Consultation Paper No. **19/2019**

Telecom Regulatory Authority of India

सत्यमेव जयते

Consultation Paper

On

Interoperability of Set Top Box

11 November 2019

Mahanagar Doorsanchar Bhawan

Jawahar Lal Nehru Marg

New Delhi-110002

Website: www.trai.gov.in

Stakeholders are requested to send their comments & Counter Comments, preferably in electronic format to the following address:

Shri. Anil Kumar Bhardwaj,
Advisor (B & CS)-II,
Telecom Regulatory Authority of India (TRAI),
Mahanagar Door Sanchar Bhawan,
J.L. Nehru Marg, (Old Minto Road)
New Delhi - 110002, India
Email: **advbcs-2@trai.gov.in** ; **jadvisor-bcs@trai.gov.in**

Last Date for submission of comments: 9th December 2019
Last Date for submission of counter comments: 23rd December 2019

Comments will be posted on TRAI website www.trai.gov.in.

For any clarification/information, Advisor (B & CS)-II may be contacted at Tel. No.+91-11-2323-7922, Fax: +91-11-2322-0442.

Contents

CHAPTER 1
INTRODUCTION

1.1 The Indian TV industry has developed into world's second largest Television viewing universe globally with 836 million[1] TV viewers. Since coming under the regulatory ambit of Telecom Regulatory Authority of India (TRAI) in January 2004, the Broadcasting and Cable Services sector has grown manifold. It has come long way from being two-channel analogue terrestrial broadcasting environment to an evolved broadcast market with 915[2] TV channels, including 328 Pay TV channels[3], offered by 357[2] broadcasters.

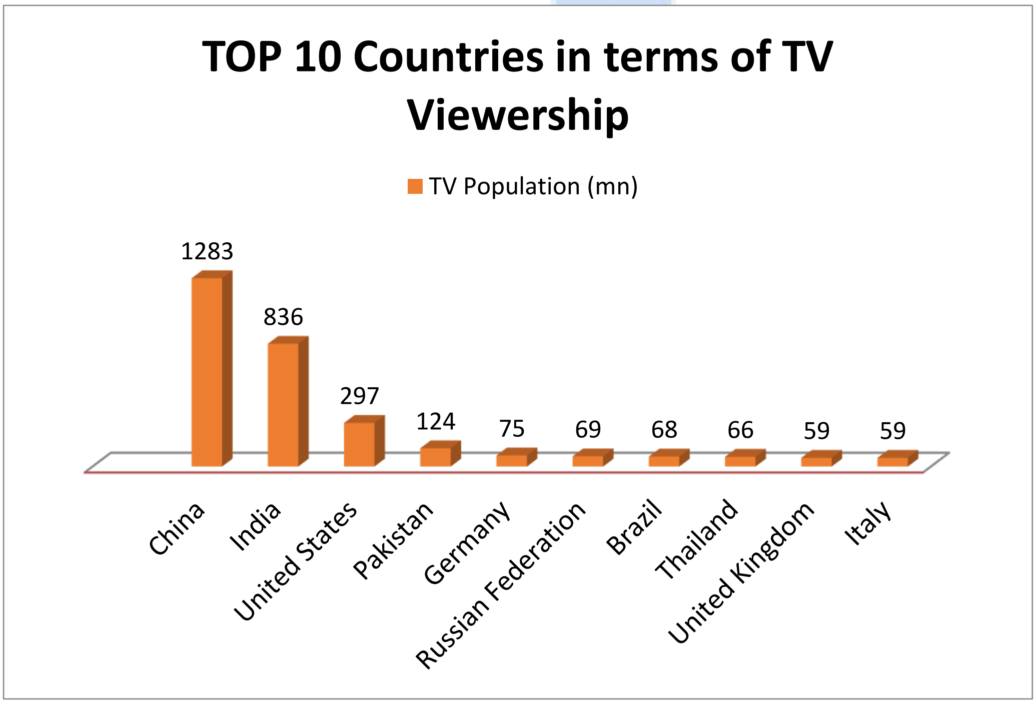


Figure 1: Top 10 Countries in terms of TV Viewership

1.2 There has been a consistent growth in penetration of TV homes in India with 66% homes covered as in 2018. As per industry estimates, at the end of year 2018, there were 298 million households in India, out of

[1] BARC Report, Broadcast India 2018 Survey, July 2018
[2] http://broadcastseva.gov.in/webpage-User-tvchannels
[3] https://channel.trai.gov.in/paychannels.php

which 197 million[4] households had Television sets. The pay TV universe consists of around 98.5 million Cable TV subscribers, 72.44 million active DTH subscribers and 1.5 million HITS subscribers.[4]

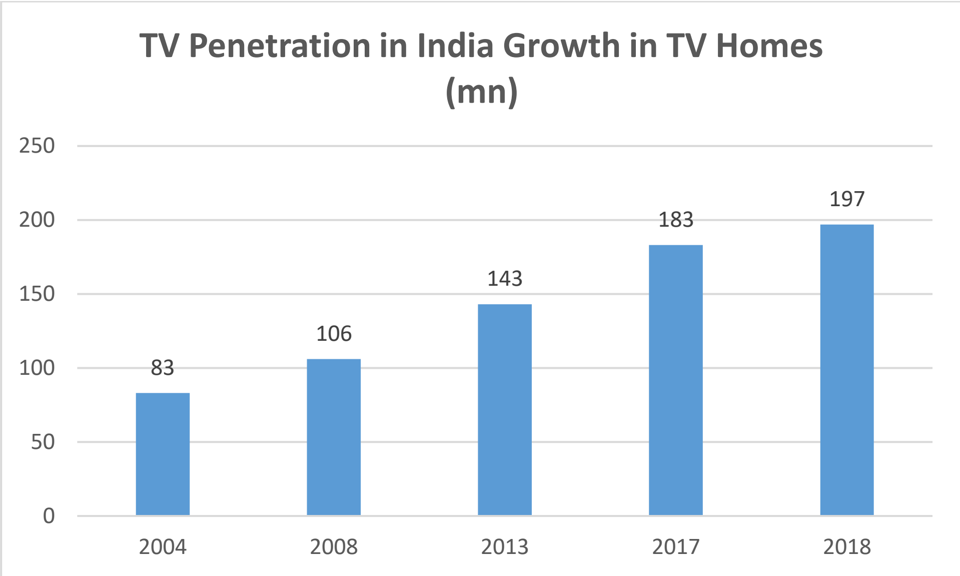


Figure 2: TV Penetration Numbers in India

1.3 Predominantly, the pay TV services are being delivered through Cable TV and Direct to Home (DTH) systems. Other modes of TV broadcasting such as Internet Protocol TV (IPTV), Head-end In the Sky (HITS) have miniscule subscriber base as compared to the Cable TV and the DTH systems. There are four pay DTH operators[5], 1 HITS operator[5] and 1143 Multi System Operators (MSOs)[6] providing TV services through Addressable Systems in the country.

1.4 Background

Television broadcasting has been one of the most popular means for mass communication. In India, Doordarshan's terrestrial television transmission was started in year 1959. This had a modest beginning with an experimental telecast starting in Delhi. The regular daily transmission started in 1965 as a

[4] FICCI-EY Report, 2019
[5] As per industry data submitted to TRAI
[6] Ministry of Information and Broadcasting data dated 21.1.2019

part of All India Radio. The television service was separated from All India Radio in 1976. Doordarshan switched over to color transmission during the Asian games in year 1982. Cable television came into existence in India in 1983 when Doordarshan started its services through cable in rural areas of Rajasthan. In 1989 few entrepreneurs setup small Cable TV networks and started local video channels showing movies & music videos after obtaining rights from film & music distributors. The international satellite television was introduced in India during 1991 with the live coverage of the Gulf War by CNN. The cable and satellite broadcast business has undergone a major transformation since then. Not only the system has migrated to digital transmission regime from an earlier analog transmission, it has also expanded to new platforms like IPTV and HITS

1.4.1 Development of Cable TV networks and inception of Multi Systems Operators (MSO): Promulgation of the Cable Television Networks (Regulation) Act, 1995, formalized the cable TV sector in India. Since then the Pay TV segment served through the cable networks has seen phenomenal growth in every nook and corner of the country. As per industry estimates the cable TV sector is served by more than sixty thousand Local Cable Operators. A significant increase in number of TV channels during 2002 to 2005 and corresponding increase in the subscriber networks led to the emergence of the Multi System Operators (MSOs). MSOs stand at the middle point in the hierarchy of the cable services sector between the broadcasters on one side and local cable operators on the other. The MSOs have established head-ends in metros and major towns to receive TV signals from different TV broadcasters, aggregate and distribute these signals further to LCOs, who further retransmit it to subscribers through cables.

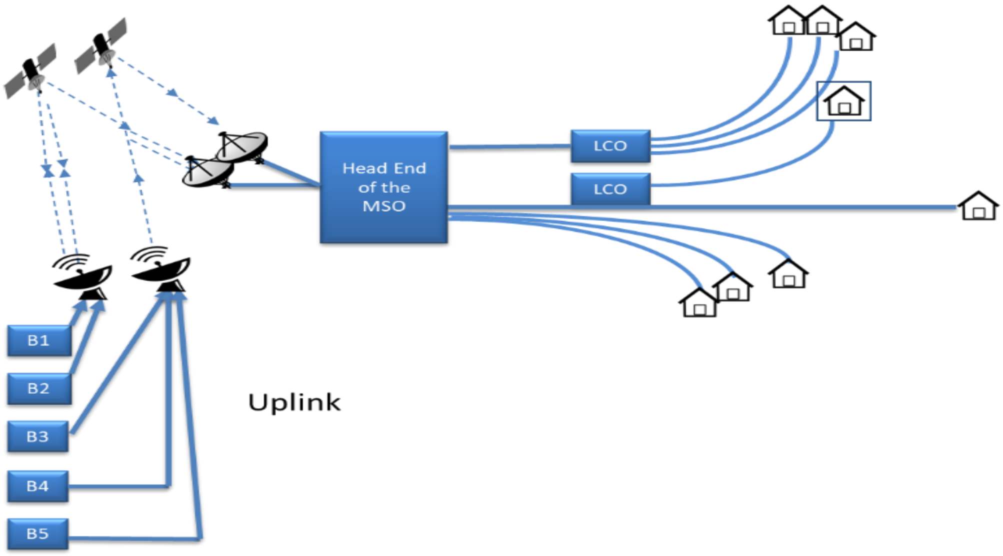


Figure 3: MSO in PayTV Distribution[7] Chain

1.4.2 Direct To Home (DTH) Services: Meanwhile, Direct-to-Home (DTH) broadcasting service were allowed by the Government vide "The Guidelines for obtaining license for providing Direct-to-Home (DTH) broadcasting service in India" issued on 15th March, 2001. The first license for DTH services was issued on 1st October 2003. The DTH segment provided a quicker reach for DTH service providers owing to superior coverage by satellite signals and easy to install dish antenna and digital signals. Thus, DTH service providers were quick to reach in far flung areas expanding the coverage of pay TV services across the country. Over the years MIB issued license to six private DTH services providers namely Dish TV, Tata Sky, Sun DTH, Airtel DTH, Reliance Big TV and Videocon D2H. Videocon D2H has since merged with Dish TV and Reliance Big TV has sold its operations to another company whose services stand suspended at present. In addition, Government also launched DD Free Dish in December 2004. DTH sector has also seen exceptional growth over the years and the subscriber base of private DTH service providers is approximately 72 Million[8].

[7] Figure depicts MSO as a distributor. Obtaining TV channel signals from the broadcaster and further extending the same to LCOs or the end consumer.
8 TRAI PMR Report Dated June 30, 2019

1.4.3 Digitization in the Cable TV Sector:

The exceptional growth of the number of TV channels (both FTA and Pay) combined with the inherent limitations of the analog cable TV systems has posed several challenges in the cable TV sector, mainly due to capacity constraints and nonaddressable nature of the network. The evolution of technology also paved way for bringing about digitization with addressability in the cable TV sector. Further, new addressable digital TV platforms like DTH, IPTV etc. were introduced to the consumers. Accordingly, after undertaking a public consultation process, the Authority, on 5th August 2010, gave its recommendations on implementation of Digital Addressable Cable TV Systems (DAS) across the country along with a roadmap to achieve the same. The digitization of cable TV was a step forward towards the removal of the shortcomings of the analog cable TV systems like the non-addressability and the capacity constraints. In the digital addressable systems, service providers can offer more channels with equitable quality of service. Subscribers too benefit, as they can select and subscribe to the channels of their choice. It also enables provision of broadband and triple play (voice, video and data) services through the network to the consumers. On the basis of the recommendations of TRAI, the Government, on 25th Oct 2011, issued an Ordinance, amending the Cable Television Networks (Regulation) Act, 1995[9], enabling the implementation of digital addressable cable TV systems in India. Thereafter, the Government notification dated 11th November, 2011, laid down the roadmap for implementation, in a phased manner, from June 2012 to Dec 2014[10]. Subsequently, pursuant to the passage of the Cable Television Networks (Regulation) Amendment Act 2011, the Government notified the same[11] on December 30, 2011 vide no. 21 of 2011[12]. Digitization of Cable TV services as mandated by the Government commenced in 2012 and has culminated in March 2017 across the country.

[9] https://mib.gov.in/sites/default/files/cab5.pdf
[10] https://main.trai.gov.in/sites/default/files/CP_DAS22-12-2011_0.pdf (Annexure II)
[11] https://digitalindiamib.com/cableamend060112.pdf
[12] https://mib.gov.in/sites/default/files/sda6_0.pdf

1.4.4 Other Pay TV Services: Internet Protocol Television (IPTV) services began in 2008. The Government in 2009 laid down a regulatory framework for Headend-in-the-sky (HITS) services which enabled the use of satellites for distribution of digital cable TV signal to last mile operators in far flung areas. A bird's eye view of the TV Broadcasting sector with multiple transmission/ last mile options is as shown in Figure 4 below:

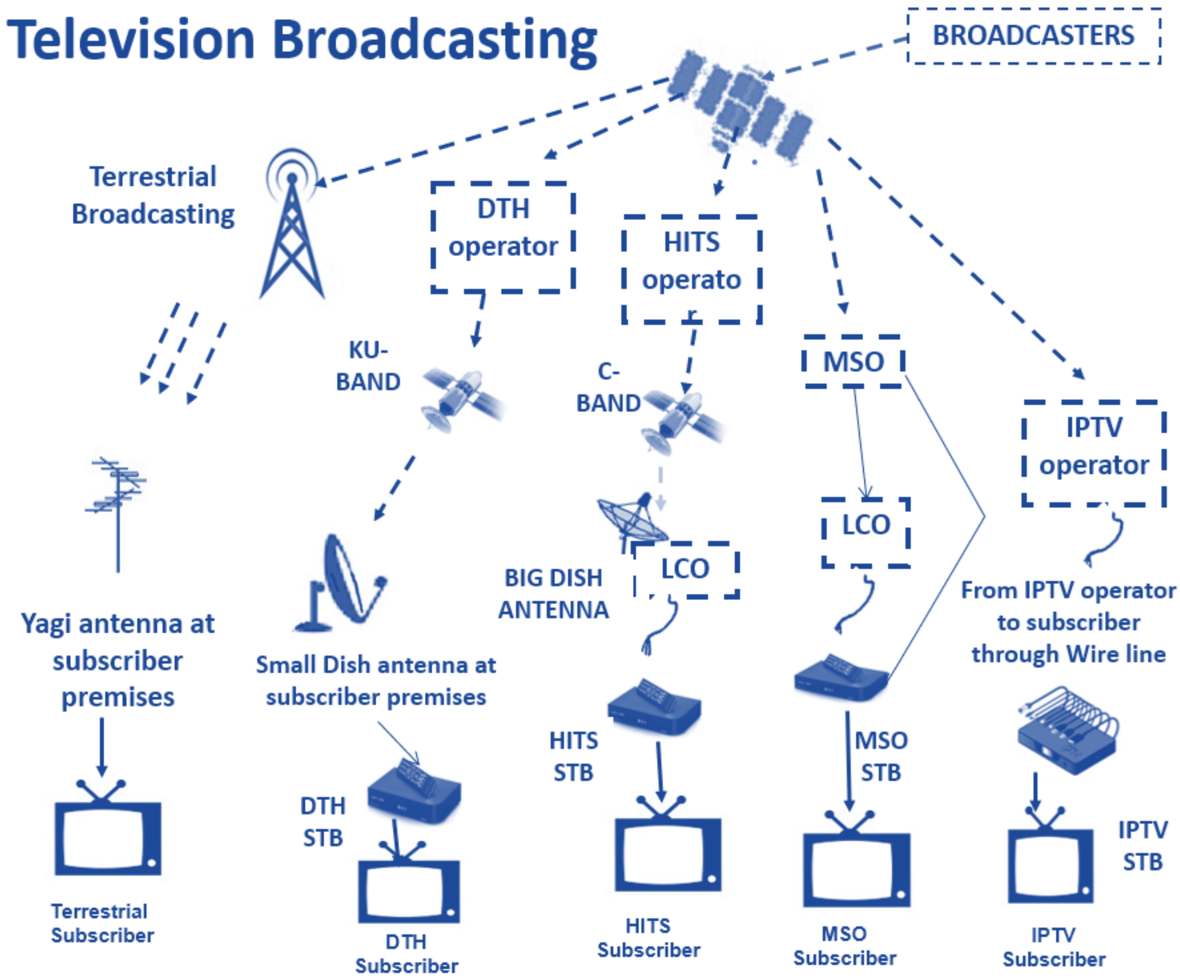


Figure 4: A Bird's eye view of the Television Broadcasting Sector

1.5 Modes of Transmission:

1.5.1 Television broadcasting commenced with Terrestrial transmission, as highlighted in previous paras. Terrestrial television refers to modes of television broadcasting which do not involve satellite transmission or cables.

1.5.2 Terrestrial television broadcasting dates back to the very beginnings of television as a medium itself and there was virtually no other method of television delivery until the beginnings of cable television, or community antenna television (CATV) in late 1950s.

1.5.3 The first non-terrestrial method of delivering television signals that in no way depended on a signal originating from a traditional terrestrial source began with the use of communications satellites during the 1960s and 1970s.

1.5.4 All the above 3 transmission standards have identical source compression and service multiplexing /transport sections. The channel modulation, however, is different and is optimized for the respective transmission media. Terrestrial Services use Orthogonal Frequency Division Multiplexing (OFDM) and standard 8 MHz channels in the UHF frequency range from 470-860 MHz. Cable TV services, on the other hand, provide services over VHF and UHF frequency bands from 50-860 MHz band using 7 MHz band in VHF and 8 MHz band in the UHF range. The modulation scheme adopted is the Quadrature Amplitude Modulation (QAM). The situation is a little different in case of satellite TV. Here the signal is first uplinked to a satellite which then retransmits the signal back to earth. Therefore, the uplink frequency corresponds to the corresponding transponder on the satellite. The downlink frequency is generally in a different band, so as to avoid interference with the uplink signal. The frequencies used are generally in the C band (4-8 GHZ), the Ku band (12-18 GHz), or both. However, the downlink signal, at the receiver antenna, is down converted by a Low Noise Block downconverter (LNBC) to a lower frequency in the L band range. This maneuver, in addition to signal processing at lower noise frequency range, allows the industry the advantage of operating in a more commercial, mass production range.

1.5.5 Cable Television and DTH platforms are the major distribution platforms for delivery of television broadcasting services in India. Whereas the DTH broadcasting services are already delivered in digital mode, the migration of Cable TV services, from analog to digital, as described earlier, has been completed with implementation of Digital Addressable Cable TV Systems (DAS). The services of DAS can be received, by a subscriber, using a Customer Premises Equipment (CPE) known as Set Top Box (STB) which is connected with the TV set (Sometimes the STB is in-built in the TV set). In DTH, along with an STB, the CPE also includes a small dish antenna, LNBC[13], feed and RF cable.

1.6 Relevant Stakeholders in broadcast service delivery chain

1.6.1 From generation of content by the Broadcaster till its consumption by the end consumer, there is a chain of stakeholders who have their own specific role in the hierarchy. A simplified illustration of the key stakeholders in the content delivery is provided below in figure 5. However, there are other stakeholders who, though not visible in this simplified illustration, play their own important roles. CAS & Middleware vendors, STB manufacturers, SoC vendors etc. are some

[13] Low Noise Block Converter (LNBC) is the receiving device mounted on satellite dishes used for satellite TV reception, which collects the radio waves from the dish, amplifies and convert received satellite signals into frequencies compatible with the satellite receiver.

key stakeholders in the STB value chain. These stakeholders are dealt with in more detail in following chapter.

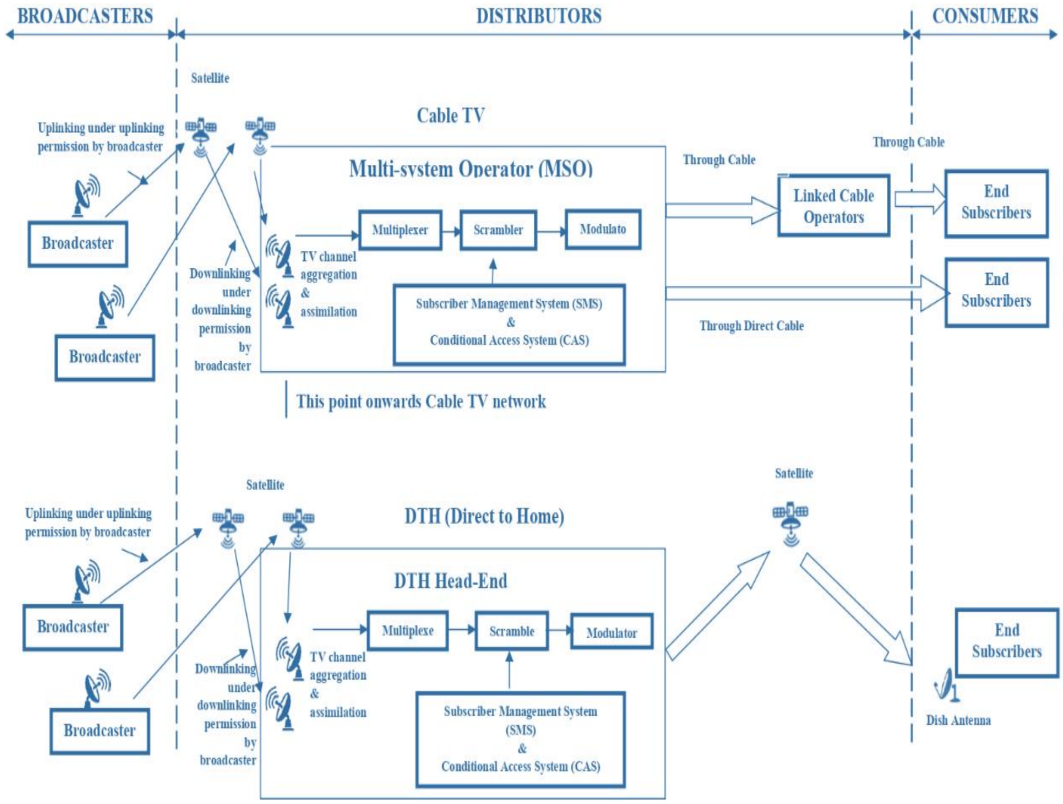


Figure 5: Key Stakeholders in Television Distribution

1.6.2 Currently, encrypted pay TV broadcasting services follows a circle of dependency in which a Distribution Platform Operator (DPO), CAS vendor and STB manufacturer have to operate together in a vertical market. A DPO decides the CAS provider as per its security needs and market requirement. The DPO then places order to the STB Manufacturer for supplying STBs. The STB Manufacturer pays a license fee to use CAS in his STB and signs a non-disclosure agreement with the CAS provider. Consequently, STBs are exclusively tailored based on the CAS employed by the DPO. The DPO supplies the STBs to his subscribers when a customer subscribes for his services. Figure 6 illustrates a typical process of subscription in a pay TV system:-

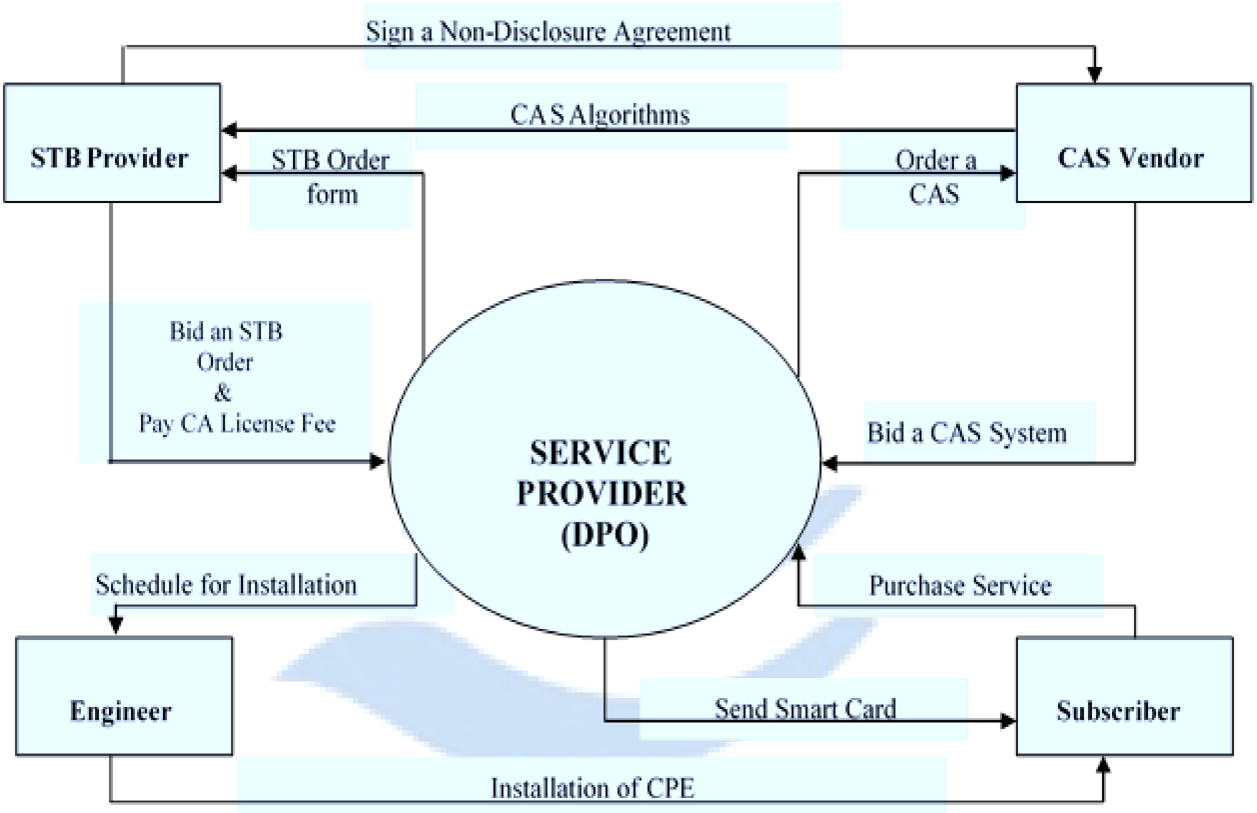


Figure 6: Business Cycle in Typical Pay Television Market

1.6.3 As can be seen from the above, the present eco system of STB is extremely rigid. There exists an end-to-end vertical of DPO, CAS and middleware vendor, STB Manufacturer and Chip designer. Effectively, this results in STB being specific to the combination of DPO, CAS provider and STB manufacturer resulting into technically non-interoperable STBs.

1.7 Demand for Set Top Box Interoperability:

1.7.1 Ever since digitization became mandatory, there have been discussions and suggestions to introduce STB interoperability. The Ministry of

Information and Broadcasting has sought recommendations of TRAI on several occasions on requirement of technical interoperability as mandated by clauses 7.1 and 7.2 of DTH License Conditions. In response to the Ministry's reference, dated July 23, 2014, TRAI recommended retention of existing technical interoperability conditions and updating of standards for set top boxes and that the license conditions should mandate the licensee to comply with the tariff order/scheme prescribed by TRAI for commercial interoperability. Further TRAI has recommended that BIS should come out with updated specifications for STBs from time to time and while doing so, BIS shall consult TRAI.

1.7.2 Subsequently, in response to Lok Sabha Unstarred Question No. 2420, dated March 11, 2016 relating to Interoperability of Set-top-boxes, an assurance was given to carry out consultation with stakeholders on the subject. TRAI floated a pre-consultation paper on Set Top Box Interoperability on April 4, 2016.

1.7.3 In light of the efforts taken by TRAI on interoperability of STBs, the Standing Committee on Information Technology, in their Forty Fourth Report (Sixteenth Lok Sabha) on 'Status of Cable TV Digitization and Interoperability of Set Top Boxes'[14] dated December 29,2017 relating to the Ministry of Information and Broadcasting had recommended MIB and TRAI to take urgent steps to achieve interoperability of the Set Top Boxes in a definite time-frame.

1.7.4 Subsequently another Lok Sabha Unstarred Question No 3343 by Mr. Srinivas Kesineni regarding Set Top Box interoperability was tabled in the Parliament on July 12, 2019. Ministry of Information and Broadcasting, based on inputs provided by TRAI, furnished details relating to efforts made by the government for achieving STB interoperability by initiating consultation with industry stakeholders for an acceptable solution.

[14] http://164.100.47.193/lsscommittee/Information%20Technology/16_Information_Technology_44.pdf

1.7.5 With this background, TRAI is exploring various available solutions for achieving interoperability in unidirectional broadcast network. This consultation paper seeks the comments and counter comments of the stakeholders on the technical Interoperability of STBs. Subsequent chapters deal with issues related to interoperability of STB. The technical issues and the challenges to interoperability along with the regulatory background are dealt in Chapter 2. Chapter 3 outlines possible approaches and available solutions for achieving interoperability. Chapter 4 presents the summary of issues for consultation.

CHAPTER 2
SET TOP BOX INTEROPERABILITY

2.1 Interoperability of a consumer premises equipment plays an important role for the growth of any sector. Think of the scenario where the devices are locked to a specific network due to non-standardization or non-interoperability. Those who undertake frequent international travel, have experienced the complication due to different power supply and sockets shapes across various countries. While non-standardization leads to poor adaptability, non-interoperability creates captive consumers. Such consumers cannot exercise their freedom to change service providers due to artificial barrier created by a non-interoperable device. Such barriers subvert the competition thereby subverting the free-market play. The capital markets and market economy thrive in open competition with minimum barriers. Barriers of any kind introduce economic inefficiencies thereby hindering growth.

2.2 Interoperability of Mobiles or Personal Computers are shining examples of how inter-operable ecosystem stimulates growth. Consumers have today tasted the freedom due to interoperable mobiles and personal computers.

2.3 At present, a STB of a particular DPO cannot be used for reception of signals of any other DPO. Therefore, if a subscriber wants to change their service provider, a new STB has to be purchased. Although any STB used for receiving the Pay-TV broadcast services performs essentially the same functions, the STBs supplied by different DPOs remain distinct from each other, as if these are different equipment. Adoption of certain service provider specific standards by intermediary solution providers is the root cause of this problem. The CPE/STB is rigidly attached to the current service provider owing to various technical, commercial and market driven reasons. Pay TV business process has a legacy of proprietary technology(ies) and vertical business models. These models, initially adopted to improve security to ward-off piracy, have become synonyms with non-interoperability. The following sections provide an overview of Set Top Box and describe key stakeholders in the STB value chain and how they factor in with regard to interoperability of STB.

2.4 Overview of Set-Top Box

2.4.1 A Set-top box is a device that receives digital signal, decodes and displays it on television. India follows the Digital Video Broadcasting (DVB) standards in Television Broadcasting. DVB group has specified different International standards for digital television broadcasting through different transmission media. They are:

1. DVB--T: Digital Terrestrial transmission
2. DVB--S: Digital Satellite transmission
3. DVB-C: Digital Cable transmission

All the above 3 transmission standards have identical source compression and service multiplexing /transport sections. The channel modulation however is different and is optimized for the respective transmission media. Typically, for satellite application QPSK modulation and L band in the 950 to 2150 MHz frequency range is deployed. For STB for cable TV application the input frequency range is 50 to 860 MHz and type of Modulation is QAM while frequency range for terrestrial reception STB is 470 to 860 MHz and type of Modulation use for it is OFDM.

2.4.2 The basic block diagram indicating the functional description of a STB is as per schematic diagram figure 7.

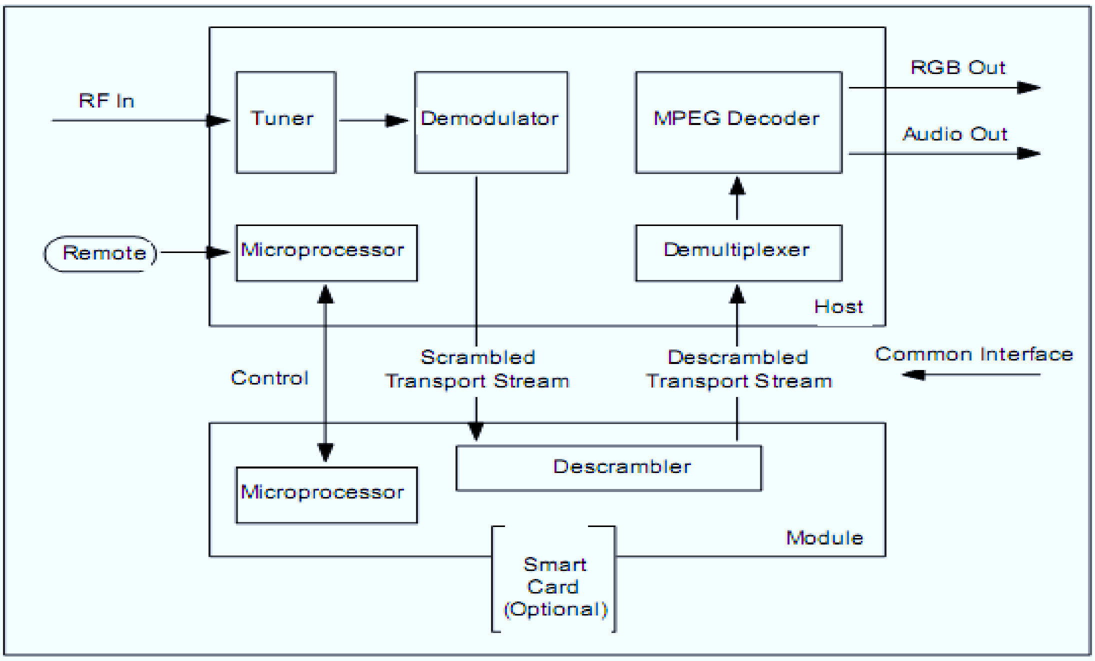


Figure 7: Functional Block Diagram of a STB

2.4.3 As indicated in the above diagram, tuner and demodulator relate to the transmission system adopted in that STB. Here, the signal gets converted from a RF signal to a baseband data stream for further processing. The next component after the demodulator is the conditional access module (CAM). In this module, the TV channels and other services, which were encrypted at the transmitting end, are decrypted on the basis of keys made available by the CAS. The function of CAM can be integrated into the STB or can be provided through a smart card or an external CAM which can be plugged into the STB through a common interface (CI). The last module, the 'MPEG decoder', decompresses the video/audio data stream in addition to converting the digital stream into an analog signal fit for viewing on an analog TV set. Compression helps in saving the transmission bandwidth. There are different video/audio compression standards that have been widely adopted by TV operators. The signals are de-compressed at the receiver end. The decoder may be compatible with MPEG-2 or MPEG-4 standards.

2.5 Conditional Access System (CAS)

2.5.1 The CAS is the key to a broadcast pay TV system, where every subscriber receives all the broadcasted channels including scrambled ones. And it is only the CAS security system that ensures that content delivery pipe from the operator to the STB is secured. In addition, CA systems provide a mechanism of addressing each STB uniquely. The CA system ensures that the control words (CW) which are used to scramble contents at the Headend are only available to the authorized customers and who are able to decrypt the control word to view the content, thus making the content secure. The role of an efficient and reliable CAS is important, as it ensures the protection to the service providers from unauthorized usage of the services and thus provides revenue protection. The basic structure of CAS at the Head end is shown in Figure 8. Figure 9 shows the structure of the CAS at STB.

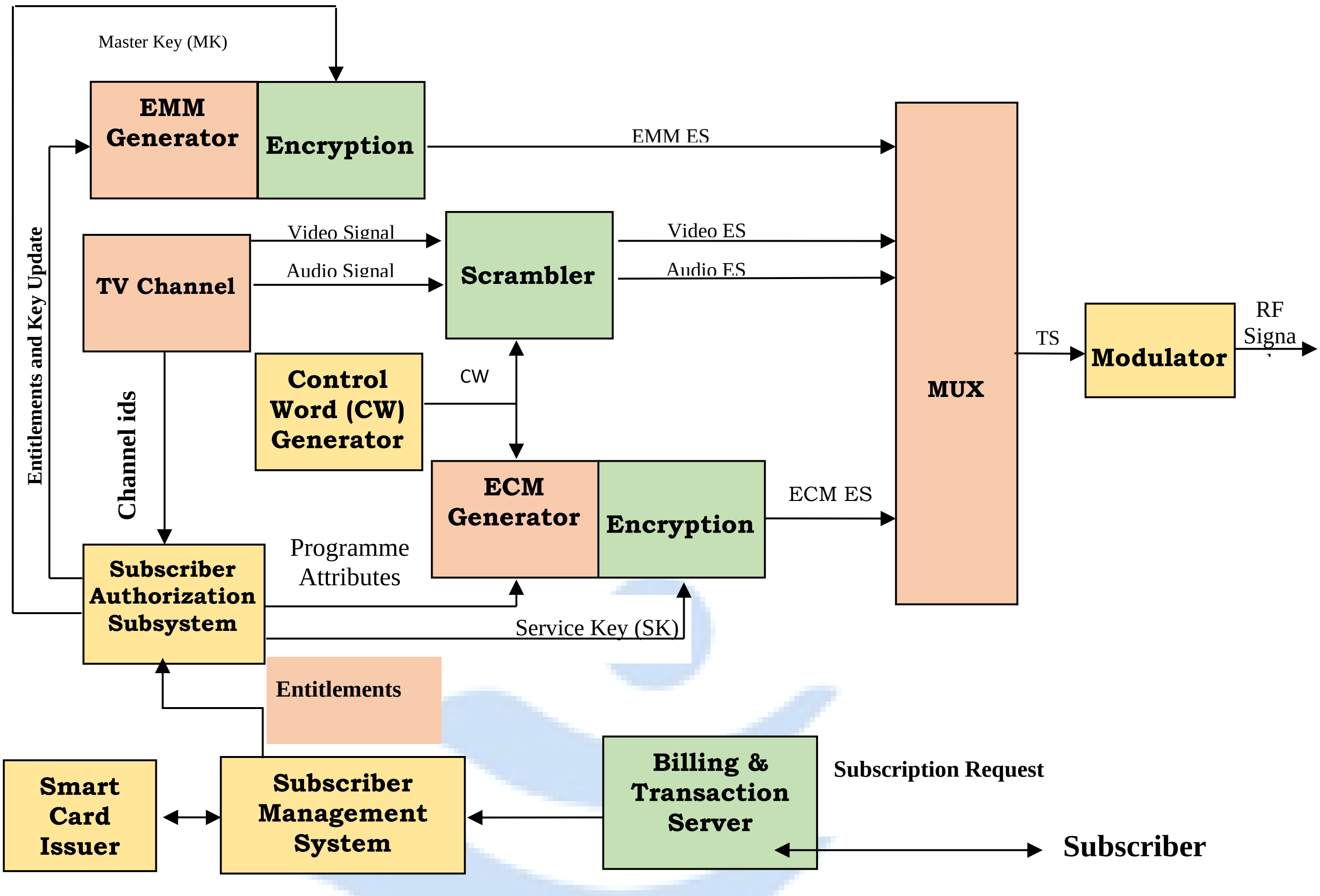


Figure 8: The basic structure of CAS at the transmitter side in an encrypted TV Broadcasting Service

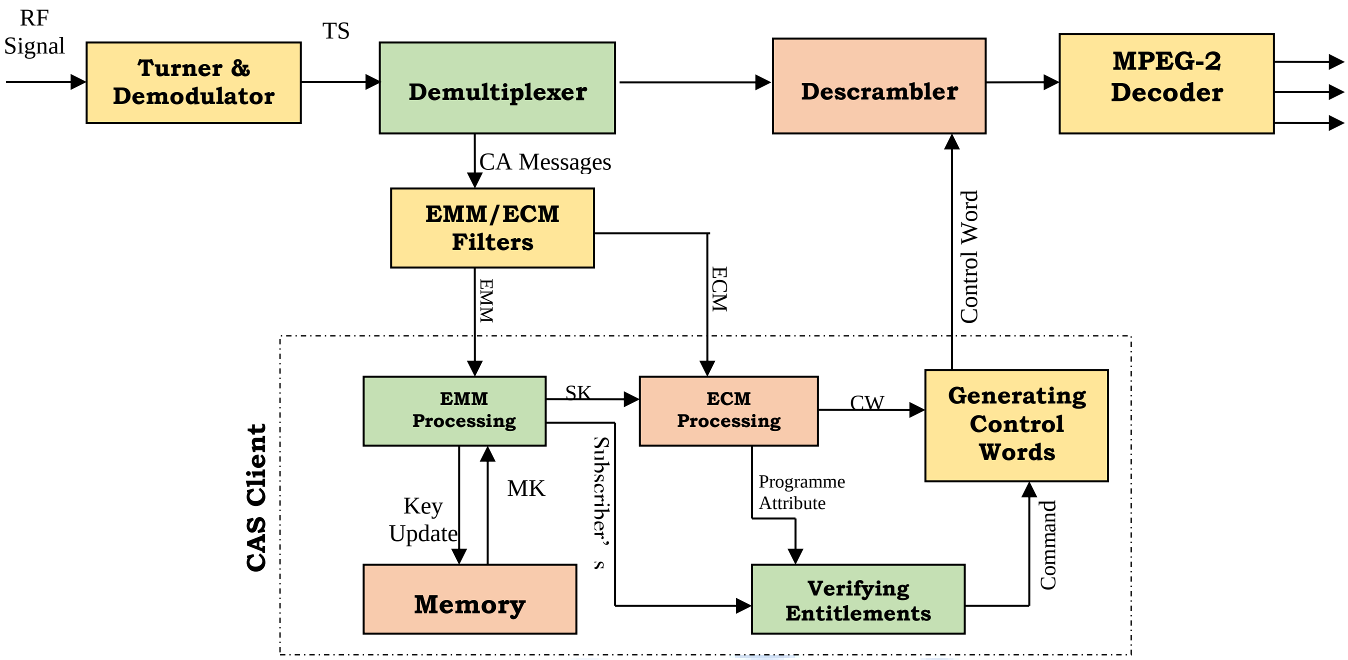


Figure 9: Structure of CAS client at STB

2.5.2 The CAS commonly adopts a hierarchical system for security key management. The TV channels are scrambled by the Control Word (CW), which is included in the Entitlement Control Message (ECM). The ECM is encoded using the Service Key (SK), which is associated with the service and is valid for a period of time depending on the subscription type. The information of SK is included in the Entitlement Management Message (EMM). The EMM also contains the list of channels which has been authorized by the DPO for the subscriber. The EMM itself is encoded using the Master Key (MK) shared with the service provider and security module residing in the CAS client at the STB. The ECM and EMM are broadcast along with TS to all receivers.

2.5.3 For reception of encrypted TV broadcasting services, a module called CAS client forms part of STB. In this module, the TV channels which were encrypted at the transmitting end are decrypted on the basis of keys made available by the CAS to the STB. This function of CAS client can be integrated into the STB or can be provided through an external module called Conditional Access Module (CAM) which can be plugged into the STB through an interface. Each STB filters its corresponding EMM messages (EMMs are addressed to the individual receiver) and decrypts ECMs using information inserted into the EMM and security module. If the subscriber is authorized to access to the channel, the CWs will be released to descramble the TV channel. Each CAS defines respective security specifications including proprietary algorithm and procedure to implement them on the Head End and STB. Every CAS vendor licenses these to the Headend operator and STB manufacturer. Each STB model is licensed, tested, verified and then certified to be compliant with a particular CAS. Their uniqueness to specific vendors and their algorithm and architecture, prevents customers from switching between content providers. CASs currently deployed in India along with their estimated market share as per industry sources is indicated in the following table.[15]

Sr No	Name of the CAS	Market Share
1	Conax/ Kudelski	23.04
2	NDS/CISCO/Synamedia	20.77
3	GOSPEL	11.52
4	NSTV	8.64
5	Verimatrix	7.49
6	ABV	6.91
7	Irdeto	6.9
8	Nagra/Kudelski	5.76
9	Sumavision	4.61
10	Latens /Arris	1.73
11	Logic Eastern	1.15
12	iCAS	1.15
13	CryptoGuard	0.29
14	Safeview	0.06

[15] As per the figures provided by the consultant engaged by TRAI for developing solution for interoperability of STBs

2.6 Middleware

Middleware is the software that sits on top of the OS in an STB. It allows a content developer to work without having to consider low level issues for an STB. It runs between OS/device drivers and the application. Middleware makes it easier to write complex applications and it allows portability across hardware and operating systems. Applications will run on any platform the middleware has been ported to. The Middleware of the STB helps in displaying the data contained in the Event Information Table (EIT). The EIT contains the planned starting and stopping time of all TV programs in form of Electronic Program Guide (EPG). DVB has provided flexibility in the structure of EIT and allows any amount of additional information to be transmitted in EIT. Due to this flexibility, different service providers carry data in the EIT differently making non interoperability of EIT data. Further, there is no standard operating system/ middleware for STBs, thereby making the STBs non-interoperable.

2.7 Set Top Box Providers

Each conditional access system requires embedding CAS specific secret key in the SoC (System on Chip), signing Software images and ensuring that the CAS cannot be bypassed. This is one of the primary reasons STBs are designed to not switch between CAS. This process also makes the Set Top Box providers dependent on the operator to identify the particular CAS to be embedded in the set Top Box which may be deployed in that operator's network. The STB vendor is also dependent on the particular CAS vendor to license the security algorithm (technology) to embed into the STB. Thus, the STB providers cannot make inter operable STBs until a framework of inter operable STB is standardized.

2.8 Distribution Platform Operator (DPOs)

As mentioned in introduction, Cable Television and DTH platforms are the major distribution platforms for delivery of television broadcasting services in India. There are other two type of DPOs, Head End In The Sky (HITS) and the Internet Protocol Television (IPTV). However, these two have limited presence in the television distribution market. A DPO receives a programming service from a broadcaster or its authorized agencies and re-transmits the same or transmits his own programming service for simultaneous reception either by multiple subscribers directly or through one or more local cable operators. It is the DPO, who, based on his business requirements decides as to which CAS/Middleware to deploy in his network. And accordingly, the STB and SoC deployed are decided based on the end-to-end vertical consisting of the chosen CAS/ middleware vendor, STB Manufacturer and Chip designer. In certain cases, the new entrant DPO may decide upon the STB first, for reasons of economy. In that case also the remaining constituents of the service delivery chain are decided as per their existing tie-up. In either case it remains a tightly coupled vertical precluding interoperability with other networks.

2.9 Broadcasters

Amidst all the elaborate infrastructure set up by different stakeholders which builds up the television broadcast network and ecosystem, eventually it is the content or program generated or procured by the Broadcasters which is sold as commodity in the Pay-TV sector. As content is the revenue driver, its security is of critical importance to the Broadcaster/ content developer. As such, content piracy or breaking down the encryption is one of the key risks which a Broadcaster faces in the provision of Pay TV services. Robustness of any solution regarding protection against content piracy would be key to its successful implementation and adoption by the industry.

Looking to the importance of content security, content developers have taken elaborate measures to develop and prescribe specific standards to safeguard their interest. A leading example is that of MovieLabs, an independent non-profit organization founded by the six major Hollywood studios to advance research and development in motion picture distribution and protection. In 2013, they published v1.0 of the MovieLabs Enhanced Content Protection (ECP) Specification. This specification describes a set of high-level security requirements for the distribution of Hollywood UHD content to consumer devices. Technologies aiming to support UHD content must be compliant with

ECP. Although targeted at UHD content, the ECP specification describes best practice for all premium content services, including Pay TV and live sports. Even in case of Indian Broadcasters and content providers, security of content from piracy remains primary concern. Any solution for interoperability of STB must pass the scrutiny on account of content security.

2.10 Technical Reasons for non-interoperability of STBs:

2.10.1 Proprietary Structure of CAS:

As explained in Section 2.5, each conditional access system (CAS) defines respective security specifications including proprietary algorithm and procedure to implement them on the Head End and STB. Each CAS is thus specific to a CAS vendor. The CAS vendor licenses these to the DPO and STB manufacturer. The CAS vendor enables the operator to broadcast protected content and prevent theft of services. The uniqueness of algorithms and architecture adopted by different CAS vendors is one of the primary reasons for non-interoperability which prevents customers to switch between different service providers.

2.10.2 Adoption of Different Technologies:

Further, broadcasting of TV signals over distribution networks involves various steps like compression, encryption, transmission etc. For each purpose, different technologies and their versions have evolved over a period of time. The rules and regulations prescribed by the Government and the Regulator provide freedom of choosing technology to service providers. Accordingly, as per their business plan, individual service provider has chosen and implemented different technologies and their versions. The adoption of different versions of technical standards by service providers is the other factor leading to non-interoperability of STBs. Non- interoperability arising from adoption of different standards by different service providers has been described below :-

a. Different methods of EMM & ECM encryption:

ECM and EMM messages are carried in an encrypted form. Whereas DVB has standardized the scrambling algorithm for scrambling of a channel (DVB-CSA), algorithms used for ECM/ EMM encryption are not standardized. Thus STBs having different CAS client retrieve the control word and therefore cannot descramble the content.

b. Different Modulation standards:

The signals are modulated before transmission. In cable the signal is modulated using DVB-C standard whereas the signal is modulated using DVB-S standard in DTH. For a STB to be able to receive signal both from DTH and cable, there will be a requirement of switchable demodulator unit. Further, efficient versions namely DVB-C2 and DVB-S2 have been deployed by the operators. While the later versions are backward compatible, earlier versions are not forward compatible. Therefore, it restricts the STB interoperability across the platforms as well as within the same platform using different versions of standards.

c. Different compression standards:

In digital TV transmission, compression plays a very important role. There are two prominent compression standards in use today. In India, most of the operators have used, either MPEG2 or MPEG4 standard for compression. In cable TV sector, due to cost advantage and availability of sufficient bandwidth in the network, most of the STBs deployed till now are of MPEG2 standard. While the MPEG4 standard is backward compatible, MPEG2 standard is not forward compatible. Therefore, MPEG2 compliant STBs cannot work in the MPEG4 networks.

d. Operating System/Middleware and EPG (Electronic Program Guide):

Boot loaders are specific to chip vendors and it allows the updating of STB software by specific operators after proper verification. There is no standard operating system for STBs. DVB has developed Multimedia Home Platform (MHP) as a standard for middleware. However, the same is not popular. Proprietary middleware, with non-standard APIs, are in use. It ensures that, the application software can be updated by specific operators only. Special end user applications like EPG installed over middleware are also unique for each operator.

e. Scrambling Algorithm:

Further, the stakeholders have raised their concern about the common scrambling algorithm (DVB-CSA) which is a 48-bit scrambling mechanism and can be broken with the help of high capacity processors. Therefore, the service providers are reluctant to use DVB-CSA. Operators due to the concerns of piracy make the STB tightly coupled by integrating the Conditional Access Sub System- into the chip.

Different methods for encryption, modulation and compression become an impediment when a subscriber wishes to migrate to a different service provider while attempting to use the same STB and leads to concerns relating to technical interoperability. As Digital TV distribution sector has grown in India since 2003, the operators has deployed different technical standards for compression, modulation and encryption. A sample illustration in respect of some DPOs is tabulated below:

Sl. No.	Name of Operators	Compression standards	Modulation Standards	Encryption (CAS)
1.	Dish TV(2003)	MPEG-2	DVB-S	Conax
2.	Tata Sky	MPEG-4	DVB-S2	Synamedia
3.	Sun Direct	MPEG-4	DVB-S	Irdeto
4.	Airtel Digital TV	MPEG-4	DVB-S2	Synamedia, Irdeto
5.	DD Free Dish	MPEG-2 MPEG-4	DVB-S	No Encryption
6.	Siticable	MPEG-2	DVB-C	Conax
7.	Hathway	MPEG-2 SD) MPEG-4 (HD)	DVB-C (QAM64/256)	NDS, Cisco-Powerkey, Verimatrix

8.	Den Networks	MPEG-2 (SD) MPEG-4 (HD)	DVB-C (QAM-64)	NDS, Cisco Powerkey, Nagra,Gospell
9.	TCCL	MPEG-2	DVB-C	Verimatrix &Suma Vision
10	VK Digital	MPEG-4	DVB-C	NagraVision,NSTV & Irdeto

2.11 Implications of non-interoperability of STBs:

2.11.1 Pay TV operators follow a tied-in business model which allows them to retain monopoly on their subscribers. The virtual lock-in of the subscribers due to non- interoperability of STBs between different service providers has adverse effect on competition and service quality in the PayTV distribution market as the operator has no motivation or drive to improve its services. An open, non-proprietary architecture of Set Top Boxes, which ensures technical compatibility and effective interoperability among different service providers shall bring competitiveness in the market and would shift the focus of the sector towards providing innovative and better quality of services to the consumers at competitive prices.

2.11.2 An important consequence of non-interoperability is restriction of choice to consumer. Interoperability of STBs allows the consumer to exit the service of any service provider and switch over to another service provider without significant cost.

2.11.3 Implementation of STB inter-operability will also make STBs available in the open market. Commoditization of the STBs and the associated increase in volumes will reduce their cost.

2.11.4 The financial implications of non-interoperability of STBs are huge. As per industry figures till March 2019, an estimated number of more than 54 million STBs are lying idle or unused in DTH segment only, and a sizeable chunk of the same is because of non-interoperability of STBs. Since the inactive STBs cannot be used for reception of services of the other operator, the money invested into the STB goes waste. Considering an initial capital expenditure around $25 per STB, a total of $1350 million capital is lying unused in DTH segment. The exact data in respect of Cable TV services is not available but it is anticipated that the number of inactive STBs would be of similar order.

2.11.5 Further, whenever a consumer changes its service provider, the STB of existing service provider becomes useless as the same STB cannot be reused; resulting into waste electrical and electronic equipment (e-waste). The dashed arrows in figure 10 show the transitions a consumer can make, when switching Pay TV providers. Whenever he is leaving a provider that uses Set-Top Boxes, he will have to discard the old Set-Top Box, which will end up as e-waste.[16]

[16] Strategy White Paper on Minimizing the e-Waste Impact of TV Digitalization in India, Condition-ALPHA, 11 March 2017s

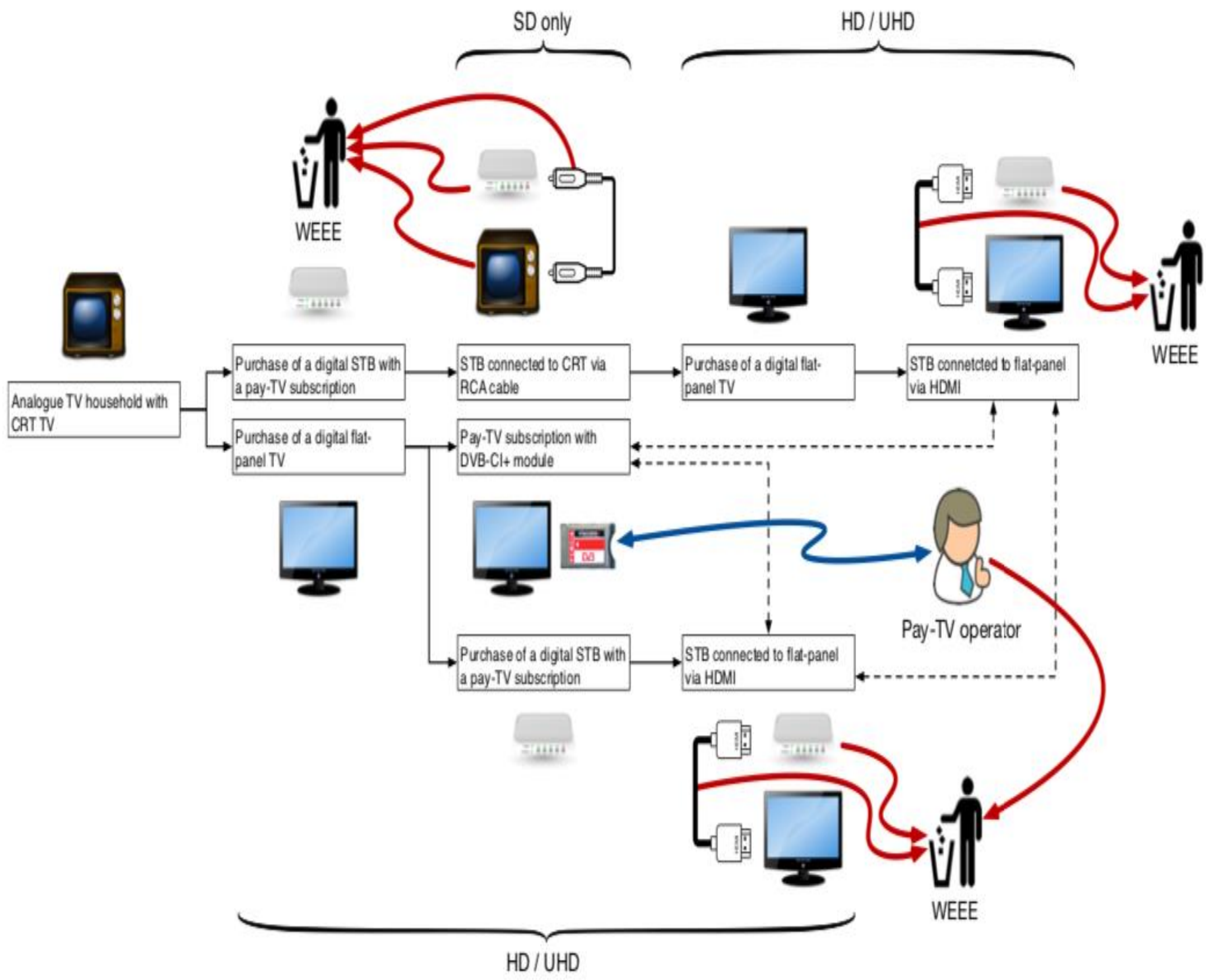


Figure 10: TV migration options for consumers and generated e-waste

2.11.6 According to the Global E-Waste Monitor 2017, India generates about 2 million tonnes (MT) of e-waste annually and ranks fifth among e-waste producing countries, after the US, China, Japan and Germany.

2.11.7 Under Section 21 of E-Waste (Management) Amendment Rules, 2018 manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler of electrical and electronic equipment (EEE) shall be liable to pay financial penalties as levied under the provisions of the Environment (Protection) Act, 1986 and rules made thereunder for any violation of the provisions under these rules. In case of Pay TV segment in India, responsibility shall fall upon all stakeholders in the value chain, and any failure to comply the said rules shall attract financial penalty.

Apropos discussions in the above sections, the issues for consultation are:-

Q1. In view of the implications of non-interoperability, is it desirable to have interoperability of STBs? Please provide reasoning for your comment.

Q2. Looking at the similar structure of STB in cable and DTH segment, with difference only in the channel modulation and frequency range, would it be desirable to have universal interoperability i.e. same STB to be usable on both DTH or Cable platform? Or should there be a policy/ regulation to implement interoperability only within a platform, i.e. within the DTH network and within the Cable TV segment? Please provide your comment with detailed justifications.

Q3. Should interoperable STBs be made available through open market only to exploit benefits of commoditization of the device? Please elaborate.

Q4. Do you think that introducing STB interoperability is necessary with a view to reduce environmental impact caused by e-waste generated by non-interoperability of STBs?

2.12 Regulatory Background of Interoperability of STBs

Post the implementation of addressability through DAS, there have been several discussions and suggestions to introduce STB interoperability, and TRAI and MIB have been exploring the pertinent issue of interoperability of STBs. The regulatory/ policy endeavors undertaken so far are outlined in the following sections.

2.12.1 DTH License Conditions and BIS Standards

The technical interoperability of the consumer premises equipment (CPE) is a condition under the license issued to DTH operators by Ministry of Information and Broadcasting. The license requires that the STB to be open architecture (non-proprietary) and effectively ensures technical compatibility and effective interoperability among different DTH operators with compliance to the specifications as laid down by the Government from time to time. Articles 7.1 and 7.2 of the DTH License Agreement, under the heading technical standards and other obligations, read as under:-

"7.1 The Open Architecture (non-proprietary) Set Top Box, which will ensure technical compatibility and effective interoperability among different DTH service providers, shall have such specifications as laid down by the Government from time to time.
7.2 The Licensee shall ensure subscribers interests through a Conditional Access System (CAS), which is compatible with an open Architecture (non-proprietary) Set Top Box."

The technical specifications are framed by Bureau of Indian Standards (BIS). The condition for open architecture for MPEG 2 STBs was prescribed by BIS in 2003 as under:
'The STB shall be open architecture (non-proprietary) and shall ensure technical compatibility and effective interoperability amongst different DTH service providers in the country. The interoperability shall be achieved by using

common interface conforming to EN 50221 'Common interface specification for conditional access and other digital video broadcast decoder applications' and via software download where software download mechanism shall be transparent, interoperable and available in public domain complying with specification ETSI TS102006. The STB must have at least one common interface slot complying to EN 50221.

The BIS specification for MPEG 4 STBs, were issued in year 2012 for open architecture as below:[17]

'3.1.1 The STB shall be based on an open architecture (non-proprietary) and shall ensure technical compatibility and effective interoperability amongst different DTH service providers in the country. The interoperability shall be achieved by using common interface conforming to EN 50221 'Common interface specification for conditional access and other digital video broadcast decoder applications' including 'TS 101669 Extensions' to DVB-CI specification and via software download mechanism shall be transparent, interoperable and available in public domain complying with ETSI TS 102006. The STB shall have at least one common interface slot complying to EN 50221.'

Technical interoperability as provided for in the existing BIS specifications/DTH Guidelines, is expected to be achieved by means of a combination of Common Interface (CI) slot in the STB and pluggable Conditional Access Module (CAM). However, technical interoperability, as envisaged in the existing DTH Guidelines, has, so far, not proved to be effective due to various techno-commercial issues.

The above conditions remain in-force. DTH service providers, however, have been representing at various fora that in the present scenario, mandatory feature of the CI slot in STB standard can be done away with, considering the technical and economic aspects of an STB.

[17] Available at http://mib.gov.in/sites/default/files/DigitalsettoBox.pdf

Hence, the STBs offered by an operator which maybe compliant with the BIS standards, do not ensure technical compatibility and effective interoperability across networks of all DTH operators, thereby hampering easy migration of the subscriber from one operator to another without re-investing in a new STB. Thus, it can be concluded that though there is a de-jure technical interoperability but there is de-facto technical non-interoperability. This was also reflected in a petition filed before the Hon'ble TDSAT by Tamil Nadu Progressive Consumer Centre, a consumer organization functioning from the state of Tamil Nadu.

2.12.2 TRAI Recommendations on "Licensing Issues Relating to DTH" dated July 23, 2014:

Ministry of Information and Broadcasting, Government of India sought recommendations of TRAI on the licensing issues relating to DTH services. In response to the Ministry's reference, TRAI recommended retention of existing technical interoperability conditions and updating of standards for set top boxes, as below:

i. "The license condition prescribed at clause 7.1 of the existing DTH Guidelines should be replaced with the following clause:
"The Set Top Box offered by a DTH service provider shall have such specifications as laid down by the BIS from time to time.
ii. BIS should come out with updated specifications for STBs from time to time and while doing so, BIS shall consult TRAI.
iii. The license conditions should mandate the licensee to comply with the tariff order/scheme prescribed by TRAI for commercial interoperability."

The Ministry of I&B accepted the said recommendations that TRAI should work with BIS and Ministry of Electronics and Information Technology to ensure interoperability of set top boxes for direct to home industry.

2.12.3 The Telecommunication (Broadcasting and Cable) Services (Seventh) (the Direct to Home Services) Tariff Order, 2015 (2 of 2015) dated April 1, 2015:

The Authority notified provisions on commercial interoperability of CPEs for DTH services enabling subscriber to choose operator/platform of his choice and enhancing transparency of charges levied. They make it obligatory on the part of DTH operators to provide set top boxes to subscribers on outright purchase basis or on hire purchase basis or rental basis. The objective of making provision for commercial interoperability for Set top box through these Regulations was to provide an easier exit route for the existing DTH subscriber to subscribe services of another DTH operator or any other available distribution platform.

Clause 5 of the Tariff Order provides a mechanism wherein the subscriber has the option to return the earlier CPE back to the erstwhile operator and claim an appropriate refund/payback. It has been elaborated in the Para 2,3 of the Explanatory Memorandum to the Tariff Order. The relevant extracts of are reproduced below:

"2. The Authority has noted that a DTH subscriber gets tied down to an operator once he is subscribed to that service provider. This is because generally, the consumer premises equipment (CPE) of one operator is incompatible with network of another operator/platform. Therefore, if a subscriber wishes to migrate to another operator/platform, he has to again procure a new CPE that is compatible with the network that he wishes to migrate to and the existing CPE is of no use to him. The Authority has also observed that there is a lack of transparency in various schemes offered by operators in the market and the charges levied on the subscriber. The Authority believes that a subscriber must be aware of all the terms and conditions of various schemes and the charges levied therein by the DTH operators. This empowers him to choose his platform/operator for reception of TV signals and also have the flexibility to migrate between operators/platforms without being tied down to a single operator/platform.

3. To address all these issues, there needs to be a mechanism wherein the subscriber has the option to return the earlier CPE back to the erstwhile operator and claim an appropriate refund/payback. This can partially offset the cost of the new CPE that needs to be acquired by him. The erstwhile operator can also reuse this returned CPE in his network. A framework for commercial interoperability enables an effective mechanism to be put in *place to achieve this objective. Commercial interoperability is also expected to promote fair competition and discourage monopolistic practices among DTH operators thereby enabling orderly growth of the sector. Given this background and the objective, the Authority has decided to notify this Tariff Order on commercial interoperability of CPEs for DTH services enabling subscriber to chose operator/platform of his choice and enhancing transparency of charges levied."*

The above notified Tariff Order was challenged in TDSAT by one DTH operator, (Broadcast Appeal no. 1 of 2015). The same has been disposed of by Hon'ble TDSAT vide its order dated 01.05.2019.

2.12.4 The Telecommunication (Broadcasting and Cable) Services Standards of Quality of Service and Consumer Protection (Addressable Systems) Regulations, 2017 (No. 2 Of 2017) dated March 03, 2017

The Authority notified these Regulations, to formulate a unified regulatory framework for QoS for different platforms. Chapter V of these Regulations deals with Customer Premises Equipment.

"24. Supply and installation of the customer premises equipment

(1) …
(2) …
(3) Every distributor of television channel or its linked local cable operator, as the case may be, shall offer customer premises equipment to every consumer under the following schemes:

- *outright purchase scheme, and*
- *rental scheme:*

Provided that, in addition to offering customer premises equipment on outright purchase scheme and rental scheme, it shall be permissible for the distributor or its linked local cable operator, as the case may be, to offer customer premises equipment under any other scheme including bundled scheme."

Hence, Commercial Interoperability in these Regulations is achieved through the provision of surrender of CPE inbuilt in the rental schemes offered by the DPOs. The issue has been elaborated in paragraph 34 of the Explanatory

Memorandum to the Regulations. The relevant extracts of the Explanatory Memorandum are reproduced below.

> *"34. A few stakeholders submitted that there is no provision in the draft regulations for return/surrender of CPE. In this regard the Authority is of the view that the ownership of CPE rests with the DPO's for the rental scheme and the other schemes being offered by DPO's. Therefore, the provision of surrender of CPE is inbuilt in the schemes excluding outright purchase scheme. A provision is also made in the regulations to enable subscribers to surrender their connection subject to terms and conditions of subscriptions, if any. Subscribers can therefore return the CPE. A few stakeholders have also highlighted the issue relating to interoperability of STB's. The Authority has already initiated an exercise to examine the feasibility of interoperability of STB's. The Authority would come up with its view in this matter in due course of time."*

Two broad observations can be made from the preceding sections. First, that the technical interoperability, as provided for, vide the license conditions through Open Architecture of STBs is applicable only to the DTH platform and does not cover Cable TV segment. Even for DTH platform, though the provision exists in letter, it has not been adopted in spirit. As such though all STBs supplied/provided by the DTH service providers remain interoperable using CI module, the availability remains elusive for consumers. The issue is dealt in more detail in Chapter 3.

Similarly, even though provision for commercial interoperability made vide TRAI Regulations described above is applicable, in practice it has remained ineffective due to opaque pricing models for STBs. As far as commercial interoperability is concerned, there is one crucial distinction vis-à-vis technical interoperability. Whereas in case of technical interoperability, the STB remains with the same customer in case of change of service provider, in case of commercial interoperability, the outgoing customer surrenders the STB to previous DPO, who, in turn, may offer it to a new subscriber. In such a scenario, even if more efforts were made by the concerned stakeholders to promote commercial inter-operability, the acceptability of old STBs by incoming consumers may be limited, as new consumers are desirous of owning a new STB. The issues related to non-transparent schemes to provide STB have been duly addressed in the Telecommunication (Broadcasting and Cable) Standards of Quality of Services and Consumer Protection (Addressable Systems) Regulations, 2017 ('QoS Regulations'), issued on March 3, 2017. The regulations provide for clarity on schemes for supply of STB to the consumer either on outright purchase basis or rental basis or on an explicit mix model of purchase and rental scheme. Further the Explanatory Memorandum to the Regulations also express the intent[18] to examine the feasibility of interoperability of STBs which are described in more detail in the following sections/ chapter.

2.13 TRAI Pre-Consultation Paper on Set Top Box Interoperability dated April 4, 2016

2.13.1 TRAI on *suo-motu* basis took up the issue of technical interoperability of STBs and issued a pre- consultation paper to solicit the views of stakeholders to identify various issues relating to technical interoperability of STBs, challenges and concerns of the industry. The said paper was released with intent to drive the focus of the TV broadcasting industry towards the suitable solutions for technical interoperability of STBs, which can be worked out. The Consultation Paper explored various available solutions for achieving interoperability in unidirectional broadcast.

2.13.2 In response to the pre-consultation paper, a total of 28 comments were received from stakeholders. Majority of stakeholders (MSOs, Consumer Action Groups and Consumers etc.) supported the interoperability of STB and welcomed TRAI initiative. However, a few stakeholders raised some concerns summarized as below:

- Technical interoperability of STB may increase the cost of STBs.
- Cost of replacement of existing STBs would be enormous and it may take longer time to market the new product. E-waste may increase as current STBs will be discarded.

[18] Expressed in paragraph 34 of the Explanatory Memorandum to the Quality of Service Regulations, 2017 (No. 2 of 2017),

- As huge subsidies are given by DPOs to their consumers in provisioning of STBs thereby interoperable STBs will not protect their investments.
- Network will become more vulnerable (Piracy) and it would be difficult to fix the responsibility for security breach and there may be difficulty in ensuring the responsibility in case of hacking.
- Technical interoperability would take away innovation. Product differentiation would be difficult and user experience will be hampered. User Interface (UI) and other services provided by operators need to be supported by the inter-operable STBs which may not be feasible.
- If the STBs are available in an open market then low quality STBs may result into fault in services. Since the broadcasting distribution networks are unidirectional and therefore the cause of fault services will be difficult to identify.

2.14 TRAI Consultation Note on 'Solution Architecture of Technically Interoperable Set-Top Boxes' dated August 11, 2017

2.14.1 To address the concerns of the stakeholders in respect of interoperable STBs, as communicated in response to the pre-consultation paper mentioned above, TRAI collaborated with IIT-Bombay and Centre for Development of Telematics (C-DOT). The issues identified by stakeholders in response to the pre-consultation paper were communicated to C-DOT and IIT-Bombay.

2.14.2 Subsequently, C-DOT, the Telecom Technology Development Centre of the Government of India, in close coordination with TRAI, developed a solution architecture for technically interoperable STBs by putting the proprietary conditional access functionality only in Smart Card (SC) and making the STB as a generic platform.

2.14.3 TRAI released a Consultation Note on 'Solution Architecture of Technically interoperable Set-Top Boxes' based on the solution developed by C-DOT on 11 August 2017. In response to the consultation note, a total of 20 comments were received from stakeholders. While CDOT designed interoperable STB and tested it under lab conditions, testing with commercial CAS systems and STBs and demonstration of interoperability is still pending.

2.15 Alternate approach based on Downloadable CAS

2.15.1 While testing and demonstration of the solution is awaited from C-DOT, TRAI held discussions with other stakeholders to help in finding alternate solution(s) to establish STB interoperability. It emerged that an alternate framework could be possible with existing chipsets and with minimal changes in the existing ways the STBs are deployed using Over-the Air (OTA) based software uploaded by respective DPOs. This solution based on Downloadable CAS was explored by the Authority by engaging a consultant having domain expertise on the subject.

2.15.2 Subsequently, the Authority conducted stakeholders' workshops to present the suggested solution architecture to the industry and invite feedback/ suggestions from them. Accordingly, two workshops were held, on May 09, 2019 and May 21, 2019 at Delhi and Mumbai respectively. Representatives from the Industry including the CAS/SOC vendors, Broadcasters, DPOs etc. participated in these workshops to share their viewpoint on the Interoperable STB project. Security against content piracy, implications of interoperability on STB cost, capability of SoC to accommodate all deployed CASs, implications on proprietary execution etc. were some of the major concerns expressed by industry stakeholders against Downloadable CAS solution during these workshops.

2.15.3 The Authority constituted a committee of experts to review the solution architecture based on Downloadable CAS. The committee flagged certain additional concerns with the proposed solution. The Committee observed the challenges in accommodating all deployed CASs and raised questions over feasibility to accommodate new entrant CAS vendor. The comments of the stakeholders and observations of the expert committee have been duly analysed. It is observed that the downloadable CAS solution may limit the choices. Further the solution may have capacity constraints to handle all the prevalent CAS solutions. The solution may have limitations in terms of future CAS solution providers.

2.16 Solution based on Embedded Common Interface

2.16.1 In view of above, the Authority intends to explore any solution that achieves interoperability of the Set-Top-Box in unidirectional broadcast network, while addressing concerns of most of the stakeholders. Though it is observed that ETSI GS ECI 001 5 2 standard offers a futuristic solution to interoperability, it is yet to be developed and deployed. There are other developments in Pay-TV sector whereby feature rich hybrid Set-Top-Boxes are being offered by leading distributors. Such hybrid boxes have provisions for connecting to internet for providing other content based services, making the return path available for communication with such boxes. Availability of return path can provide for better solutions to implement interoperability of such STBs. However, as penetration of such STBs is a very small sub-set of total consumer base, there is a need to find a solution that helps all the consumers.

2.16.2 In the next chapter various solution approaches to STB interoperability are described in more detail, including their benefits and constraints and field experience, if any.

CHAPTER 3

SOLUTION APPROACHES TO INTER-OPERABILITY

3.1 Based on the details in previous sections, it is established that inter-operability of Set-Top-Box is desirable. An interoperable STB will extend freedom of choice to the consumers, create an open market, commoditize the STB thereby providing the advantages of scale and reduce e-waste. It will also enable the DPOs by enabling them to save lock-in capital as-well-as service-related issues of STBs. Identifying possible solution(s) which addresses the concerns of stakeholders will help in engendering support from all. As per available information, there are few solutions that promise to enable interoperability of the STB. Some of these solutions have already been deployed in different countries, while others are still at development stage. These solutions differ not only in their approach but may also have varying degree of applicability. For example, while earlier solutions might have been developed specifically for linear TV broadcast, recent standards are designed with far broader scope extending beyond conventional TV broadcast to include IPTV, OTT etc. Different solutions for interoperability of the Set-Top-Box are discussed in following sections:

3.2 Separation of CAS from STB (Card based approach)

3.2.1 Developed by Centre for Development of Telematics (C-DoT) for Indian Market, this solution pivots on separating the network specific software features of distributor and the STB hardware. The proprietary features of the distribution network are put into a Smart Card (SC), thereby making the STB as a generic platform. In this case the interoperable STB would contain operator configurable blocks and the configuration of those blocks would be done through the SC. Each operator will have their own smart cards that will inter-work with the interoperable STB. Whenever a subscriber wants to change the DPO, she/ he would require to obtain the smart card from the new DPO. Operator specific part of CAS in the SC (ECM, EMM decryption etc.) is retained unaltered leaving enough memory space for innovative service offering by DPOs while maintaining the proprietary nature of CAS.

3.2.2 For facilitating interoperability, C-DOT has envisaged establishment of a trusted third party which acts as a Nodal Agency. The nodal agency will be responsible for issue of authentication codes to STB manufacturers as well as

to the DPOs. STB manufacturers and DPOs would be required to apply for getting an authentication code from this nodal agency. Using these authentication codes, the STB manufacturer would fuse the STBs at the manufacturing stage with individual secure keys. These secure keys can serve as the STB identifier in a similar manner as to the IMEI numbers of mobile phone handset.

3.2.3 The smart card based solution has been successfully tested in lab conditions, using separate instances of CAS developed by C-DoT. However field testing with the third party CAS solution is still to be conducted with different industry stakeholders.

3.2.4 The authority has invited stakeholders comments on the C-Dot solution vide a Consultation Note on 'Solution Architecture for Technical Interoperable Set Top Box' in August 2017. More details on the solution can be accessed at https://main.trai.gov.in/sites/default/files/Consultation_note_on_STB_interoperability_110817.pdf.

Challenges:

- Most of the advanced smart Card based CAS systems in use have implemented advanced key-ladder embedded into the SOC of the STB to improve robustness of the security. Such CAS systems will still be anchored to the Key ladder of the SOC of the STB. To ensure robustness of security while separating CAS from the STB is a challenging task. A comprehensive demonstration on this account is essential to gain acceptance of the industry.

- In past few years industry has seen a shift from card based STBs to card-less STBs. However, this framework is developed for card-based STBs. The card introduces another cost element in the STB value chain.
- As the solution introduces an additional layer in the form of TA/ILA, it may add procedural and commercial costs to the solution.
- The solution introduces a third-party Trust Agency which becomes nodal to the functioning and success of the solution, thereby bringing in an added layer of function/ regulation.

3.3 DVB CI

3.3.1 One of the first exchangeable Conditional Access/ Digital Rights Management (CA/DRM) solutions introduced by DVB (Digital Video Broadcast) group in the European market was Common Interface (CI). The DVB Common Interface (DVB-CI) specifications describe a system whereby a removable Conditional Access module (CICAM), given the appropriate rights, unscrambles protected content and routes it back to the Host over the same interface. These DVB Common Interface specifications were extended by the CI Plus specification, which provides common methods (i.e. methods that are independent of the up-stream CA system) for mutual authentication of the CICAM and Host, and link encryption over the return interface from the CICAM to the Host. The host device (STB or TV) is responsible for tuning to pay TV channels and demodulation of the RF signal, while CAM is responsible for CA descrambling. The Common Interface allows them to communicate with each other. A subscriber who desires to change her/ his service provider can buy the CAM module of the new service provider and insert in interoperable STB or iDTV.

3.3.2 This industry specification, including a trusted environment, soon was accepted by the market participants, although not developed by DVB as an ETSI (European Telecommunications Standards Institute) standard but instead as an industry specification by the CI plus consortium. All Host equipment (STB or TV) built with DVB Common Interface must comply with the EN 50221-1997[19] standard, that enables the addition of any CAM in STB or DTV to adapt it to different kinds of CAS.

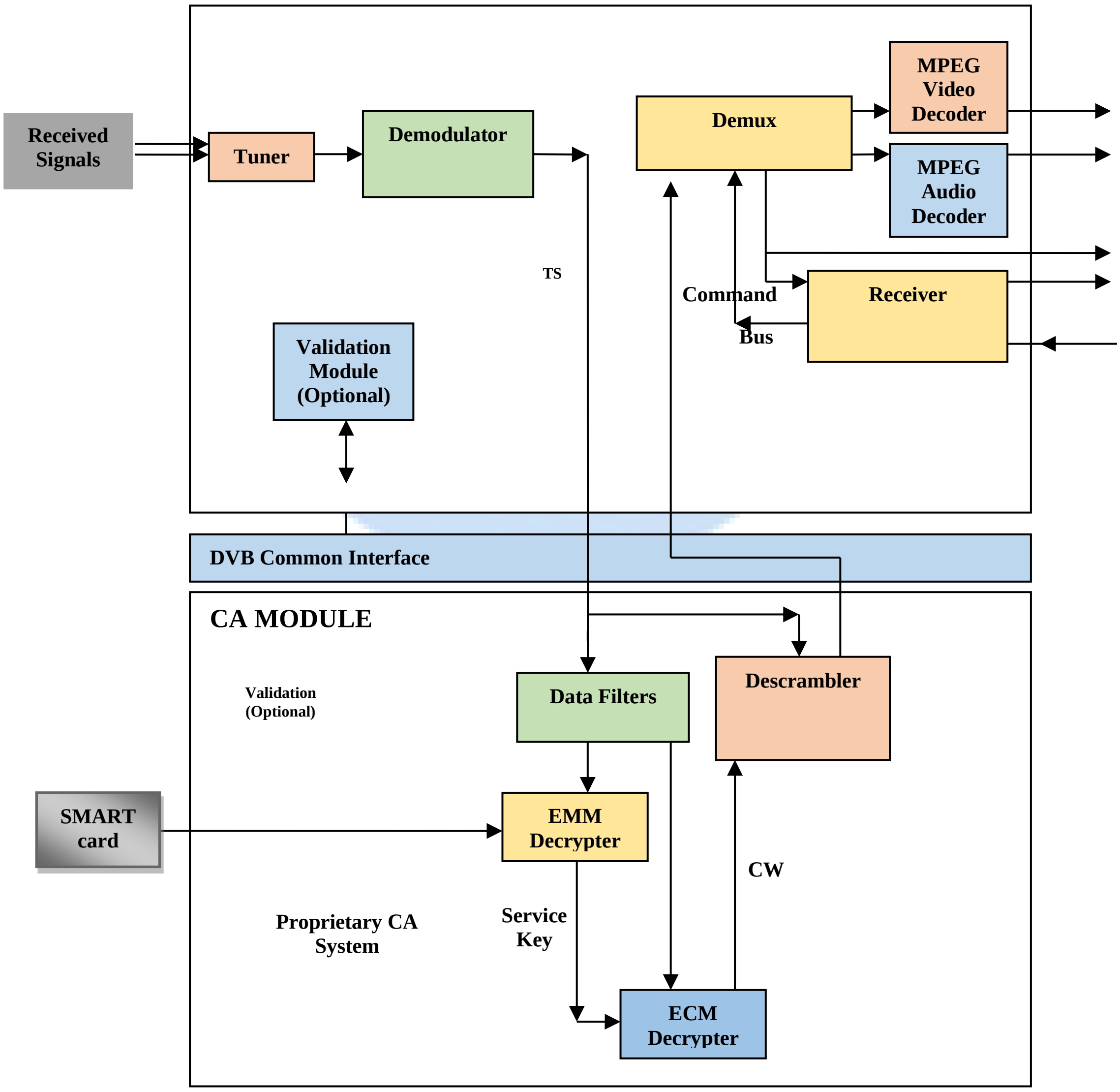


Figure 11: STB with DVB-CI Interface

For receiver end, DVB Common Interface (DVB CI), along with common scrambling system has been used worldwide to promote inter-operability of

[19]https://www.dvb.org/resources/public/standards/En50221.V1.pdf

different CAS systems either with different smart cards or with soft CAS which uses no smart cards.

3.3.3 This approach is widely in use in Europe with an annual sale of approximately 5 million modules as per industry inputs. In Europe since 1998 all digital TV sets of 30 cm screen diagonal or more are required to be equipped with an "Open Interface socket" and hence are equipped with DVB CI + socket. The penetration of the CICAM is also supported by the rental model adopted by service providers in Europe to absorb the cost of CICAM which was high to be successful under a retail model.

Challenges:

- The solution relies on hardware modules that have their associated disadvantages e.g. relatively high production cost, necessary hardware change in case of update by service provider etc.
- A similar approach was explored in the United States in 1998 when FCC mandated separation of CAS from STB. The device/module, in the US, was called as the Cable Card. However, the approach did not see much success and only 0.45 million interoperable cards could be sold against 17.7 conventional STBs between July 2007 to April 2010. Main reason for poor results of the approach was recognized as the fact that such third-party STBs were unable to provide range of functionality as provided by the conventional STB leased by the Operators. The subscribers were often unable to access many of the operator's services that leased STBs used to provide.

Constraints:

- The solution supports on one CAS/DRM system at a time,
- The solution does not address mobile and smart devices in multi screen scenarios, etc.

3.3.4 Indian Experience with DVB CI Interface

The same approach of DVB CI interface had also been put as a license condition for STB of DTH broadcast in India, wherein the STB would be sold with a DVB CI interface. The guidelines[20] entail that subscriber may buy the CAM modules from a different operator and use it to change the service.

This could have created a huge open market for standard STBs without any embedded CAS. And the demand of CAM modules should have increased. However, that did not happen.

The CAS vendors/ service providers either did not sell any CAM modules or the price remained high compared to the STB. Customers did not find it financially prudent to buy CAM module and rather bought different STB when they wanted to change the service.

Further, perhaps more due to commercial considerations, rather than other reasons, the DTH companies are reluctant to fully imbibe the DVB CI interface. The cost of CAM module could have been easily absorbed by the price of a TV, but the same is not possible for STB.

However, some policy shift has been observed recently and Samsung R&D, India, have tested interoperability using DVB CI + standard in their iDTV[21] with few operators. (Annexure I)

3.3.5 DVB-CI + 2.0 with USB:

Some of the constraints mentioned above with the CI/ CI+ solution have been addressed in the updated Common Interface standard, DVB-CI + 2.0. The connector for the second-generation Common Interface[22] is an industry standard USB Standard-A connector **USB 2.0 and USB 3.1** which can be connected in almost all the STBs/ TV because USB connector is present in almost all the devices. The ubiquitous presence of USB interface in almost all new devices makes it a logical and easily integrable solution. Further, it should also bring down the implementation costs for devices and TV sets by removing the single purpose PCMCIA interface. It will also bring even higher data rates by taking advantage of the capabilities of USB 2.0 (240 Mbit/s full duplex), up to 3.1 Gen 2 (5 Gbit/s full duplex).

[20] https://mib.gov.in/sites/default/files/GuidelinesforDTHServiceDated15.3.2001.pdf
[21] Inputs received from Samsung R&D Institute India-Delhi
[22] https://www.etsi.org/deliver/etsi_ts/103600_103699/103605/01.01.01_60/ts_103605v010101p.pdf

Further, for compatibility with the previous generation PCMCIA CAMs, an adapter as shown in Figure 3 of Annexure II[23] can be used.

Challenges:

- Though a significant reduction can be expected in CAM prices in the long run due to universal availability of the USB interface. However, in the initial phase, prices may be fixed by the developers and manufacturers, thereby causing some escalations. In the long run too, the various players in the STB eco-system (CAS vendors, SOC chipset provider and Middleware vendor) may hold the key to pricing of the STB/ CI module.
- Due to limitations on User interface, User experience as compared to the conventional broadcast may not be feature-rich for the Common Interface user.

3.4 Downloadable CAS

This solution is based on the change of CAS on a STB using over the air download. The underlying feature of this solution requires that basic CAS version of different CAS solutions with its security features is pre-loaded in the SOC chipset. It creates an environment for the coexistence of multiple secure CAS technologies in the network. The full feature CAS of a service provider can be downloaded on any STB as and when service is configured for a specific customer. During this process the pre-loaded basis building block of the CAS software is expanded with the full version. Security of the CAS is implemented through key-ladders which are fused onto the SoC at the fabrication stage. Operationalisation of the functionality is envisaged through a Trusted Authority (TA)/ Industry Licensing Authority (ILA). TA/ILA shall be custodian of the secret chipset key (SCK) and SCK manipulation function.

3.4.1 Technical Background

Presently at manufacturing stage of STB, CAS software is downloaded on to the STB as an image. However, there is provision for Over the Air modification or upgrade of CAS as required from time to time. The modified part of CAS is

[23] Mr. Alexander Adolf, Vice-Chair, DVB Technical Module in DVB SCENE, October 2016 issue (Annexure II)

received by all the STBS in the network through OTA in broadcast mode and required modification is implemented on the STB. Modification through OTA is done both for CAS and middleware. The STB is built with protection measures using keys/ Key Ladders which prohibit any unauthorized OTA activity. Presently proprietary algorithm is deployed to block any other CAS to be downloaded through OTA.

Presently in most of the STBs deployed in India, such unidirectional download is possible and the same is used to upgrade the Cas solution from time-to-time. However, the downloadable CAS solution proposes to use the same OTA process to download a different CAS on the STB keeping similar protection mechanism in place but standardizing it. The solution envisages availability of bidirectional path at the time of switching of the CAS.

Following paragraphs elaborate the technology framework :

3.4.2 Framework to enable inter-operability on STB through Down-loadable CAS

There are following key items are necessary to enable interoperability:

3.4.2a Standard Software Downloader

The standard software downloader is essential in order to ensure that all deployed STBs have a practical means by which a new software image can be installed and downloading of new images are not blocked. Several standards exist for Software downloader which could be used as a standard in this framework. A variety of means of signaling may be standardized to control the Over the Air (OTA) download and target the update at individual STBs.

3.4.2b Standard Boot loader

It may be impractical to replace the boot loader on a STB once the box has been deployed. For this reason, within a standard Conditional Access Framework, it must be standardized to use the same boot loader. There should be no intellectual property belonging to CAS vendors within the boot loader which is not freely available for use by other CAS vendors. The boot loader must provide the features necessary to initialize the chipset and verify the application image but contain no CAS vendor specific functionality.

3.4.2c Standard Key Ladder

CA vendors typically hold critical signing keys and use proprietary key ladder configurations. Initially there was only one set of key ladders which used to get fused into the SOC. However, now it is possible to fuse multiple set of key-ladders pertaining to different CAS solutions. The Key sets of different conditional access vendors to work with key ladders are kept securely isolated from one another. ETSI TS 103 162[24] Key Ladder Standard is the most accepted configuration for standard key ladder implementation for all CAS and SOC vendors.

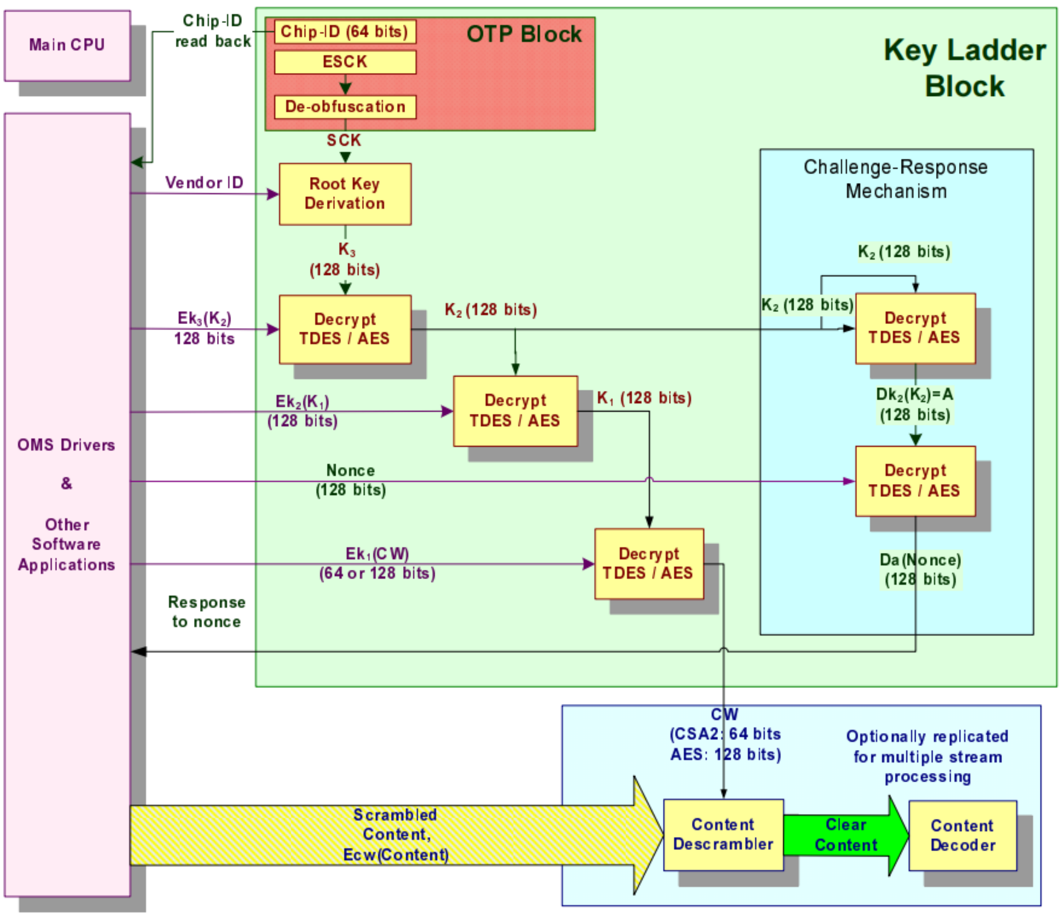


Figure 12: Key Ladder Block Diagram[25]

[24]https://www.etsi.org/deliver/etsi_ts/103100_103199/103162/01.01.01_60/ts_103162v010101p.pdf
[25] Source:https://www.etsi.org/deliver/etsi_ts/103100_103199/103162/01.01.01_60/ts_103162v010101p.pdf

This key ladder specification had been designed to support the dynamic substitution and replacement of either sink or source device in a manner that maintains the security and integrity of the underlying content distribution network. The specification enables the portability of sink devices between content distribution networks by permitting the field upgradeability of sink devices to work with previously unknown source devices. The specification also enhances the capability of networks to upgrade their source devices without disrupting the capabilities of already fielded sink devices.

In conjunction with information regarding the keys/key ladders and other STB specific details required for the framework may be held in escrow enabling this data to be released under clearly defined criteria to a specific operator and/or CAS vendor for addressing a particular STB for downloading. Operationalisation of the functionality is envisaged through a Trusted Authority (TA)/ Industry Licensing Authority (ILA). TA/ILA shall be custodian of the secret chipset key (SCK) and SCK manipulation function.

For the unrestricted downloading through OTA process, the CAS Libraries are to be updated by the Head End as per requirement. The CAS specific parameters are downloaded and upgraded into the box as per requirement by Head End. If smart cards are used for the STB, pairing of CAS ID and Smart Card is performed through OTA.

Challenges:

- As the solution introduces an additional layer in the form of TA/ILA, it may add procedural and commercial costs to the solution. In fact, in this solution at any change over of operator, STB needs to be connected to TA. This may add procedural delays and be a deterrent to the consumer.
- The number of CASs for which interoperability can be achieved will be limited by the number of key-ladders that can be fused onto the SoC.

Technical feasibility and cost implications of extending the solution for more number of CASs is as yet not known.

- Any new entrant CAS vendor will have constraints to be adopted in the solution framework.

3.5. Embedded Common Interface (ECI)

As the name suggests, ECI is Embedded Common Interface. The DVB CI specification was a hardware implementation of Conditional Access interchangeability where as ECI specification has been conceived to have embedded common interface for exchangeable CA/DRM solutions incorporated through software download ability. It envisions working of legacy unidirectional Pay TV, two way IP TV and currently developing OTT solutions all on a single STB platform. The specification also incorporates the requirement of multi screen environment of video consumers; where in the same household consumers use number of video screens, such as TV, computers and other mobile devices and consume videos concurrently and move from one display to the other. The specifications incorporate number of CA/DRMs working concurrently and connect different devices from one CPE (consumer premises equipment). However, to incorporate all these required functions a new STB structure has been envisioned.

3.5.1 Technical Background

ETSI GS ECI 001 standards have been released by ETSI as a group of 6 standards from ECI 001 01 to ECI 001 06 from 2017 to 2018. Subsequently the standards have also been recommended by ITU. A brief description of the standards has been provided in the following paragraphs.

The CPE structure as envisaged in the ETSI GS ECI 001 Standards includes at least two ECI Containers meaning at least two CA/DRM systems should be able to run on the CPE simultaneously. The standard allows both smart Card and non-smart card based systems.

The ECI specifications define, amongst others, the interface between an ECI Client and the ECI Host. Figure 13 shows the block diagram of a CPE with

ECI Clients, and the other functions in the ECI Host that the ECI Clients may make use of. During the installation of an ECI Client and during launch of an ECI Client, the ECI Host specifies which relevant functions it has available to the ECI Client. The concept is based on a hierarchical loader concept consisting of a chip-based loader, the system software loader and the ECI Client Loader.

The ECI Host Loader loads the ECI Host software. This includes besides other elements the virtual machine, access to advanced security components, and the ECI Client Loader. An ECI Host can load multiple ECI Clients into separate virtual machine instances, which run independently and isolated against each other.

When loading an ECI Client into the system a virtual machine instance is created in which the ECI Client is started. This VM Instance acts as a sandbox between the ECI Client and the ECI Host. The interface between the ECI Host and the ECI Client is the key interface which the GS specifies. The interface also specifies the information flow and protocols between multiple instances of such an ECI Client and to other functionality inside the CPE, like advanced security, display, etc.

The ECI Host itself depends on the manufacturer implementation. ECI specifies the APIs for the communication of the ECI Host with the ECI Clients. The ECI Host interfaces to the OS and the driver layer and provides all functionalities defined by the ECI Client interface specification. The ECI-Host needs to be certified by the Trust Authority in order to ensure compliance with the ECI specifications.

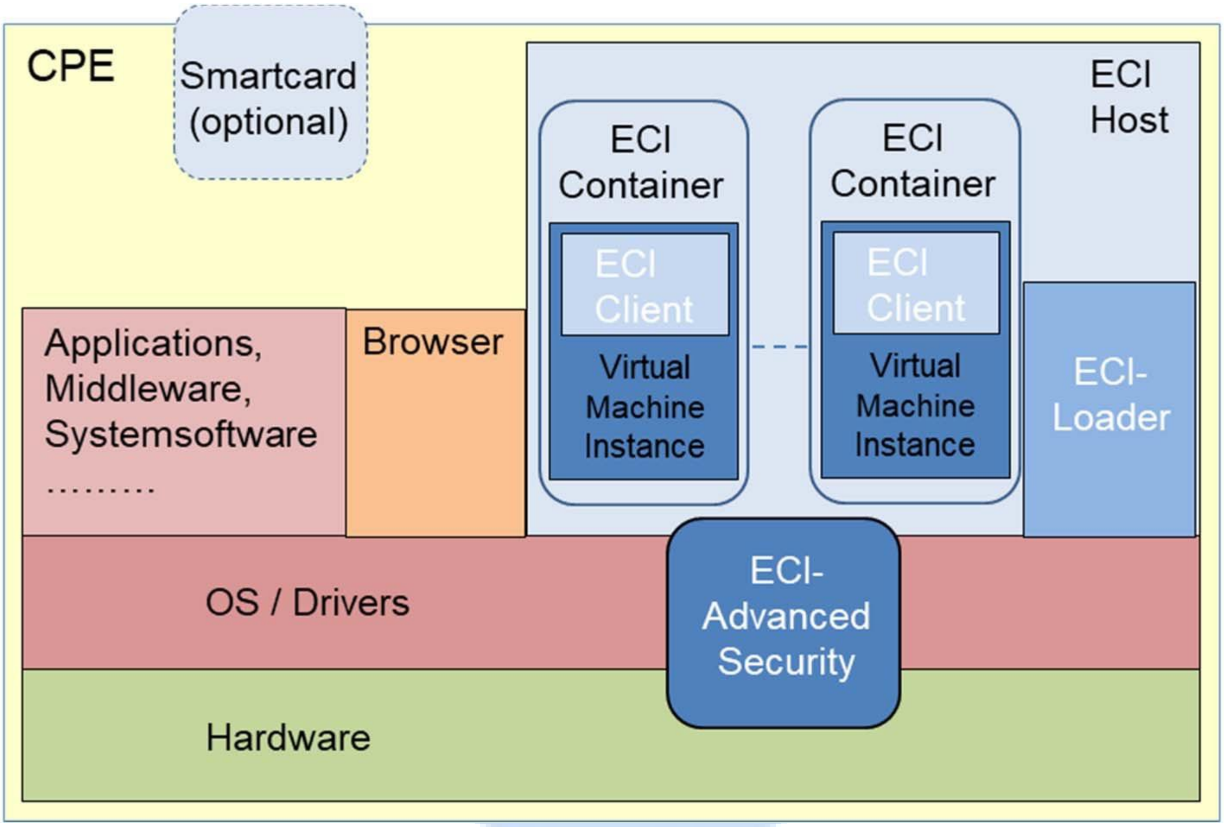


Figure 13: Block Diagram of CPE as per ECI Standard

CPEs essentially need a virtual machine capability to incorporate virtual Machine instances. TV-centric devices are defined as devices which include MPEG-2 transport stream processing inside the chip-set. ECI requires that those chipsets implement ECI-compliant Advanced Security functionalities. The standard specifies provisions to leverage Advanced Security mechanisms in the chipset, such as to protect the key associated with the content during its travel into the CPE processor chip's content decryption facility. This Advanced Security concept allows all ECI Clients using the facility, if needed, to operate simultaneously and independently from each other.

The CPE is capable of working as a micro server for other CPEs in the home environment where the content is shared after re-encryption within the CPE.

A content provider encrypts their digital content and uses a content protection system in order to protect the content against unauthorized access. A consumer uses a content receiver to access protected content. To this end, the content receiver contains a chipset that implements one or more content decryption operations. A cryptographic key establishment protocol is used to secure the transport of content decryption keys from the content protection system to the chipset. The steps of the protocol that are implemented within the chipset are referred to as a key ladder in the standard. The standard specifies a key ladder for the key establishment protocol.

The key ladder and the protocol may also be used to secure the transport of content encryption keys to the chipset. Such keys are required for use cases in which the chipset re-encrypts content. The chipset may implement one or more content encryption operations for this purpose. Personal video recording and exporting protected content to a different content protection system are typical examples of content re-encryption use cases. Content decryption keys and content encryption keys are both referred to as control words.

The standard also specifies an authentication mechanism. This mechanism is closely related to the key ladder and may be used for entity authentication; in other words, this mechanism may be used to authenticate the chipset.

The key ladder and authentication mechanism specified in the standard are agnostic to both the content protection system and the content provider. This enables a content provider to use any compliant content protection system, and it enables a consumer to use the content receiver for accessing content of any content provider that uses a compliant content protection system.

A certification authority manages a public-key certificate of each chipset in the mechanisms specified in the standard. In particular, the certification authority distributes such certificates and certificate revocation information to content providers that want to make use of the key ladder and/or the authentication mechanism. Next, the content providers use the certificates and certificate revocation information as input to their compliant content protection system; the knowledge of the public key in the certificate of a chipset enables the content protection system to generate suitable input messages for the chipset's key ladder and authentication mechanism.

3.5.2 Trust Authority

The technical ECI specifications provide significant freedom for making technical implementations, enabling ecosystems to make their own choices on how to implement certain features. In addition, the openness of the ECI system allows for certain components to be interchangeable. These properties require mutual trust between parties participating in the system and compliance to a common set of rules. These rules are collected in a Trust Environment and created and maintained by an ECI Trust Authority (TA).

The Trust Environment is defined by the Trust Authority and consists of the contractual framework, policies, and technical specification required for creating a real-world ECI Ecosystem. The TA is a legal entity that governs all rules and regulations for a specific Trust Environment and enforces them through legal and technical means. In addition, the Trust Authority serves as trusted root for the chain of certificates use to authenticate Entities of the ecosystem.

A stakeholder of an ECI Ecosystem is any legal entity that commits itself to the contractual framework of the ecosystem by entering a contractual relationship with the Trust Authority.

The following key stakeholders exist in an ECI Ecosystem:

- Platform Operator / Service Provider
- CPE Manufacturer
- Security Vendor (creates ECI Clients)
- ECI Chip Manufacturer

The ECI standard specifies legal trust Authority at multiple levels.

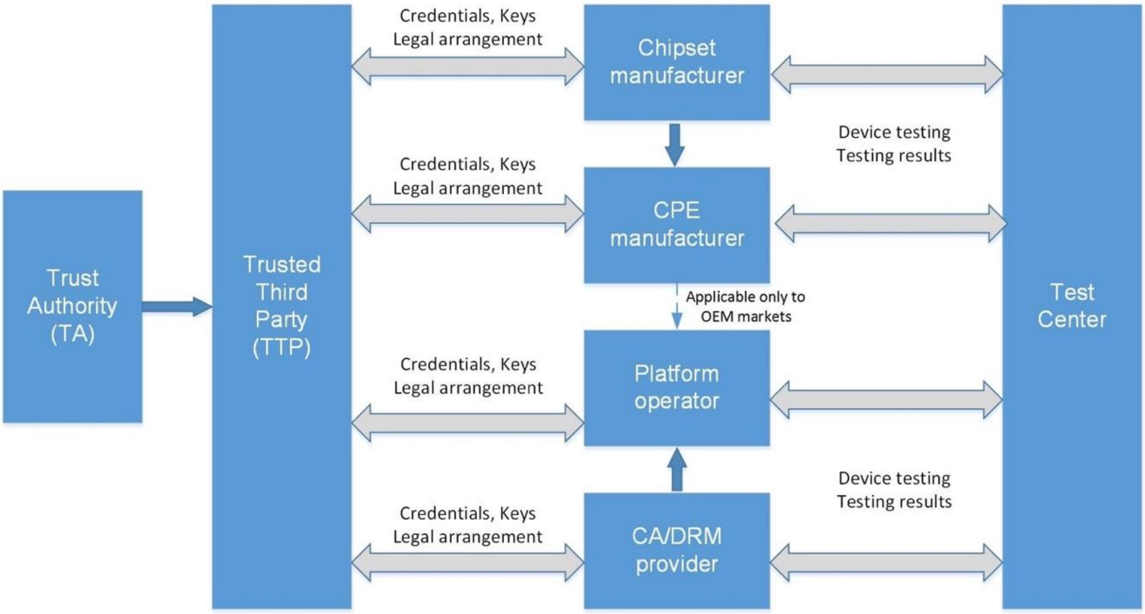


Figure 14: ECI Trust Environment Framework

3.5.3 The implementation of comprehensive ETSI GS ECI standard would offer following unique possibilities not provided by other solution approaches:

- Embedded CI shall be applicable to any broadcasting, broadband and hybrid (means a combination of broadcast and broadband) services, delivering Protected Content via any type of appropriate access network to any type of applicable device.
- Embedded CI shall support the implementation of more than one CA/DRM client in a CPE which provides a solution for the concurrent processing of at least two different Protected Content events.
- Embedded CI shall allow changing to a new service provider without a required consent of the CA/DRM manufacturer, device manufacturer, platform, or service operator.
- Embedded CI shall not unreasonably restrict the possibilities of CA/DRM vendors to develop different interoperable/swappable ECI Clients according to the market requirements.
- Embedded CI shall support system implementations both with and without Smart Cards as security devices and shall provide the resources for both types of solutions.

3.6 Recent Technology Trends

The evolution of internet and high-speed broadband in India has transformed the user behavior with regard to consumption of audio-visual content. Further fueled by low data rates, there is a fast-growing preference for online video services. Converged services are now being offered in a market, comprising content, service and network providers, as well as device manufacturers. The concept of convergence has led to blurring of boundaries between the traditionally distinct ICT sectors, namely: the telecommunications, media (including broadcasting) and device (or IT) industry.

With the combination of broadcast and broadband, cable TV is no longer confined to a set of linear television services delivered over a dedicated wired broadcasting network requiring transmission over standard compliant receivers like Set Top Boxes (STB). It is rather emerging as a platform for comprehensive service offering, comprising of other integrated services, like video on demand (VOD) services, internet access services, cloud storage and application services.

With the entry of Telecom network operators in this space, bundled services with other traditional telecom services are being offered to the consumer e.g. Reliance Jio's JioTV, Airtel's Airtel TV. Thus, TV homes in India are increasingly emerging as consumers of diverse media content including both traditional as well as online content. This shift in user preference has led to the launch of new product offering such as Android devices and Hybrid Set Top Boxes.

Connected TV

Connected TV and Ultra High Definition Television (UHDTV) are specific developments for high quality video delivery in a converged marketplace. They extend the Integrated Broadband Broadcasting (IBB) concept, by providing apps for smartphone and tablets to facilitate 'second screen' functionality (like participating in games, surveys, providing feedback and more detail background information), whilst watching the main television screen. Connected TV sets are either:

1. Integrated connected TV sets, whereby the functionality to access the Internet is built into a single device or set (i.e. the smart TV set), or;

2. TV sets with an external device, often connected to the TV set through the USB port, which provides access to the internet (i.e. TV sets with dongles, such as Amazon's Fire TV stick, Google's Chromecast or the recently launched, Airtel's Xstream stick etc.)

Hybrid Set Top box

Hybrid set-top boxes are used consumption of Smart TV programming, enable viewers to access multiple TV delivery methods (including terrestrial, cable, internet, and satellite). They include video on demand, time-shifting TV, Internet applications, video telephony, surveillance, gaming, shopping, TV-centric electronic program guides etc. By integrating varying delivery streams, hybrids enable pay-TV operators more flexible application deployment, which decreases the cost of launching new services, increases speed to market, and limits disruption for consumers.
Major DTH players are looking to introduce hybrid set-top boxes to gauge consumer viewing pattern using return path data (RPD) technology. Airtel has recently launched Airtel Xstream 4K Hybrid set-top Box. Reliance Jio has also rolled out their 4K hybrid set-top box and Dish TV have announced their own plans for launch of Hybrid Set Top Box.

TVkey/ TVkey Cloud:

In a parallel development, there are industry led developments to exploit technology to bring increased flexibility and user convenience in TV viewing sector. One such example is the TVkey and TVKey cloud solution, developed jointly by Nagra and Samsung. TVKey is implemented directly within the connected TV set to display encrypted pay-TV channels without requiring a set-top box. Recent Samsung TVs contain a hardware Root of Trust in the TV

System on a Chip (SoC). This allows the highest level of security in the industry and meets MovieLabs requirements for the Enhanced Content Protection of premium 4K UHD/HDR content. TVkey Cloud leverages the connection to a secure back-end platform to move part of the security and the management of user entitlements to the cloud - allowing a smooth introduction of the solution into any Operator's environment. The customized HbbTV OpApp is within the control of the operator, so can be upgraded independently of the TV vendor and offers the same user experience on screens offered by different TV brands. TVkey supports HTML5-based HbbTV applications to provide operator branding and functionalities that are also TV-vendor independent. TVkey also supports other key MovieLabs requirements like forensic watermarking. The current version, TVkey Cloud, has removed the need for an external hardware device and is based on the security offered by a back-end platform in the Cloud coupled with a software component on the TV that relies on a hardware Root of Trust embedded in the chipset. The solution has been commercially launched in Germany in 2019.

3.7 Way Forward:

From the foregoing discussions, it can be averred interoperability of STBs cannot be implemented in the currently deployed STBs in the cable TV segment as the hardware is locked in a proprietary eco-system. The existing STBs cannot be unlocked unless both the service providers use the same CAS vendor; or both the CAS systems use exactly same structure and are willing to share secret keys. All the possible technical solutions encompass a new implementation mechanism that can be applied on future supply / deployment of STBs. Therefore, the interoperability can be implemented only on prospective basis for new installations. As of now based on analysis of available technical solutions, if interoperability is introduced using any one model, it becomes applicable to the future supplies of STBs. A question thus remains as to, can there be a solution that enables interoperability, either on commercial terms or on the basis of a technical solution?

Even as technologies continue to evolve to keep up with the ever-changing preferences of the end users and the industry requirement to fulfill them, a common trend over the years can be seen in the form of a shift to software-based solutions. And reasons for this paradigm shift are quite simple and intuitive. The benefits of economy, faster deployment and flexibility, which are inherent to software solutions are now further gaining importance in view of the increasing complexity of networks and devices. With the trend towards convergence of services and applications, there is a need for technologies that facilitate not only fast and smooth delivery of such services but also offer flexible and cost effective solutions to the network or service provider in operation, maintenance and upgradation of their network or services.

Thus, in networking technology we see the emergence of SDN (Software Defined Networks) which allow prioritizing, deprioritizing or even blocking specific types of packets with a granular level of control and security. This is especially helpful in a cloud computing multi-tenant architecture, because it enables the administrator to manage traffic loads in a flexible and more efficient manner. Essentially, this enables the administrator to use less expensive commodity switches and have more control over network traffic flow than ever before.

Another example of the exploitation of capabilities of the software technology can be seen in the Virtualization techniques, which allow to share a single physical instance of a resource or an application among multiple customers and organizations. It does so by assigning a logical name to a physical storage and providing a pointer to that physical resource when demanded. Virtualization in Cloud Computing brings in a number of benefits like, protection from system failures, hassle-free transfer of data from a physical storage to a virtual server, and vice versa, firewall and security, smoother IT operations etc., in addition to being a cost-effective strategy to bring down operational costs.

The field of digital commerce, or ecommerce, has also grown hand in hand with technological advancements in secure networks, advanced cryptographic algorithms etc. together with increasing access to internet. As per the Economic Survey 2017-18, the electronic commerce (e-commerce) market in India is estimated at US$ 33 billion, with a 19.1% growth rate in 2016-17 and is further expected to exceed 100 billion USD by 2022.[26]

These instances reflect a trend towards increasing shift to software-based solutions because of the inherent benefits associated with them including faster deployment, flexibility, cost-effectiveness etc. An additional capability of a software-based implementation is the ability to revise and upgrade security as threats and vulnerabilities evolve.

The authority considers that consider the trends towards software enabled solutions, it would be perhaps more appropriate is for interoperability of STB a software-based approach is adopted. Stakeholders may consider and suggest the way forward for a all-encompassing solution that is efficient and most cost-effective.

Apropos discussions in this chapter, the issues for consultation are: -

Q5. Is non-interoperability of STBs proving to be a hindrance in perfect competition in distribution of broadcasting services? Give your comments with justification.

Q6. How interoperability of STBs can be implemented in Indian markets in view of the discussion in Chapter III? Are there any software based solution(s) that can enable interoperability without compromising content security? If yes, please provide details.

Q7. Please comment on the timelines for the development of eco-system to deploy interoperable STBs for your recommended/ suggested solution.

Q8. Do you agree that software-based solutions to provide interoperability of STBs would be more efficient, reduce cost of STB, adaptable and easy to implement than the hardware-based solutions? If so, do you agree ETSI GS ECI 001 (01-06) standards can be adopted as an option for STB interoperability? Give your comments with reasons and justifications.

[26] https://www.pwc.in/research-insights/2018/propelling-india-towards-global-leadership-in-e-commerce.html

Q9. Given that most of the STB interoperability solutions become feasible through a common agency defined as Trusted Authority, please suggest the structure of the Trusted Authority. Should the trusted authority be an Industry led body or a statutory agency to carry out the mandate? Provide detailed comments/ suggestion on the certification procedure?

Q10. What precaution should be taken at planning stage to smoothly adopt solution for interoperability of STBs in Indian market? Do you envisage a need for trial run/pilot deployment? If so, kindly provide detailed comments.

Q11. Interoperability is expected to commoditize STBs. Do you agree that introducing white label STB will create more competitions and enhance service offerings from operator? As such, in your opinion what cost reductions do you foresee by implementation of interoperability of STBs?

Q.12 Is there any way by which interoperability of set-top box can be implemented for existing set top boxes also? Give your suggestions with justification including technical and commercial methodology?

Q13. Any other issues which you may like to raise related to interoperability of STBs.

CHAPTER 4
ISSUES FOR CONSULTATION

Q1. In view of the implications of non-interoperability, is it desirable to have interoperability of STBs? Please provide reasoning for your comment.

Q2. Looking at the similar structure of STB in cable and DTH segment, with difference only in the channel modulation and frequency range, would it be desirable to have universal interoperability i.e. same STB to be usable on both DTH or Cable platform? Or should there be a policy/ regulation to implement interoperability only within a platform, i.e. within the DTH network and within the Cable TV segment? Please provide your comment with detailed justifications.

Q3. Should interoperable STBs be made available through open market only to exploit benefits of commoditization of the device? Please elaborate.

Q4. Do you think that introducing STB interoperability is absolutely necessary with a view to reduce environmental impact caused by e-waste generated by non-interoperability of STBs?

Q5. Is non-interoperability of STBs proving to be a hindrance in perfect competition in distribution of broadcasting services? Give your comments with justification.

Q6. How interoperability of STBs can be implemented in Indian markets in view of the discussion in Chapter III? Are there any software based solution(s) that can enable interoperability without compromising content security? If yes, please provide details.

Q7. Please comment on the timelines for the development of eco-system to deploy interoperable STBs for your recommended/ suggested solution.

Q8. Do you agree that software-based solutions to provide interoperability of STBs would be more efficient, reduce cost of STB, adaptable and easy to implement than the hardware-based solutions? If so, do you agree ETSI GS ECI 001 (01-06) standards can be adopted as an option for STB interoperability? Give your comments with reasons and justifications.

Q9. Given that most of the STB interoperability solutions become feasible through a common agency defined as Trusted Authority, please suggest the structure of the Trusted Authority. Should the trusted

authority be an Industry led body or a statutory agency to carry out the mandate? Provide detailed comments/ suggestion on the certification procedure?

Q10. What precaution should be taken at planning stage to smoothly adopt solution for interoperability of STBs in Indian market? Do you envisage a need for trial run/pilot deployment? If so, kindly provide detailed comments.

Q11. Interoperability is expected to commoditize STBs. Do you agree that introducing white label STB will create more competitions and enhance service offerings from operator? As such, in your opinion what cost reductions do you foresee by implementation of interoperability of STBs?

Q.12 Is there any way by which interoperability of set-top box can be implemented for existing set top boxes also? Give your suggestions with justification including technical and commercial methodology?

Q13. Any other issues which you may like to raise related to interoperability of STBs.

List of Abbreviations

Abbreviations	Description
API	Application Programming Interface
BIS	Bureau of Indian Standards
C-DOT	Centre for Development of Telematics
CAM	Conditional Access Module
CAS	Conditional Access System
CATV	Community Antenna Television
CI	Common Interface
CPE	Customer Premises Equipment
CW	Control Words
DAS	Digital Addressable Cable TV Systems
DPO	Distribution Platform Operator
DRM	Digital Rights Management
DTH	Direct to Home
DVB	Digital Video Broadcasting
DVB-CSA	DVB Common Scrambling Algorithm
DVB-S	DVB standards for Satellite Transmission
DVB-T	DVB standards for Terrestrial Transmission
DVB-C	DVB standards for Cable Transmission
ECM	Entitlement Control Message

EEE	Electrical and Electronic Equipment
EIT	Event Information Table
EMM	Entitlement Management Message
EPG	Electronic Program Guide
ETSI	European Telecommunications Standards Institute
HITS	Head-end In the Sky
IPTV	Internet Protocol TV
LCOs	Local Cable Operators
LNBC	Low Noise Block Downconverter
MHP	Multimedia Home Platform
MIB	Ministry of Information and Broadcasting
MK	Master Key
MSOs	Multi System Operators
OFDM	Orthogonal Frequency Division Multiplexing
OTA	Over-the Air
OTT	Over-the-Top
QAM	Quadrature Amplitude Modulation
QoS	Quality of Services
QPSK	Quadrature Phase Shift Keying
SC	Smart Card
SK	Service Key

SoC	System on Chip
STB	Set Top Box
TDSAT	Telecom Disputes Settlement and Appellate Tribunal
UHF	Ultra-High Frequency
VHF	Very High Frequency
iDTV	Integrated Digital Television
PCMCIA	Personal Computer Memory Card International Association
TA	Trusted Authority
ILA	Industry Licensing Authority
SCK	Secret Chipset Key
ECI	Embedded Common Interface
ITU	International Telecommunications Union
OS	Operating System
SDN	Software Defined Networks

Pay TV: Horizontal Market- CAM(DVB-CI)

- Equipments
  - Receiver supports standard CI (digital interconnection between a host and CAM)
  - CA module goes in CI slot in receiver
  - CA Smartcard goes in CA module
- Advantages:
  - For operator
    - Don't need to care for STB
    - If software upgrade not sufficient: Security upgrade easy (only CAM to change)
  - For customer
    - No need additional box except IDTV
    - Simplicity to use
    - UI subscription independent
    - Only one remote controller
    - Subscription easy to switch
  - For TV maker
    - No proprietary S/W or H/W inside receiver
    - Less software maintenance due to CA security
    - Receiver can support any CA system via CAM

SAMSUNG

Annexure II (Chapter no. 3/ Para no. 3.3.5)

Waiting for the Bus

DVB-CI+ 2.0

Alexander Adolf, Vice-Chair, TM

Alexander Adolf is an independent consultant in digital broadcast technology through his company Condition-ALPHA. He is the representative to DVB for LG Electronics. As Chair of the DVB TM-CI-Plus technical working group he lead the development of CI+ 2.0 . Since 2000, he has been Chair of the TM-GBS and in January he was appointed Vice-Chair of the DVB Technical Module.

If you attended DVB World in Copenhagen last year, you will have an insight into the upcoming DVB-CI+ 2.0 standard. This article provides an update on the recent developments and unveils further details of the technology involved.

The most visible update to CI+ 2.0 will be the use of a new connector: the Universal Serial Bus (USB). This will not only bring down the implementation costs for TV sets by removing the single purpose PCMCIA interface, but it will also bring even higher data rates by taking advantage of the capabilities of USB 2.0 (240 Mbit/s full duplex), up to 3.1 Gen 2 (5 Gbit/s full duplex). Standard USB device discovery and description allows CAMs and hosts to offer various interface speed options, and still interoperate.

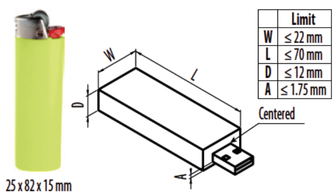
USB CAMs will also work to the power limitations of high-power bus powered USB devices. This means that hosts are not required to feature specific 'CI+ enabled' USB sockets, but as per the speed and power characteristics could be able to accommodate a USB CAM in any of its USB 2.0 or 3.1 sockets.

Besides the electrical characteristics and protocol, space restrictions in the back of a slim flat-panel TV set are a restraining factor. The DVB-CI+ 2.0 specification therefore defines a mechanical bounding box, within which the USB CAMs will fit. Figure 1 shows this bounding box, along with a well-known object for size comparison.

On the protocol side, all of the upper layers of DVB-CI+ are retained (see Figure 2). This means that there will be no need to develop an entirely new CI+ stack. Instead, existing implementations can be ported to the new USB transport.

Apart from being able to retain the larger part of the existing CI+ stack, we also took the opportunity to introduce some enhancements for conveying protected content between CAM and host. As of CI+ 2.0, there is only a single mechanism for covering single-stream and multi-stream data, as well as TS and sample data. This implies removal of the encapsulation of ISOBMFF data into TS packets.

Figure 1: The mechanical bounding box for DVB-CI+ 2.0 CAMs, compared to the well-known lighter



The move to USB also enabled us to upgrade the network connectivity for the CAM from CI+ 1.4 low-speed communications (LSC), to a native network connection for the CAM via the Ethernet emulation mode of the USB communications device class (CDC EEM). This will enable many more internet use-cases, and provides a much improved CAM player mode support due to direct, high speed network access.

Despite all these improvements, it is still possible to easily map data between a CI+ 2.0 host and a PCMCIA CAM, so that an adapter as shown in Figure 3 can be used. This will allow the decoupling of the market introduction of USB hosts from that of USB CAMs.

The new USB form factor currently exists in a draft specification document in the TM-CI-Plus Sub-Group. What still lies ahead before its publication as DVB BlueBook A173-1 and subsequently as an ETSI specification, is a validation and verification (V&V) exercise for the USB functionality of CI+ 2.0. This is to make sure that USB CICAMs will behave well 'out in the wild' in the presence of USB hubs, various other USB devices, and USB host implementations. Since the number of deployed USB devices is enormous, this will be an important exercise to ensure that no interoperability issues will arise, and for DVB CICAMs to be good USB citizens.

Figure 2: Re-use of protocol layers between DVB-CI+ 1.4 and 2.0

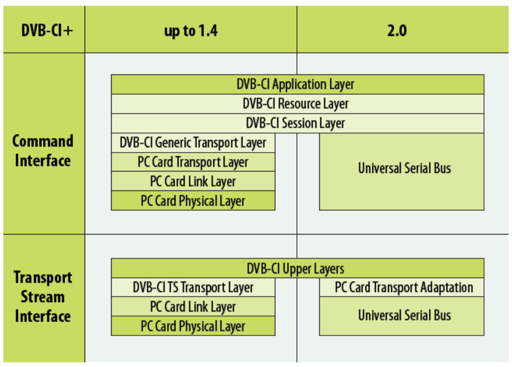


Figure 3: Adapter to connect legacy PCMCIA CAMs to USB hosts