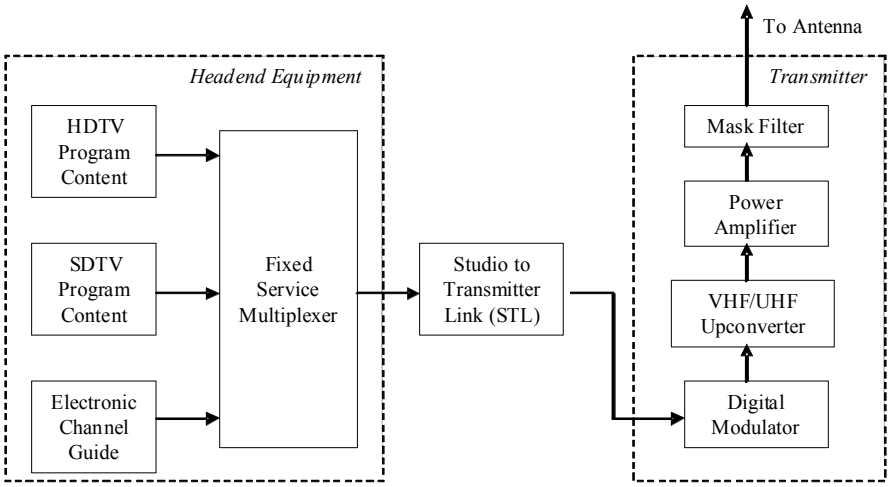

Figure 1
Typical Digital TV Transmission System

Terminology Note: Throughout the remainder of this paper "digital TV fixed service" will be used to which describes programming to fixed television receivers and "mobile TV service" will be used to describe which describe programming to handheld and mobile receivers.

The functional components of digital television transmission systems include:

Digital TV Fixed Program Headend Equipment

This headend equipment includes program source encoders, multiplexers and an Electronic Service Guide (ESG) generator. Various types of encoders and multiplexers are available for digital TV fixed service to address the features required by each broadcaster. Equipment is selected based upon the requirements for standard-definition (SDTV) and/or high-definition (HDTV) capability; number of programs; static or dynamic multiplexing; etc. All digital television stations that generate local program content use a multiplexer for their current digital TV fixed service. Whether these multiplexers can remain in service with the addition of mobile TV service and whether they must be augmented with additional equipment depends on the digital television standard.

Studio to Transmitter Link (STL)

The STL can be microwave, fibre optic or satellite. As long as the digital STLs are capable of transmitting the bandwidth required for both fixed and mobile TV services they should not require replacement with the addition of mobile TV service to a broadcast facility.

Digital Transmitter

The digital transmitter includes a modulator, upconverter, power amplifier and mask filter. The digital TV modulator accepts baseband ASI or SMPTE310M bitstream and modulates the bitstream to the appropriate digital modulation scheme at an intermediate frequency (IF), typically 36 or 44MHz. The upconverter converts the IF signal to the desired final VHF or UHF broadcast channel. The pre-amplifier that amplifies the RF signal to the necessary level required to drive the final high power amplifier(s) (HPA). With the possible exception of the modulator, all of the legacy digital TV transmitter components are capable of passing a mobile TV transmission signal, so for the purposes of this paper, the discussion will be limited to the modulator.

IMPLEMENTING MOBILE TV SERVICE IN AN ATSC DIGITAL TELEVISION TRANSMISSION FACILITY

Figure 2 shows the functional components of and ATSC transmission facility with the addition of ATSC M/H components described below for mobile TV service.

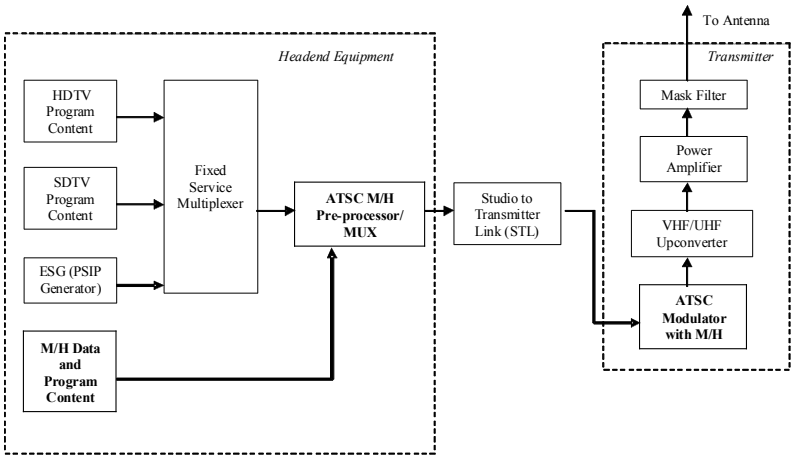

Figure 2.
ATSC Transmission System Including M/H

ATSC Multiplexer

Existing ATSC multiplexers can remain in service, but they will continue to handle only the fixed digital TV programming. An ATSC M/H multiplexer must be added which includes an ATSC M/H pre-processor to incorporate the ATSC M/H content into the ATSC bit stream. The ATSC M/H multiplexer accepts inputs from the ATSC fixed service MUX and the ATSC M/H encoder(s), as shown in Figure 2. The ATSC M/H MUX will typically include an ASI and/or SMPTE 310M input for the ATSC fixed content, as well as an IP input for the ATSC M/H content. The ATSC M/H pre-processor adds the additional forward-error correction (FEC) and timing sequences to ensure that the ATSC M/H signal is robust enough to provide reliable reception by mobile receivers.

ATSC Modulator

Most legacy ATSC modulators cannot be updated to operate in ATSC M/H mode or to operate as part of a Distributed Transmission System (DTS). However, some newer digital signal processing (DSP) based designs, such as Axcera's "Axciter" Intelligent Modulator, are capable of being upgraded to mobile TV and DTS operation with a firmware update from the manufacturer. For ATSC M/H operation, the firmware update allows the modulator to recognize the incoming ATSC M/H packets that were created by the mobile TV pre processor. It also adds a post processor block that manipulates the mobile TV packets of the stream to ensure backwards compatibility with ATSC fixed receivers. For DTS, the modulator must also be able to operate in DTS slave mode.

IMPLEMENTING MOBILE TV SERVICE IN DVB-T, ISDB-T AND DTMB-T/H DIGITAL TELEVISION TRANSMISSION FACILITY

Figure 3 shows the functional components DVB-T/H, ISDB-T/H and DTMB-T/H transmission facilities supporting both fixed and mobile services.

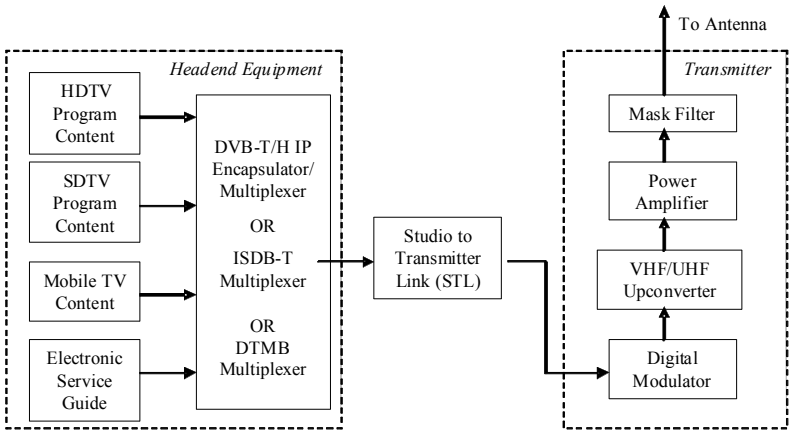

Figure 3
Typical DVB-T/H, ISDB-T/H or DTMB Transmission System

OFDM IP Encapsulator, Multiplexer and SFN Adapter

Since DVB, ISDB-T and DTMB were initially developed to support both fixed and mobile service most existing multiplexers support both fixed and mobile TV programming. For DVB the multiplexer adds the Forward Error Correction (FEC) whereas for ISDB and DTMB the modulator adds FEC. ISDB-T multiplexers also have the capability for conditional access. The ESG is also an input to the multiplexer and becomes part of the data transmission stream.

OFDM Modulator

DVB, ISDB and DTMB modulators from most manufacturers support both fixed and mobile service in the same hardware. Enabling the mobile TV service capability in these modulators is achieved in the software or firmware of the modulator. This is accomplished with either a change in the user changeable configuration settings, or through an update of the unit's software.

SINGLE FREQUENCY NETWORKS & DISTRIBUTED TRANSMISSION SYSTEMS

Mobile TV can be implemented with each of these standards by broadcasting from a single transmitter. However, unlike fixed TV service where viewers in weak signal areas can improve reception with directional rooftop antennas, mobile TV receivers are close to ground level, are often indoors and use relatively small omni-directional antennas that can be oriented in any plane. In addition, mobile TV receivers are not just portable; they can be mobile, meaning they are often moving, which creates a Doppler effect. To create commercially viable mobile TV service, broadcasters will be challenged to determine how to improve their fixed broadcast systems to also reach an acceptable percentage of their target mobile TV viewing audience.

Fortunately, Single Frequency Networks (SFN) have been used extensively in fixed broadcast networks where terrain shielding has created gaps in coverage. SFN functionality is similar for all OFDM technologies and Distributed Transmission Systems (DTS) is the SFN equivalent for ATSC. In a SFN all transmitters are locked (usually by GPS) to output the same carrier frequency with identical symbols, at nearly the same time (as received at the receiver). An SFN can be deployed with a single RF channel providing efficient spectrum utilization as well as simplicity for users where receivers only require tuning to one channel. An SFN can also be implemented using translators which receive the signal from the main transmitter and rebroadcast the signal on a different channel. However, the use of translators is less desirable than on-channel systems since additional spectrum is required and it requires receivers to change frequency during the handoff as a viewer travels between signal areas.

The most significant element of any SFN is differential delay of the transmitted signals so that the signal arrives at the receivers within the guard interval of OFDM systems or within the receiver equalizer tolerance for leading and lagging multi-path signals in ATSC systems. This is accomplished by setting the delay of each transmitter so that coverage is optimized. In mobile TV systems this is further complicated by the Doppler effect of receivers in motion which causes the signals to vary in frequency and thus delay. Designing a mobile multi-media system requires RF coverage planning that determines the optimal number, location and power levels of SFN transmitters as well as the optimal differential delay of each transmitter to achieve the target coverage area and maximum vehicular speed. In general, to improve indoor mobile TV reception with a SFN, there is an advantage to deploy more transmitters of lower power rather than fewer transmitters of higher power.

Implementation

SFN and DTS can be incorporated into most any mobile TV capable transmission system with the modification of existing equipment and the addition of new equipment. Figure 4 shows the functional components of a transmission system that includes both mobile TV services and SFN or DTS capability. For operation in an ATSC DTS system, a Distributed Transmission Adaptor (DTxA) is added to the signal path prior to the STL(s). The DTxA adds the necessary timing and synchronization information to the transport stream sent to all the transmitters in the network. The modulator of each transmitter must be capable of DTS slave mode to analyze the timing/synchronization information and delay transmission accordingly. For OFDM SFNs, an SFN Adapter (called TX Adapter for ISDB-T) performs the role similar to a DTxA and inserts the time

stamp (or in the case of DVB; the MIP-megaframe initialization packet) and mode data into the MPEG transport stream that is sent via STL(s) to the transmitter modulators in the network. The modulators delay transmission according to the timing information sent by the SFN Adapter. DTS and SFN networks use GPS receivers for synchronization of the DTxA or SFN Adapter and the transmitter modulators.

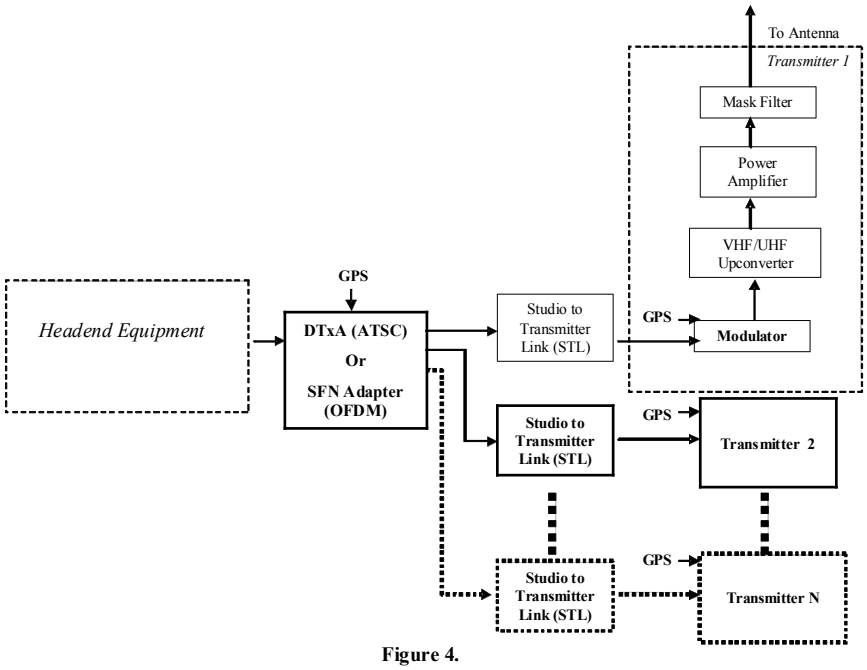

Figure 4.
SFN or DTS Mobile TV Transmission System

CONCLUSIONS

Mobile television offers broadcasters new revenue opportunities along with some technical challenges to implement. Fortunately these challenges can be managed with forethought and planning when building or modifying a digital television transmission facility.

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