The Evolution of Over the Top (OTT): Standardization, Key Players and Challenges

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ABSTRACT:
OTT users has gained momentum through the evolution of low cost smart TV and other consumer electronic, open nature of Internet, and ever growing contents. Among consumer electronics, Smart TV with Web 2.0 features integration has given OTT service a wider range of audience through bigger screen. This has replaced broadcast TV, cable TV and IPTV models. Motivated by this scenario of OTT services, we studied standardization activities of different key players including Content Providers (CP), Cloud/Content Distribution Network (CDN), Consumer Electronics (CE) and Internet Service Provider (ISPs) in TV market space. We have summarized several key challenges for OTT services from ISPs point of view for ex, single sign on for multiple OTT, scalability, heavy tail content availability, live TV etc. We also analyzed the suitability of the next-generation Internet architectures, in particular, Content-Centric Networking (CCN), Open Cache and Multicast Adaptive Bitrate (mABR) for OTT service delivery from ISP point of view.

KEYWORDS: Smart TV, HbbTV, CCN, Future Internet.

1. INTRODUCTION

TV services have evolved from free-to-air broadcast TV to IPTV and then Smart TV in the past fifty years. Smart TV is integration of internet with modern television sets. The latest terminology used in TV space is Over the Top (OTT) [1] services, which means providing TV services over internet. Historically, free-to-air-tv evolved into cable TV and then to IPTV and now the new phenomena of TV exposed in market is called OTT, which is provided over smart TV and other consumer electronics through various apps. 70% TV shipments in 2018 are smart TV [2]. It is important to understand and clarify these different type of TV services. Hence, the second section of our paper explains the history of the TV services and the current state of art.

Cable TV and broadcast TV viewers are now limited. The younger generation are preferring to watch TV "anywhere" and "anytime". OTT provides such a model where people can watch their favorite TV channels on their smart devices everywhere at any time. Providing these OTT services needs several market players to work together, including CP, CDN and cloud service providers, ISP and CE. All these key market players have to follow standardization and protocols in order to work together so that viewers can have a seamless experience of watching video content. Thus the third section of the paper explains all these several key players and their standardization initiatives.

When multiple market players such as ISPs, Cloud and CDN service providers are competing as well as collaborating for providing similar services, then there is a high chance that they also compete for their market share and perk benefits. It is a fact that high speed internet access has given birth to the OTT related business models, despite the ISPs have to face several challenges to provide the desired QoE for users. Therefore, in this paper we compared ISPs area of challenges as compared to CDN and cloud providers.

We found that ISP have to deal with continually changing business and technology environment and are experiencing several challenges including scalability, single sign on, QoS and QoE, cost, interoperability, netneutrality and last mile service provisioning etc. Consequently, in the final section of the paper we studied different futuristic proposals and standards including CCN, OpenCache and mABR streaming techniques that can help ISPs to solve several of these challenges and provide an improved OTT services.

This paper is organized in the following manner. Section II starts with shedding some light on the TV history followed by Section III which elaborates different key players and their efforts in TV market space. Section IV compares and contracts ISP and CDN/Cloud services efforts in TV space. Section V then lists several challenges faced by the viewers. Section VI proposes the possible futuristic models for ISPs to

improve the user's experience. Section VII concludes the paper.

2. HISTORY OF TV SERVICES

Television historically was owned by Broadcasters and free-to-air TV. Cable TV then started bundling all the different broadcasters and provided the bundled services to viewers through wired cable network or satellite. ISP then started providing these bundled TV services combined with internet access and telephone services so called IPTV [3]. Later Web 2.0 features started to integrate with modern TV sets and set-up boxed, such TV was referred to as Smart TV, Connected TV or Hybrid TV. These new TV have higher focus on online interactive media, Internet TV, OTT content, as well as on-demand streaming media, and less focus on traditional broadcast.

The broadcast TV (free-to-air TV) has old generation of viewers, hence it will remain around even if the TV market is getting revolutionized through smart TV, however it might become merely an application in smart TV. Cable TV is also dead soon as in future it will be possible to buy channels independently using smart TV and broadband connection. So we will not need to buy the bunch of channel provided by broadcasters, rather we can buy the channels which we would like to watch. Cable TV revolution was soon followed by internet revolutionized TV experience by offering web TV, which is still very popular among youngsters, however integrating it with the present free-to-air TV systems would be revolutionary. IPTV model was introduced a few years ago in the market, which was mainly owned by Internet Service Providers. This model at present will also not work in future as it did not make the huge impact on broadband market, mostly because of high cost.

At present, the revolutionary smart TV is offering integration for internet and TV services with social networking and online gaming facilities. Moreover, it will also offer great Video on Demand services, virtual reality interactive game services, 360 video services and various types of applications similar to smart phone but on bigger TV sets. The key of success of smart TV is contents and applications. Presently broadcast TV, cable TV and IPTV models are all deprecated and are replaced by OTT apps on smart TV. Key players for OTT market and lack of end to end solution are shown in Fig. 1.

3. STANDARISATION

The researchers in academia and the industry are using various key terminologies to refer to TV services, such as IPTV, HbbTV, Smart TV etc. The key difference in these keywords is that they are different initiatives taken by different key players in TV market to standardize TV services. IPTV is an ISP and Telecom driven approach however, smart TV is CE driven approach for TV viewing. HbbTV is European initiative for smart TV and it is driven by broadcasters and cable companies as shown in Table 1.

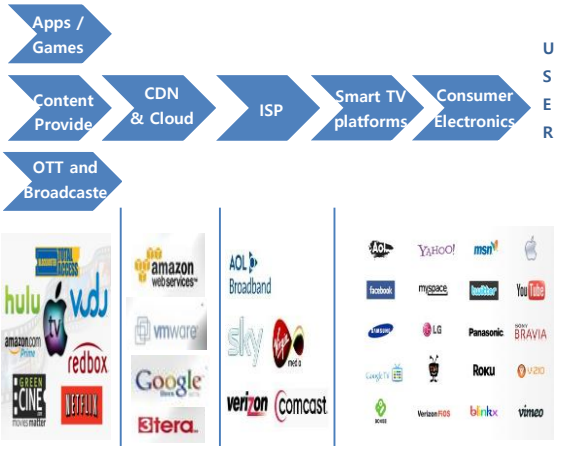

Fig. 1. Key players for OTT market and lack of end to end solution.

Apart from these Cloud and CDN, service providers have their own preparatory approach of deploying services.

ISP driven IPTV model is mostly broadband owned television services model that uses internet protocol suite for services delivery. The drawback with IPTV is that the contents and services provided are only ISP subscribed; hence, it does not utilize the open nature of Internet.

Consumer Electronics driven Smart TV initiative focuses on standardizing the smart TV application framework, such as Smart TV alliance [4] standards for App development, HTML5 SDK, multi-screen support standards, HTML 5 based smart homes etc. Smart TV alliance focuses on app development for all kinds of OS including Google's Android and Apples iOS.

HBBTV standards [5] provide consumers with a seamless entertainment experience combining with richness of broadcast and broadband. The basic difference between smart TV initiative taken by consumer electronics, google TV, IP and HBBTV is that HBBTV standard harmonizes the traditional broadcast video delivery with the IPTV and broadband services. In general, all connected TV sets have two inputs: one for the broadcast signal (TV tuner) and one for the Internet (Ethernet/WLAN) connection, they do not necessarily offer converged services by making use of both distribution paths. This cannot be considered as converged services; for the truly hybrid services enabling a seamless user experience, an "engine" is required that links the broadcast content offered via the CATV network and the internet content offered via the interaction channel, be it via Ethernet on DSL or via Ethernet on CATV – or via any other IP connection.

HbbTV provides such an engine. The HbbTV specification is based on elements of existing standards and websites technologies including OIPF (Open IPTV Forum), CEA-2014 (CE-HTML), W3C (HTML etc.) and DUB Application Signaling Specification (ETSI TS 102 809)[5].

Table 1. Comparison among Smart TV, HbbTV and IPTV.

	Smart TV	**HbbTV**	**IPTV**	**OTT**
Driven by	Consumer electronics	Broadcasters	ISP/Telco	Cloud/ CDN
Strength	Established TV market	TV Contents	Infrastructure	Cloud/CDN infrastructure and technologies
Standards	Smart TV alliance - UI and App Standards [4]	Hbbtv specification W3C and DVB(very active), ETSI TS 102 809 and OIPF [5]	OIPF, ETSI TISPAN, ITUT NGN, ATIS IIF [1]	ISO/IEC 19941:2017 and ITU-T Y.3502[6,7]
Delivery mode	Internet	Harmonized broadcast, IPTV and broadband delivery network	Private IP Network	Internet
Contents	Web + OTT + Virtual MSO	Web + OTT + broadcast content	ISP subscribed contents	Web + OTT
Community	Global	Global	Local	Global

Cloud and CDN service standards are also defined by ISO/IEC 19941:2017[6] and ITU-T Y.3502 [7]. However, these standards are limited to defining terminologies only. Mostly cloudy and CDN providers do not follow any particular standards to avoid migrations and competitions with other cloud providers.

OTT services such as YouTube, Netflix, Amazon Prime, Apple TV etc. are run through apps on smart TV and other consumer electronic devices. These apps are mostly developed using JavaScript, android or iOS API. Most of the consumer electronics have their own app development APIs such as Samsung Tizen API [8], LG webOS TV API [9], apple TV API [10], roku TV API [11], amazon fire API [12] etc. Smart TV Alliance has also standardized these API, and several of these companies are member of this standardization body. While developing these apps, it is important to consider remote control experience for users.

As we see that CE companies have an established market in TV manufacturing and strong application supports; still the contents are residing with broadcasters. These days all Netflix, Amazon, Disney etc are also focusing on original content creation for their OTT apps. TV has evolved and revolutionized. There are several TV initiatives driven by different market players. The key players in TV market include OTT Service Providers, CDN/cloud, ISP/Telecom and Consumer Electronics as shown in Fig. 1. Each of these key players has their own initiatives and views towards TV services, and there is lack of end-to-end solution. In this paper, we analyzed various initiatives and studied their standardization activity. This work also studies the future internet architecture and their benefits in Smart TV service delivery.

4. CDN VS ISP

Through the history of the TV services, we noticed that traditional mode of TV service delivery such as broadcast TV through satellite and bundled TV through cable network is being replaced by internet supported OTT services. Cloud, CDN and ISPs are the prime contributor to deliver the OTT services over internet to the end users as shown in Fig. 1.

Most of the CDNs apply peering model to deploy their datacenters in different locations and then reduce the utilization of the ISPs network and eventually reduce their cost to the customers. Netflix, amazon and google own their own CDN services named, Open connect [13], Cloudfront [14] and Google peering [15] networks to delivery their OTT services to end users. They usually prefer a settlement free peering with ISPs in the respective countries.

This way Cloud and CDN service providers are now offering services that were the prime revenue generator for ISPs a decade ago. Hence, ISP driven IPTV services are taken over by CDN and cloud driven OTT apps, such as Netflix, amazon prime, YouTube etc. The impact of CDN effecting revenue of telecom is being reflected in the financial statements as well [16] [17].

There are several reasons for the popularity of the cloud and CDN based OTT services over IPTV. Data centers solve scaling issues, interoperability issues, and security issues; by deploying many services in their own cloud services, and decreasing data exchange through internet significantly. In addition, cloud and CDN service providers do not follow any standards and protocols. Usually their communication services, logging, reporting etc. are all preparatory. This way, they can avoid the competitors. The newly defined SDN paradigm is also benefiting datacenters and CDNs in

tremendous way [18] [19]. CDNs can deploy their own version of at their own AS level. This helps them reduce service cost, increase content availability and user experience and provide new features in faster rates. Hence, the growth potential is also very high for all these CDNs. ISPs usually have to interoperate with several AS together, therefore SDN based management becomes challenging to deploy at ISP level. SDN extensions at ISP level or inter-as level is also challenging. There might be several interoperability issues, as each AS can implement SDN in their own ways. ISPs have to take care of interoperability among different AS to be able to provide the seamless communication.

ISPs invest in infrastructure upgrade, spectrum usage charges (5 MHz in 1800 MHz pan in India) [20], customer service, QoS, Security, local municipality issues etc. However, for CDNs and clouds these costs are zero.

Table 2. CDN vs ISP.

	CDN and Cloud	**ISP**
Spectrum cost	Nil	Heavy
Last mile service provisioning cost	Nil	Heavy
Customer care	Not necessary	Must provide
Interoperability	Nil	Must provide
SDN	Helps manage Datacenter network	Not very useful, as ISPs involve several ASs
Containerization	Helps Datacenters	Not very useful
Standardization	Proprietary	Must follow
QoS & QoE	Nil	Should follow SLA
Net Neutrality	Beneficial for CDN and Cloud	Takes away power of blocking or manipulating traffic

Going forward ISPs will only get limited to the access network and last mile service provisioning. We can see how 4G, LTE and 5G has added to the revenue of telecom providers [21]. Standardization and protocols proposed for interoperability among ISPs, sometimes deprecate even before they are fully proposed.

Net neutrality [22] has also proven to be adverse for ISPs business model. With effective net neutrality policies imposed by government, ISP Operators cannot block a specific OTT service provider. It makes it hard for ISPs to negotiate for business revenue with the traffic hogging OTT apps. Net neutrality has proven to be a good omen for CDN and cloud service providers.

This growth of CDNs and cloud service providers is not so favorable for ISPs. ISPs constantly invest in their infrastructure to support the last mile service delivery, keeps on increasing their spectrum, struggle with interoperability and are also usually blamed for the bad QoS and QoE issues.

5. CHALLENGES OF TV INDUSTRY

There are several challenges that OTT service providers are facing. Content is not an issue, there is a multitude of contents, but making all these contents available to the appropriate audiences is still a challenge.

5.1. Scalability

ISPs are constantly acquiring spectrum and upgrading infrastructure for better scalability of OTT services. Today we have 5G network and widespread edge cloud services to improve the deployment of the video streaming services. Content delivery is done using HTTP-DASH [23] based adaptive bit rate algorithm which utilizes the network bandwidth in the optimum ways. All these technological advantage has improved the scalability. However in future, the amount of content will increase, moreover 3D content and 360 degree video are entering the market space. To satisfy ever increasing demand of high quality content and better QoE, it is important to scale infrastructure to next level.

The other reason of why these services are not able to scale to the wider range of audience is related to Digital Right Management (DRM) and watermarking systems [24]. Netflix offers only 148 US shows and 480 US movies to South Korea. 197 shows and 537 movies in India. However, they offer 1157 shows and 4598 movies in USA [25]. That means expats living in South Korea or India cannot watch all the contents. The main reason behind this is cross border DRM issues. There is a need of sophisticated DRM systems which will allow expats to watch the contents cross border.

5.2. Heavy Tailed Contents

Most service provider caches the most popular contents to the edge infrastructure and caches, however the least popular heavy tailed contest still remains in the origin server. The success of VoD service providers depends on providing these heavy tailed less popular requests with high quality.

Most users may want to watch popular content, but when they request for a non-popular content, they still expect the same QoE. Nevertheless, streaming those contents from origin server does reduce the QoE for users. However, to provide all these contents, the services infrastructure needs to be improved beyond just edge caching provided by CDNs. Only a few research and investigations have been done in this area [26, 27].

5.3. Community Specific Bundled Services

All the service providers including Netflix, Amazon and YouTube, do consider community and the user preferences while creating their home page. The recommendation systems of these apps have several AI logic to analyze user behavior. However, there is a need for a service provider who can provide a bundled service from multiple vendors in single sign in. For example, expat might want to watch all the contents from their countries provided by Netflix, Amazon Prime, and YouTube on one integrated screen, thus, they do not have to login to all different service provider's portals and go through recommendations separately.

There are several OTT services in the market, but users have to fumble around with all these apps to search for the content they want to watch. Hence, aggregating these contents and making a common recommendation system would increase user's comfortability around these apps. All these apps are based on JavaScript APIs and CSS, hence integrating these recommendation systems into one is just a matter of willingness and openness of these service providers.

5.4. Live TV & Limitations

Most of the OTT services usually use HTTP-DASH protocol to provide the streaming services. HTTP-DASH follows adaptive bit rate algorithms to stream data based on the network bandwidth. This is a unicast based approach for streaming. In the case of live streaming as well these OTT service providers use same approach. That means the network sends the same chunks of videos to different users at the same time. If one thousand users are watching a specific live TV at the same time, all these users will have a separate stream of same content being delivered on the same route. That is a lot of bandwidth consumed for just one stream. For this reason, live TV apps are more expensive. In future, multicast based ABR techniques are required to streaming live TV over internet.

6. FUTURE OTT TRENDS

Internet service providers might lose a lot of business to the content delivery service and cloud service providers as they focus on building their own network. ISP will get confined to the delivering traffic only to the local communities at access network, as the app developers choose cloud to host their services. In addition, the cloud service provider starts to depend on their own infrastructure at the core. ISPs need to validate and implement the latest architecture which would benefit.

6.1 OpenCache

ISPs are mostly connected to the CDN and CP nodes outside of the operator network to provide OTT services. These CDN providers expand their networks by deploying edge server nearby users through peering. Using OpenCache[28] ISPs can provide an open caching infrastructure which can penetrate at the access network deeper. This approach will bring CDNs best practices closer to the end users. This can also bring a new level of transparency in video distribution workflow and eventually the bundled services can become reality and all of this can be driven by ISPs. ISPs have to start providing an aggregation point for content and service providers, where they could aggregate their storage and compute using OpenCache.

6.2 mABR

ABR assisted HTTP-DASH is a delivery technology adopted by most of the OTT providers. Because of unicast nature of HTTP-DASH, it creates a lot of traffic for live TV streams despite ABR techniques adjusting the bit rate based on the available bandwidth. Multicast Assisted ABR is a technology that could help alleviate some of that congestion for on-network delivery. HTTP traffic travers through NAT and firewall very well, hence any mABR[29] based on HTTP-DASH can take advantage of that. However, leveraging the multicast capabilities will come with the cost of deploying specific hardware supporting multicast client, server and controller for ISP networks.

6.3 CCN at the Edge

The most popular future internet architectures includes TRIAD [30], DONA [31], CCN/NDN[32]. Content-Centric Networking" (CCN) in particular has gained a lot of attention in recent years. CCN has several attractive advantages such as network load reduction, low latency, energy efficiency and secure networking. Even though CCN is an attractive future internet model, it is still in experimental stage and research community is still figuring out the advantages and disadvantages of various aspects of CCN. One of the important feature of CCN's core architecture is In-network caching, which allows the intermediate nodes or routers to store the contents temporarily acting as a server. This feature plays an important role in reducing network traffic and increasing a response time. Using this feature, the entire CCN network can act like a big network aware CDN. Internet wide deployment of CCN is still in question however feasibility of implementing CCN at the edge network has been proven and verified by several research [33].

7. CONCLUSION AND FUTURE WORK

Cloud services, ISPs and Smart TV together are providing a great commercial opportunity for the content providers. ISPs are struggling to improve their infrastructure to accommodate the growing need of OTT services, on the other hand, CDN and Cloud service

providers need not require any business or technology affiliations with ISPs to provide these OTT services and do not contribute to the ISPs revenue.

In this scenarios, Telco's can increase their revenue by exploiting the access network advantage that they have. Access network is all about the local communities. Hence they have to design the OTT services particularly for local communities. ISPs can also provide bundled OTT services by following OpenCache standards. ISPs can also facilitate live TV by deploying needed infrastructure for mABR technologies. Another way to facilitate the better caching is by utilizing CCN architecture at the edge of the ISP networks. This study has given us an insight on various futuristic technologies such as OpenCache, CCN and mABR which can help ISPs to compete and overcome the loss caused by Cloud and CDNs.

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