Utilizing Open Source in Terrestrial Digital TV Broadcasting

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Abstract

Indonesian terrestrial TV broadcasting has just started its migration to digital standard. Digitalization offers more roles for software development in various functional blocks of digital TV system. This paper presents utilization of open-source softwares in assessing some aspects of terrestrial digital TV system. We propose technical specification and measurement standard operating procedure for basic services using DVB-T standard, and set-up a software-based platform based on open source softwares for testing a DVB-T set-top-box.

Keywords— **Digital TV broadcasting, digital migration, DVB-T, audio/video coding, multiplexer, STB testing, open source softwares, DekTec**

1. Introduction

It is argued that Free and Open Source Softwares (FOSS) can create value in the economy of developing countries [16]. FOSS offers new business opportunities, reduction of Information Technology (IT) cost and improvement in the effectiveness and efficiency of government. As a developing country, Indonesian government realizes the need for utilizing FOSS as an alternative way for providing legal software. Through its openness, it is expected that the country can avoid dependence or locked-in to a particular software vendor solution, and foster more innovation in the future. So far, the government with its marketing brand IGOS (Indonesia Go Open Source!) movement has had some impact in rapid use of FOSS for desktop applications in government institutions.

While FOSS are intensively used in Internet infrastructures and recently in office applications, there is a need to expand its utilization in various emerging technologies reflecting the convergence of multimedia services. In Indonesia, the participation of IT research and development agency, such as PTIK-BPPT, in utilization of FOSS is mainly in government, education and small-medium enterprises. With its expertise in FOSS and its involvement in the migration process towards terrestrial digital TV in Indonesia, then it is natural to start looking for a strategy to use FOSS in digital TV. Note that based on Indonesian ICT indicator, TV broadcasting penetration is higher than telecommunication [13]; hence, this is a potential alternative tool for improving information access in remote rural area of Indonesia.

The nature of open source development and vast information access offered by terrestrial digital TV system provide a promising information technology framework for open source communities in Indonesia. This paper then describes open source software deployment in a laboratory-based terrestrial digital TV system. The deployed system has been found useful in understanding concepts, experimentation, and justifying proposed the standard specification and regulation.

General description of terrestrial digital TV broadcasting in VHF and UHF bands, particularly in the context of DVB standard, is reviewed in Section 2. Section 3 then highlights the proposed Indonesian DVB-T technical specification. The need for experimentation and budget constraints require exploration on open-source softwares available in various functional blocks of digital TV system, which is discussed in Section 4. Section 5 summarizes our current stage of work and presents some future work.

2. Terrestrial Digital TV Systems

Migration from the current analog system to fully digital in terrestrial TV distribution is inevitable. Using digital provides advantages such as:

- Availability of sophisticated compression techniques which consequently results in much better spectrum utilization. This is particularly important in Indonesia where frequency allocation for terrestrial broadcast is already saturated.

- Robustness against interference and radio multipath effects; hence, the system can offer much superior audio and video quality, even with relatively lower transmit power and mobile receiver.

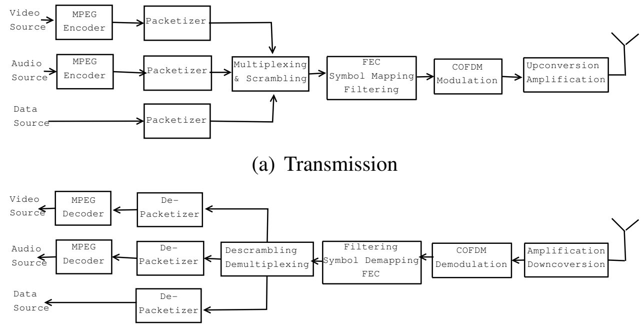
- Data transmission inside digital streams. The availability of various return channel will enable interactive and mobile services that demonstrates the convergence phenomenon of telecommunication, broadcasting, IT and media industry

Digital broadcast (Pay TV) using satellite and cable are already available for several years in Indonesia, but it is still at early migration stage for terrestrial services. Currently, most free-to-air terrestrial broadcasters in Indonesia are using digital system partially, e.g. for digital audio/video processing and program distribution to their remote relay stations using digital satellite broadcast (DVB-S). The first step in successfully migrating to terrestrial digital system is in adopting the standard. The ideal criteria for adopting a standard need to consider technology, industry, and economic aspects. The adopted standard needs to be technologically superior and open, and fosters local industry (content, infrastructure, etc.) development. Furthermore, it is important to benchmark the situation in neighboring countries and assess important industry consortium, in order to ensure equipment compatibility and interoperability

It is hard to fairly compare various standards that can fulfill all requirements above. As an initial step to push migration and keep the digital momentum going, selecting the most popular standard, that is also used by the neighboring countries, is a wise decision. For fixed terrestrial digital TV, Indonesian government regulates the use of European DVB-T standard [3]. In this case, one aspect of technology uncertainties has been reduced. For mobile services, the standard used is not limited by regulation, in which from positive view can be seen as a vast technologically-driven business opportunities, conditioned on the availability of spectrum frequency.

2.1. DVB-T Standard

DVB (Digital Video Broadcasting) standard is the family of standards developed by a consortium of over 270 broadcasters, manufacturers, network operators, and regulatory bodies, in order to ensure open technical standard for delivery of television and data services. For terrestrial services, there are two available standards, i.e. DVB-T for fixed services, and DVB-H for mobile and handheld receivers. General description of DVB-T system can be illustrated in Figure 1.



(b) Reception

Figure 1. Simplified view of the DVB-T chain.

Figure 1(a) shows data/signal flow on the transmission side. An important aspect of this digital data flow is on the choice of MPEG-2 as a data container. With this container, data of different format can be flexibly transported. It can be seen that raw data and compressed video/audio of various format can be just treated as packetized data and simply multiplexed and scrambled before wireless transmission. Further sophistication of compression techniques is simply reflected by the encoder at the transmit side and the decoder at the receiving end. The outputs of the multiplexer are 188 byte transport packets embedded with various service information such as tables in PSI (Program Specific Information) and DVB-SI (Service Information) that are used for EPG (Electronic Program Guide), conditional access in pay-TV, etc. Streams of these transport packets are then processed by the RF part of the system through FEC, symbol mapping (vector modulation), filtering before being modulated on multiple sub-carriers using OFDM (Orthogonal Frequency Division Multiplex). DVB-T offers two modes of OFDM: 2K and 8K mode. The choice of mode depends on the target service and coverage, e.g. 8K mode (8192 sub-carriers) is more suitable for SFN (Single Frequency Network) operation. The modulated signal finally goes through up-conversion and amplification stage for aerial transmission. The steps for data/signal reception is shown in Figure 1(b), i.e. a reverse of the above steps. In the migration process (simulcasting programs from both analog and digital TV infrastructures), a device called STB (set-top-box) is needed for receiving digital signal and display it on the conventional analog TV receiver.

The digital TV system can also be equipped with a return channel which sends information back from the audience to the broadcaster, i.e. creating a bidirectional communication. This enables enhanced and interactive features for various innovative services that are traditionally offered in telecommunication/Internet infrastructures, e.g. televoting, gaming, teleshopping, web browsing, etc. Several technologies used for a return channels are such as PSTN, GSM/3G, DEC, satellite, UHF terrestrial (e.g. DVB-RCT), etc. In addition to protocols that depend on the technology used as a return channel, DVB also provides a network-independent protocol called DSM-CC (Digital Storage Media Command Control) to control and manage MPEG streams, such as control of audio/video streams and events indicated by markers in the audio/video stream, download of data, etc. In the receiving side, the STB must have the ability to run applications that have been downloaded as a part of the broadcast streams. To achieve application portability across various STB platform, there needs a specialized software (middleware) which provides low-level access to the broadcast stream and STB hardware, and offers a unified standard for application developers. Among various middlewares available, MHP (Multimedia Home Platform) has received much interest due to its openness, supported by DVB that released GEM (Globally Executable MHP), and commonly used in multimedia application development. Applications for MHP can be written in either Java (DVB-J) or HTML (DVB-HTML).

The description above shows the importance of software in various functional blocks of digital TV system. The system itself is potentially a convergent network infrastructure where the STB can simply be treated as a computer or gateway server. This fact presents many opportunities in software development and services where open source communities can contribute.

3. Proposed Indonesian DVB-T Specifications and Measurement

There are approximately 140 millions TV audiences in Indonesia [1], and this clearly shows potential market for digital TV deployment. To foster digital migration, audiences need to be aware of the benefits of digital system, and this awareness can be achieved if affordable STBs are available in the market. To successfully deploy digital TV infrastructure using the proposed DVB-T standard, and to accommodate local industry interest, technical specifications for both transmitter and receiver need to be formalized by both government (regulator) and participants in digital broadcast industries.

As one of Indonesian government technical institutions, PTIK-BPPT proposes DVB-T technical specifications [14] based on worldwide standards, e.g. [7], [8], and the specifications adopted in neighboring countries with the objective to have local industries' participant in producing affordable STBs. A snapshot of some DVB-T parameters used in Malaysia and Australia is shown in Table 1. More details can be referred to [10], [14], and [15]. It can be seen that the proposed parameters in Indonesia are very basic in general, i.e. suitable for producing affordable STB. Some

	Malaysia [10]	Australia [15]	Indonesia [14]
Ch Bandwidth	8 MHz	7 MHz	8 MHz
Freq Range	470-860 MHz	174-230 MHz, 519-582 MHz, 582-820 MHz	470-860 MHz
Video	MPEG4/H.264AVC, MPEG2 (opt)	MPEG2, MPEG4/H.264AVC (opt)	MPEG2
Audio	MPEG-4 HE AAC, Dolby Digital AC-3	MPEG-1 layer II, Dolby Digital AC-3 (opt)	MPEG-1 layer II
Format	SDTV, HDTV	SDTV, HDTV	SDTV, HDTV (opt)
Function	+ Interactive	+ Interactive, Internet	Basic
Middleware	MHEG-5	DVB MHP	-

Table 1. Comparison of some DVB features with neighboring countries.

notably differences are seen in the choice of video/audio coding. In Malaysia and Australia, the more advanced video/audio coding are used. Consequently, this will provide much better quality of service and more efficient use of frequency spectrum. Despite the obvious benefits, discussion with several local manufacturers indicate that currently it is not feasible to manufacture affordable STBs using those advanced video/audio coding. Some options for high resolution format (HDTV) and middleware for enhanced services are left open, at least until simulcast period begins where TV audiences begin to appreciate digital TV benefits. Some STB's features which might be important for Indonesia, e.g. features for disaster early warning system, will be considered in the revised technical specifications. Last thing to note is on middleware selection. It is interesting to see that Malaysia and Australia turn to different middleware technologies.

To ensure that all STBs used in Indonesia are compliance with the proposed technical specifications, a measurement standard operating procedure (SOP) was developed; i.e, the STBs are subject to a set of verification tests. The SOP is based on NorDig test specifications [11], customized to the proposed basic technical specifications.

The measurement SOP will test each functional block of STB, that include:

- RF front-end: Tuner and Demodulator; e.g., to test that STB is able to receive all DVB-T mode and in all UHF bands specified.
- MPEG-2 demultiplexer; e.g., to test that STB can demultiplex transport stream with maximum bit rate as specified which carries one or more services with video/audio content and teletext components.

- Video/audio decoder; e.g., to test that STB can decode MPEG-2 video at bit rate of 1Mbit/s for video content at resolution 720x576, to test that STB can decode MPEG-1 layer II audio.

- System information and navigator; e.g., to test that STB allows user to select a service from the displayed service list, to test whether inserted text strings into the stream can be displayed correctly.

- Teletext and subtitling; e.g., to test that teletext and subtitles can be decoded and displayed correctly.

Section 2.1 already illustrated the role of software in the working of digital TV; furthermore, this indicates the potential of some software-based measurement. More specifically, in the above SOP various testing can be assisted by tools developed in open-source communities, and they are explained in Section 4.

4. Software-Based Test Platform

To gain experience in assessing digital TV system, especially in testing compliance to the proposed technical specifications and measurement SOP, it is convenient to have a small/laboratory-scaled digital TV system with reasonable costs. Note that some RF-related aspects still require measurement in a realistic outdoor environment. Nonetheless, a lot of insight can be learned in a laboratory-scaled measurement.

There are some expensive off-the-self dedicated equipments for doing DVB-T measurement available in the market, but in this experiment we resort to a cheaper and more flexible software-emulated digital TV system. The system is also applicable for open source software utilization, which is very valuable in gaining insight of internal mechanism of the system. Note that open source communities have been involved in digital TV domain, e.g. LinuxTV [9] which has actively developed and maintained various DVB drivers supporting Linux STB and USB/PCI-based DVB-T tuners.

Figure 2 depicts a view of equipment set-up in our laboratory. On the left-hand side is the PC-based digital TV transmitter, which consists of a personal computer running Ubuntu 7.10 and a Dektec DTA-115 modulator PCI card modulator [2] that transforms the transport stream into an UHF RF signal for transmission. DekTec DTA-115 is a multi-standard modulator with VHF/UHF upconverter; hence, this set-up is also potential for testing other terrestrial digital TV systems, such as DVB-H, DTMB and ATSC. The system on the left-side is referred to as a playout server which performs specified encoding, multiplexing and modulation. On the right-hand side, on plastic display, is the basic DVB-T STB prototype and its associated analog TV monitor. Various softwares for creating components in a playout server are explained later, and their usage for testing the STB is monitored using LCD monitor connected to the transmit personal computer.

The status of our work is still preliminary, and the current activity mainly involves creating reference transport stream and its analyzer before being used to test DVB-T streaming to the prototype basic STB in a small-scaled environment (indoor laboratory). There are three types of software used, as explained as follows.

Figure 2. A view of Testing STB prototype at PTIK-BPPT.

4.1. Video and Audio Coding

There exists several open source softwares for encoding source audio and video into a compressed format supported by DVB-T. Even though the proposed technical specification only requires MPEG-1 layer II (audio) and MPEG2 (video), it is important to have encoder which can support many other formats. We also need a tool for converting audio/video format (transcoding) for flexibility in finding audio/video samples. Availability of supporting various formats will enable future testing of advanced STB. In this work, we selected FFmpeg [6] which can handle many different audio/video codecs, and is also widely used by many other audio/video transport projects (e.g. VideoLAN) or players (e.g. mplayer). FFmpeg includes libavcodec as audio/video codec library and libavformat as audio/video container multiplexer and demultiplexer library. Note that in this context, multiplexer refers to as creating a container which includes audio/video streams and other information that corresponds to a particular program stream.

It is interesting to note that there exists an open source movie such as Elephants Dream [5] where it is a computergenerated film made by open source graphics software, and all production files are freely available for changes or new composition of user's own movie.

4.2. Packetizer and Multiplexer

Compressed audio/video sources and other data will be packetized and multiplexed resulting in streams of 188 byte transport packets of synchronized audio/video embedded with various system information. We found a collection of source codes in C and Python called OpenCaster [12] which perform the above task. OpenCaster supports FFmpeg MPEG-2 audio/video encoder output, generates PSI object and data carousel, processes packets such as PID filtering, PID remapping, null packet replacement, etc. Most importantly, OpenCaster has been tested on DekTec PCI-based low-power transmitter. OpenCaster also provides extended features such as support for DVB-H (mobile and handheld version of DVB) and IP (Internet Protocol) encapsulation.

4.3. Transport Stream Analyzer

To verify correctness of the resulting transport stream, a transport stream analyzer is needed. The analyzer shows data structure, transmission parameters and payload of a transport stream. Having dvbsnoop running in parallel with visual measurement on the analog display as STB's output, provides additional checking on STB measurement SOP. A software-based receiver utilizing dvbsnoop and DVB-T player provides back-up visual analyzer. In this work we selected dvbsnoop [4] which can perform analysis of one transport stream, both in offline and online mode. Dvbsnoop is a command line based program, and it's text output can be used for postprocessing via some graphical analysis softwares.

5. Concluding Remarks

This paper has described some activities in terrestrial digital TV systems, aiming at supporting digital migration in Indonesia. Technical specifications and measurement SOP for DVB-T standard are proposed for achieving affordable STB manufactured preferably by local industries. Most importantly, this paper has shown software-based test platform based on open-source softwares which can be used to test standard-compliance of a DVB-T STB prototype using the proposed measurement SOP.

This work is still at the early stage, but the nature of digital TV shows a lot of potential usage of open-source software development. By focusing more on software issues related to digital TV, further exploration can be conducted more extensively in the future; e.g., developing applications with interactive features for e-commerce, e-learning, etc. over digital TV infrastructure. Hopefully, this prospect of software development can further drive local innovation.

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