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A Survey on Requirements and Challenges of Internet Protocol Television Service over Software Defined Networking

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***Abstract*—**Over the last years, the demand for high bandwidth services, such as live (IPTV Service) and on-demand video streaming, steadily and rapidly increased. It has been predicted that video traffic (IPTV, VoD, and WEB TV) will account more than 90% of global Internet Protocol traffic that will cross the globe in 2016. Consequently, the importance and consideration on requirements and challenges of service providers faced today in supporting user's requests for entertainment video across the various IPTV services through virtualization over Software Defined Networks (SDN), is tremendous in the highest stage of attention. What is necessarily required, is to deliver optimized live and on-demand services like Internet Protocol Service (IPTV Service) with low cost and good quality by strictly fulfill the essential requirements of Clients and ISP's (Internet Service Provider's) in the same time. The aim of this study is to present an overview of the important requirements and challenges of IPTV service with two network trends on solving challenges through virtualization (SDN and Network Function Virtualization). This paper provides an overview of researches published in the last five years.

***Keywords*—**Challenges, IPTV Service, Requirements, Software Defined Networking.

I. Introduction

IN this paper, we present an overview of the current research regarding requirements and challenges that Service providers face in offering IPTV Services. Our main aim is to add attention and importance on the essential requirements of IPTV service providers for optimizing the use of IPTV Services and to increase importance on solving challenges through virtualization and two networks trends that will significantly influence future IPTV delivery (Software defined for Networking and Network Function Virtualization).

The rest of this paper is organized as follows: In the Section II we present the methodology used for this study. In the Section III we present results and analysis of the searches in a quantitative perspective. Then Section IV presents results on the two questions formulated during the first sub activity of phase 1 and in the Section V it is given shortly a grouping of papers based on seven important challenges with two network solutions, SDN and NFV Network trends. At last conclusions and references at the end of the review.

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II. Methodology

Methodology used for writing this literature review is adopted from systematic literature review process used by researcher as in [1] [2]. The process has three phases with nine sub stages. In the first phase (Plan Review phase) the following questions are formulated:

- **Question1**: Which are the essential requirements of ISP's for optimizing the use of IPTV Service?
- **Question2**: Which are the important challenges of IPTV Operators and two network trends for solving them?

The questions are formulated during the first sub activity of phase 1, and then a review protocol is developed. The review protocol includes time period of review performed, requirements groups of IPTV Operators and solving challenges via SDN and NFV. The research period time is over years 2011 to 2015.

In the second phase (Conduct review phase), the search is focused on Requirements and Challenges of IPTV Service. All the papers studied and downloaded were based on the two questions formulated in the first phase as described in Table I.

TABLE I
Review Protocol

YEAR	Classification of IPTV Operator's requirements based on Question 1	Solving IPTV Operators Challenges based on Question 2
2011-2015	Service Resource Consumption Requirements	Limitations to deploy Services
	Integration and Management with other services	High CAPEX/OPEX
	Technical Requirements	No Service Agility
		Dedicated IT Hardware
	Service IPTV Requirements	Continuity with multimedia
		Network Latency
		End to End Latency

The idea was to collect all information from 30 papers over five years in order to answer the questions created above.

Another step in the search process was performed by searching the related work area of the selected papers during last four years by giving a full and qualitative review. Finally, in the third phase of the review process (Document review phase), the review report was written and validated.

III. Results

The results of the review are presented in this section. A year wise result representation is pointed out in Table II. The

results are characterized taking strictly in consideration questions posed earlier.

TABLE II
FOUR YEARS WISE SEARCH RESULTS

Year	No. of Papers
2011	8
2012	9
2013	4
2014	7
2015	2
Total:	30

IV. IPTV REQUIREMENTS FOR OPTIMAL IPTV SERVICE

Question 1: What are the essential requirements of ISP's for optimizing the use of IPTV Service [3]?

TABLE III
REQUIREMENTS RESEARCH RESULTS BASED ON QUESTION 1

Question 1:	Requirements
Which are the essential requirements of IPTV Service Providers for optimizing the use of IPTV Service?	OpenFlow Support
	Compatibility with other services
	Clearly Service definition
	Secure appropriate Scalability
	Delivering predictable performance
	Realizable and available technology
	Consumption of OpenFlow resources
	Restricted Bandwidth usage
	Providing a Generic Service
	Increasing network upload capacity
	High synchronicity
	Good stream quality
	System stability
	Network upstream capacity Improvement
	Packet loss Decreasing
	Transmission latency Decreasing

The result of review is achieved taking strictly in consideration 16 essential specific Requirements of ISP's for optimizing IPTV service in cloud Networking mirrored in Table III. These results are categorized into 4 categories where each of them contains specific requirements of itself:

(1) **Service recourse consumption requirements** in which one import requirement for OpenFlow-based services is to secure appropriate scalability delivering predictable performance on it and what is more important consumption of OpenFlow resources: Keeping the number of rules for OpenFlow services as low as possible. The number of rules per service must not scale linearly with their amount of users, but at much lower costs

(2) **Integration with other services and their management requirements** where compatibility with other services running in the same OpenFlow domain is required and the service should not be restricted to single use cases; it should be as generic as possible. The whole service should be defined comprehensively and clearly. This includes predictable resource usage and the possibility to apply traffic engineering making possible reduction of the network traffic inside the network and to the outside it resulting more beneficial.

(3) **Technical requirements** where the system is required to improve the effective network upstream capacity of the peer using it. Other parameters of the P2P LVS systems should not be impaired by the service. Specifically, it should not increase the bandwidth requirements for the peers, increase packet loss or increase the latency of the transmission.

(4) **Service IPTV Requirements** in which IPTV service's goal is to improve the performance and quality of Peer to Peer Live Video streaming systems. It achieves this goal by increasing the network upload capacity of single peers. The general requirements of P2P LVS systems are meeting the deadline for synchronicity, providing a good stream quality and system stability.

Based on requirements belonging to four categories, results of research performed on question 1 are summarized in Fig. 1.

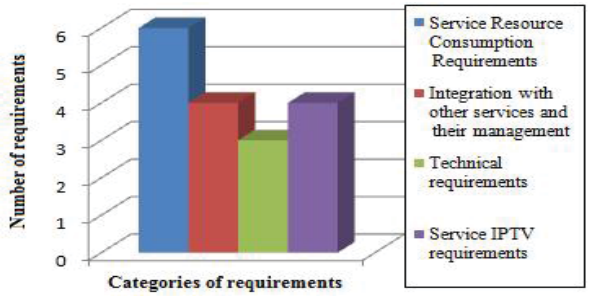

Fig. 1 Numbers of requirements for each category of ISP requirements

Resource Consumption requirements category take the highest part (6 Requirements, 37.5% of total requirements) of all ISP requirements and mostly of the papers read for this review are based on this kind of requirements in order to optimize IPTV service in cloud. This category contains requirements as: OpenFlow Support, Secure appropriate Scalability, Delivering predictable performance, Realizable and available technology, Consumption of OpenFlow resources and Restricted Bandwidth usage.

V. IMPORTANT CHALLENGES OF IPTV OPERATORS

Question 2: What are important challenges of IPTV Operators?

Based on the number of papers read and analyzed regarding the challenges of IPTV Operators on providing IPTV Service, we have performed a division on 7 categories: (1) Limitation to deploy services, (2) High CAPEX/OPEX, (3) No service Agility, (4) Dedicated IT hardware, (5) Continuity of multimedia, (6) Network Latency, (7) End to end Latency. The results based on the category wise detail related to the second question are presented here in Fig. 2, which shows the that the highest number of papers developed by researchers is focused on the biggest challenge that IPTV Service Providers face, which is ***High Cost (High CAPEX/OPEX) for***

delivering multimedia services. (19 papers, 63.33% of total papers)

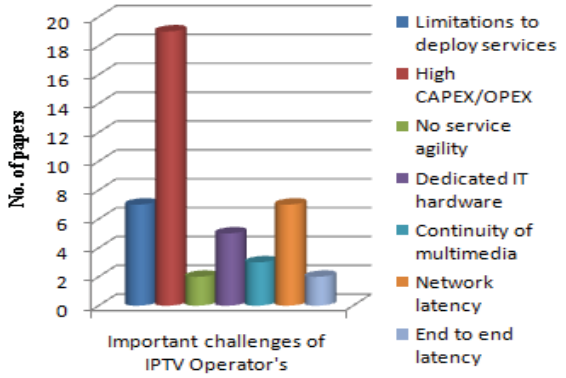

Fig. 2 Number of papers corresponding to each category of Operator's Challenges

A. High CAPEX/OPEX Challenge

All researchers focused on this challenge [4], seek to lower a provider's cost of real-time IPTV services through a virtualized IPTV architecture and through intelligent time shifting of service delivery. It was provided a generalized framework for computing the amount of resources needed to support multiple services, without missing the deadline for any service and implementing a simple mechanism for time-shifting scheduled jobs in a simulator and study the reduction in server load using real traces from an operational IPTV network. Results show the reduction of the load with 24% (compared to a possible 31%).

There was performed a progress on migrating from IPTV service to Open IPTV services [5], which includes Nomadism but also several improvements such as obtaining the same home services like (LIVE-TV, VOD and WEB-TV) anywhere, anytime and on any personal device. Moreover, this approach allows us to obtain the service from any operator in a transparent means to users. Most of IPTV operators either in Triple-play or Quadruple-play services provides the IPTV services based on physical Set-Top-Box (STB) devices, restricting the users' presence in the domestic sphere. Open-IPTV aims at extending the access to services outside the domestic sphere and outside the home network. Also, cost analysis issues are discussed a new architecture driven by the collaborative model between different providers taking in consideration design factors as:

1. Capital Expenditure (CAPEX): It is representing the cost of network foundation and all non-consumable system devices and infrastructure.
2. Operational Expenditure (OPEX): It is representing the running cost for provider network including all cost of operation and maintenance.

For the long term investments, the operators will reduce those costs in the domestic Cloud. Moreover, the new added services related to quality and interactivity will be costless.

The project developed [6], attempt to lower a provider's costs of real-time IPTV services through a virtualized IPTV architecture and through intelligent time shifting of service delivery. In this project the network optimization is arrived by using Cloud Computing achieving agility of the service, eliminating dedicated IT hardware through virtualization and of course with low cost of service delivering.

The Elastic Video Endpoint (EVE) resource proposed [7] is a virtualized multimedia distribution resource that can utilize cloud resources to dynamically provision capacity in real time and lower delivery cost of the Internet Protocol TV service. Initial results have shown that the system can respond to increased load and provide extra bandwidth capacity on demand decreasing network latency and core network bandwidth.

The demands for video traffic is increasing rapidly and it is predicted that these video and live streaming services will account for around 90% of the 966 Exabyte's of global Internet Protocol traffic crossing over the globe in 2015 [8]. The requirements for high bandwidth and strictly high Quality of Service (QoS) consisting in lower start up delay, in reduction end-to-end delay and offering higher continuity of multimedia, creates many challenges in the content management and content delivery perceptive across the global Internet. The essential key is not to degrade any of the above factors which effect on the user's Quality of Experience (QoE), because otherwise the big complains of users might lead in changing the service provider's they are using for. By building Content Delivery Networks (CDN) with clusters of machines connected to the Internet containing replicated data in different geographic locations, can combat these challenges in improved performance.

Content Delivery Networks (CDN) [9], [10] decrease in a good manner core network bandwidth, reduce network latency and lower delivery costs. An CDN Network will perform several important and necessary functions as: a) redirection of connection requests to the nearest suitable surrogate server while the end user attempts to download content; b) provides the ability to deliver various content from a set of surrogate servers that are placed at various geographic locations; c) taking under control the content stored and how the data are replicated inside it; d) provides management services that will monitor and store data based on requests, accounting usage content and cache functionalities. It has been noted that CDN in any guise, are many times over provisioned and therefore underutilized [16] where there is shown that "10% of connections are server-limited at least 40% of the time.

Cloud Content Delivery Networks (Cloud CDN) are a new and emerging approach [17]-[21], implementing content delivery services by using cloud storages in order to reduce the cost. Although these cloud recourses are created at different locations across multiple clouds networks, they cause overload provisioning and suffer from the lack of overload protection.

Potential of utilizing virtualization is investigated [22] to support multiple services like Video on Demand (VoD) and live broadcast TV (Live TV). It is explored how we can carefully configure the cloud infrastructure in real time to sustain the large scale bandwidth and computation intensive IPTV applications (e.g. Live TV instant channel changes

(ICC) and VoD requests). There is proposed an optimal algorithm that provides the minimum number of servers needed to fulfill all requests for these services. This optimality is proved in a general setting for any number of services with general deadline constraints. By using real world data from an operational IPTV environment, results show that anticipating and thereby enabling the delaying of VoD requests by up to 30 seconds gives significant resource savings even under conservative environmental assumptions. Via virtualization adopted by service providers, it is achieved minimization of resource usage and cost for offering IPTV service.

Mainly, the aim to lower a provider's costs of real-time IPTV services through a virtualized IPTV architecture and through intelligent time shifting of service delivery [23], brings up request to provide a generalized framework for computing the amount of resources needed to support multiple services, without missing the deadline for any service. It constructs the problem as an optimization formulation that uses a generic cost function. Also IPTV service providers can leverage a virtualized cloud infrastructure and intelligent time-shifting of load to better utilize deployed resources.

Data possession in distributed cloud environment with high security, high performance and transport verification [24], requires the development of a verification framework with multi-cloud storage associated by two fundamental techniques as: hash index hierarchy (HIH) and homomorphism verifiable response (HVR). By experiment it is noted that IPTV service was delivered with low cost and with very limited computation and communication overheads.

"SDM" [26] is an SDN application to push overlay live streams into the underlay using an OpenFlow-based cross-layer approach, attempts: a) to reduce intra-ISP traffic, b) to deliver Content with performance and costs at the level of IP multicast c) to provide fully transparent to receivers (end-users), d) to keep under fully control ISP's.

High level concept of SDM which is an ISP service for OTT live streaming providers, requires OpenFlow-enabled switches and incremental deployment possible. Hence, the ISPs [28] have a huge incentive to provide new services for an efficient delivery of live streaming data that is originated from outside their own network. To address this problem, the concept of SDN promises to be the key. SDN is a network paradigm that gained increasing popularity in the form of OpenFlow, a specific realization of SDN. OpenFlow enables network switches and routers to be controlled remotely using a logically centralized software entity. Besides a generally simplified network management, it allows new networking concepts to be applied that have been unfeasible before. The RASP (Rent-a-Super Peer) new OpenFlow approach, atempts to allow ISPs in providing network-layer multicast functionality as a service for P2P live video streaming and to improve in the same time P2P video delivery for users, content providers, and ISPs by solving the challenges faced as: limitations to deploy services and providing the uncast-based live streaming in low cost.

There was proposed a new application-controlled NMS approach for SDN [29], considering the resource and performance characteristics of the underlying network. The goal is to model the network utilization and to forecast the usage profiles of applications to prevent resource shortages before they occur. The proposed concept focuses on OpenFlow due to its generic approach, well defined resource requirements, and prevalence in scientific research. This approach promises to drastically reduce OPEX by translating application requirements into network behavior without human intervention.

Focused on user-centric mobile TV service and taking in considering the user's consumption style, the cost reduction of network resources and the enhancement of End-User's Quality of Experience (QoE) [30], there was supposed a nomadic access scenario where each user is able to access his mobile TV content AnyTime, AnyWhere and from Any Device (ATAWAD), based on eMBMS (Evolved Multimedia Broadcast Multicast Service) diffusion. The solution introduced was to adapt the multicast delivery for mobile TV service through optimizing the tree structure of multicast nodes in a dynamic manner according to the different context of the user and the network. This solution optimizes the investment cost (CAPEX) of multicast sources (streaming points) and opens the way to an enhancement of the Quality of Experience (QoE) of End User.

B. Limitations to Deploy Services Challenge

There are proposed highly distributed variant of Commercially CDNs [12] that consist in renting or placing servers in the data centers of many Internet Service Providers (ISPs) around the world and to make possibility of securing service agility, a distribution of services without any limitation.

Bittorent [14] gave a P2P Assisted variant of CDN sharing content in a collaborative from many different sources, users, web caches and proxies achieving deploy of the services all over the world without limitation and reducing end to end latency.

C. Network Latency Challenge

There is proposed a new traffic management architecture that uses the concept of SDN to extend the existing Ethernet-based broadband network architecture, enabling a more efficient traffic management for an ISP [27]. By using SDN-enabled home gateways, the ISP can configure traffic flows more dynamically, optimizing throughput in the network, especially for bandwidth-intensive services. Furthermore, a proof of-concept implementation of the approach is presented to show the general feasibility and study configuration tradeoffs. Analytic considerations and test bed measurements show that the approach scales well with an increasing number of subscriber sessions.

D. Dedicated IT Hardware (Resource Usage) Challenge

There is built a Big Data variant of CDN [13], running their own data centers on the world providing continuity multimedia service in a simply manner and without of dedicated IT hardware.

Amazon [15] gave a Cloud variant of CDN enabling content providers to provision capacity from Amazons cloud resources in a pay as you go manner securing continuity of multimedia service with no dedicated IT Hardware.

For optimizing provider's cost of implementing virtualized IPTV architectures through Intelligent Time shifting, there are proposed optimal algorithms that insure minimum numbers of servers needed to implement and full fill primary and important requests of these services [6], [22], [23].

VI. Two Networks Trends for solving IPTV Challenges

Two network trends that will significantly influence future TV delivery chain are: SDN that consist in decoupling control plane from the physical hardware and contain software-based programmability of the virtualized network, NFV that is a concept to realize network functions on commodity IT servers as pure software by using modern virtualization and cloud technologies and provide functions that can be provisioned, configured and managed as a virtual entity [11], [25]. Fig. 3 shows that the future for IPTV services is Virtualized TV services depending on Software Defined Networking (SDN) and Network Function Virtualization (NFV) Operators network.

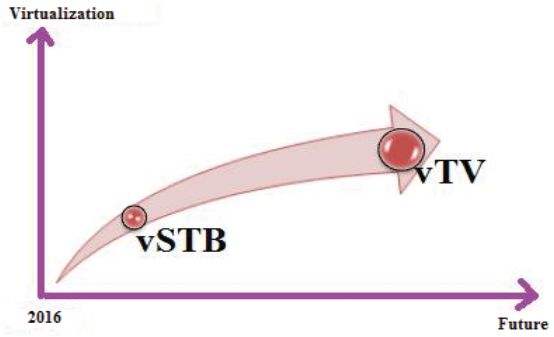

Fig. 3 vTV evolutions via SDN/NFV approaches

VII. Conclusion

In this paper, we gave an overview of the current level of research on requirements and challenges of IPTV Service. We presented a literature review classifying a selected group of publications, a total of 30 papers published in the four recent years. We provided results and analyzed them. We identified that 37.5% of all research papers include Service Resource Consumption Requirements of IPTV Operators and 63.33% of them include the most important challenge that is High Cost for delivering multimedia services (High CAPEX/OPEX). Two network trends for solving these challenges are SDN and NFV (Network function virtualization). We also perform a topic-related analysis to show the main current research network trends for solving IPTV Service challenges through: Cloud and Virtualization of the complete TV delivery chain that leads to a) Quick delivery of superior TV services b) Significant OPEX/CAPEX reduction c) Uniform user experience d) New, advanced use cases e) No device and experience fragmentation but needed for standardization.

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