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The Evaluation of (CapEx/OpEx) Cost reduction of IPTV Service delivery using SDN Solution

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Abstract:*This paper aims to quantify and evaluate the cost saving of offering IPTV service through the 'Gold' Network Solutions implemented in IPTV SMC ISP data center; SDN and NFV.Recently, the demand for Streaming services like Real-time Video Streaming, IPTV Application service, Video Game,etc. is tremendous increased,and the end-users are pretending to deliver these services with high quality and low Cost. On the other hand, the Service Providers are facing several problems through offering the services, such as a problem with bandwidth, difficulties in Management, Controlling and Monitoring of huge data collected, the problem with Performance and quality of service delivering by the clients.Through SDN capabilities, the IPTV ISP's can benefit to reach cost saving in order to increase their Revenue and to enable IPTV service delivery with high QoE and low Cost to the end-users.Our work focuses on the real evaluation of Capital Expenditure Cost (CapEx) of the offered IPTV Service;byTraditional networks(without using SDN Principles) and by the Networks based on SDN Solution and Virtualization. In the analyses, we evaluate the impact of SDN Solution not only on the CapExCost but also on the operational expenditure (OpEx). From the results, it is concluded that the benefits of SDN technology in offering IPTV service are very high, where especially the CapEx cost of offering IPTV service through SDN is reduced with more than 80%. In this way, one of the most important challenges of the IPTV ISP's is solved.*

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I. Introduction

Through the SDN technology, offering IPTV services to thousands of end-users simultaneously is realized globally, unconditionally, with low cost and high QoE. SDN Technologies Promises Continued Service Improvements and Reduced Cost of Delivery of this Service. One of the most important functionality of SDN is the possibility to exchange the channels through SDN Controllers between many SDN providers around the world, bringing significant benefits to end-users such as; increase the number of television channels, reduce the cost of service, and increase the quality and service performance. The key functionality of the SDN controller is to allow any SDN providers to purchase content easily, as well as allow the development of Android-based iOS client-based SDN applications. Already, SDN technology brings very innovations by which there is made possible to produce many receivers and TVs with Android systems. In this way, the delivery IPTV service is made possible by avoiding the need for STBox information equipment to end-users.

Consequently, the Capex cost of providing IPTV service was also significantly reduced (One STBox device cost 70 Euros). Compared to Internet Service Providers (ISPs), SDN providers have insured the largest number of end-users who are delivering IPTV Service, while the ISPs have still the same problems mentioned before which are dominant and caused major disadvantages during providing this service. Also, with the increased number of end-users that delivered the IPTV service from the current huge SDN Video Networks such as Netflix, Hulu, Youtube,and Amazon Prime, ISPs observed an increase in bandwidth requirements from their customers. In this way, more bandwidth is required from the ISP side, which is converted into additional costs for the ISP.In such a way, with the purpose to avoid the increasing of the IPTV service delivery cost (necessarily also increasing bandwidth), the ISP itself offer to Streaming Video Service Providers the services and functionalities such as; SDN possibility, Hosting Server, Cache Hosting Server and other spaces in their network free of charge, in order to optimize bandwidth on the network (in the same way as Youtube Cache). On the other hand, for SDN IPTV Service offers, this situation brings the cost reduction of service delivery, increasing in the same time also the quality of the IPTV service, because SDN providers do not pay any more for Hosting Server (CapEx cost reduction). Consequently, the delivery of the IPTV service is realized with low CapExand OpEX costs, a high performance by successfully meeting the essential objectives of SDN technology.

II. Video Streaming Service and Techno-Economic Analysis

In order to evaluate the feasibility of a technical solution, is used the Technological-Economic Analysis by utilizing investment, forecasting, and network design methods. It can also focus on cost modeling, including financial results. The developed model is used to analyze the impact of system parameters on the feasibility of the SDN solution applied to the system [1]. In [2], a technological, economic approach has been used to identify business alternatives and opportunities for IPTV service providers based on SDN technology. Technological-economic modeling is also often used by the National Regulatory Authorities to evaluate the price or policy options in regulated markets [3].

The purpose of this paper is to quantify the changes of the two important costs; CapEx and OpEx based on the principles and application of the SDN solution for providing IPTV service. Through this 'Art' and strategic opportunity, the SDN providers have achieved to reduce the cost of providing the services. This modeling type is widely used to determine potential cost savings. For example, the cost modeling in [4] is used to analyze the savings in CapEx that can be accessed by taking in consideration the advantages of the SDN network (for packet control and network circuits). At [5], there are defined the formulas and sizes to be used in cost modeling for Cloud Computing. In [6], cost modeling is used to estimate CapEx cost on multi-layer optical networks. In most cases, the cost of a device is used to estimate CapEx costs, while the OpEx cost is neglected or it is agreed that this cost is calculated as a proportion in CapEx cost.

However, there are very problems in correctly determining the costs CapEx and OpEx. A cost model should have in advance a detailed classification of what costs are considered as CapEx and OpEx, as well as an explanation of how each of them is quantified and evaluated. OpEx costs are rarely evaluated because this cost does not include a high proportion of the total cost of businesses. However, it will be included a split OpEx cost in the evaluation that will carry a relative cost of the operational processes required to provide IPTV service to the end-users through SDN network (It is not included in CapEx cost).

Cost modeling is used to quantify the changes in CapEx and OpEx costs, which are resulting from the attributes of Centralized Control (SDN Controller), Virtualization and Softwarization of the network based on SDN Solution. In-house developments have a high propensity to increase the risks of a service corruption. One of the possible ways to avoid and reduce these risks is to train together in a highly skilled DevOps group; the developer and operational team.

DevOps consists of a set of practices for development of software products and services, resulted on close collaboration between the Development Department (which writes and test the Codes) and Operational Department (which operates on virtual infrastructure, network functions, and applications). DevOps practices focus on the automation, prediction,and repeatability of operational actions, similar to the integration of different cultures between members of different working groups.

Similarly to [7] - [9], in this paper cost modeling will be realized based on the impact of SDN technology. Also, the cost of the network migration (for example, operating two parallel networks at a given time) and the costs associated with organizational changes (for example, the cost of training DevOps groups) are not included in the cost model.

III. The cost model

To determine the total cost of providing IPTV service from a software-based SDN intelligent network, there are takeninto consideration; the CapEx and OpEx costs.CapEx cost is related to fixed network infrastructure. OpEx Cost represents the cost of holding all the Operational activities ofthe Company and includes three important operations; technical, commercial and administrative operations. As previously estimated, the categorization ofCapEx and OpExcosts is primarily based on the study described in [10], which were previously used for quantitative analysis of the total cost of a transport network provider in Germany. Based on the respective costs, there are formulated the equations 1 and 2.In an SDN network adequate for delivering IPTV service, CapEx cost includes the cost of purchasing and installing switches, the cost of SDN controllers to deliver service transport and to have under control the network, cost of Content (which is dynamic) as well as cost per client thatis added to the ISP network.

Evaluation of CapEx cost based on SDN Solution

Realistically, the CapEx cost is reduced to scenarios that use the SDN solution for providing streaming video services because the control plan is already placed at a higher level, from the Router Equipment to a centralized SDN controller, which is based on Virtualization and Networking software. By using SDN technology, SDN service providers can prevent monopolization and 'The Locking' of services from different ISPs, by developing programmable software switches.

$$\textbf{CapEx}=\sum\left(N_E \,\mathrm{X}\,\frac{cost}{1\ Equipment}+N_{SDNC}\,\mathrm{X}\,\frac{cost}{1\ SDNControll\ er}+\text{cost of software development}+ cost of the first installation\right.$$

Equation 1: The CapExcost model based on SDN Solution
Where:
N_E Represents the number of Equipment in Network, like Switch, Servers and Routers. All these components form the 'Network Components'.
N_{SDNC} Represents the number of SDN Controllers in Network. All these SDN Controller form the 'SDN Components'.

The cost of software development and the cost of the first installation represent the 'Installation Cost.'

The CapEx cost is calculated based on resource bill and cost types, as it is describedin Equation 1.In the case of networks based on the SDN solution for providing the IPTV service, two additional costs related to the SDN Controller are added to the CapEx, the cost of developing the software of the control plan and the cost of the SDN Applications that operate in the upperLayer of SDN controllers. Inside the cost of SDN network components, the cost of SDN controllers and the cost of installation are basedon the best price that SDN Controller is bought. We will assume that with SDN, the control plan is built into software and can be replaced with optimized software. We will model this by removing the cost of the VPN license from the bills of materials and add the cost of a group of developers. Also, in an SDN network, operating systems can be simplified because they require less update, modifications. In this way, the cost of the operating system is reduced by 25%.

Evaluation of OpEx cost

Calculation of the OpEx cost is divided into four categories: continuescost of infrastructure, maintenance and repair cost, service provision cost and cost of service management.

Continues cost of infrastructure - this cost is calculated including from floor space until the energy consumption of networked equipment. Inside an only cost are included all calculation of the cost of power, the cost of back-up and also the cooling power. The power of the device is based on the power required by the chassis of the router, the line cards and the processors of the switch or the router in the network.

In the case of the SDN network, continues cost of the infrastructure is very low because it consumes very little energy from the control plan of the network toward to Switches. SDN controllers consume less energy than it could be saved as a function of centralization of the control Plan. Power Consumption of a control plan is estimatedat 11% of full power consumption [11]. Due to the SDN Controllers, the floor space cost has increased slightly.

Cost of maintenance and repair - this cost includes the cost of preventive measures in the network, such as monitoring, network maintenance, and protection of network against possible failures as well as also repairingthem directly on the network. Monitoring and Care of the network is a process that is carried out by the Network Operations Center (NOC), the most important unit in Operation and Maintenance Department which is active 24/7.

In the case of SDN networks, this process is considered quite simple due to the centralization of the distributed software components. Network failures are divided into two categories: software failures and hardware failures. In the case of the hardware damages, the damaged equipment may be replaced by the new one. In the case of software failures, the software failures have been solved by a software update, patch or reboot.

The cost of repair and maintenance is lower when SDN networks are used because the system is united and controlled by the centralized SDN Controllers. The process of Software management is easy because all the software versions running in the system are reduced to an only sophisticated version. Similarly, it is also performed the management of the security and stock.

Service Provisioning–it starts with a service request from a potential user and involves the process of entering the order from the administration by administration and continue until testing, service provision, service change or movement, and service interruption.

Service management – it is related to the process of keeping active services, makingthe services active once they have been deployed. It also includesthe configuration of the existing and re-configured services.

In the case of SDN networks, the cost of service provisioning and service management are very low because the SDN solution itself enables automatic network configuration and maintenance. The service is preliminarily defined as a point to point configuration between two positions using the transport layer. The management of the service includes service connection configurations and documentation. By SDN solution, this process is very easy because the automatic configuration is enabled in a high-level and manner.The Equation 2 presents the evaluation of the OpEx cost taking in consideration all the necessary parameters.

$$\textbf{OpEx}=\sum\left(N_D x S_r x \frac{yearly\ \ rent}{m2}+N_D\, x \frac{yearly\ \ consumption}{1\ \text{Equipment}\ \ (kW)} x \frac{cost_{kW}}{year}+\ N_{sh} x \frac{Number\ \ of\ \frac{hours}{shifts}}{n\ddot{e}\ vit} x \frac{price}{1\ hour}+\right.$$

$$Number\ of\ hardware\ failures x\ [DfKmxcostKm+\ TRFxprice 1\ \text{hour}+\ TFFxPrice 1\ \text{hour}+cost\ of\ the\ hardware\ replacement]+Number\ of\ software\ failuresxTAFSin\ 1\ hourxprice 1\ hour+Number\ of\ connections\ yearly\ configuredx\left[T_{CC}(in\ 1\ hour) x \frac{price}{1\ hour}+T_{DC}(in\ 1\ hour) x \frac{price}{1\ \text{hour}}\right]+$$

$$\text{number of yearly connections to be re}-\text{configured}\ x\ [T_{CC}(in\ 1\ hour) x \frac{Price}{1\ \text{hour}}+T_{DC}(in\ 1\ hour) x \frac{Price}{1\ hour}\ ]$$

Equation 2: The evaluation of OpEx cost
Where**:**
N_D is the number of Equipments
S_r is the space of the Rack
N_{sh} is the number of shifts
D_f is the distance toward a failure
T_{RF} is the time to reach the failure location
T_{FF} is the time to fix the failure
T_{AFS} is the average time to fix a software failure
T_{CC} is the configuration time for a connection
T_{DC} is the documentation time for a connection

Network costs

The economic and operational aspects of networking bring fundamental architectural changes to the network. Nowadays, programmable instant networks clearly illustrate the economic aspects of network technologies.

SDN as a network technology has attracted not only academic and scientific research but also industry because it allows network costs to be reducedduring offering the services and increase in the same time the revenue of service providers (such as Video Streaming, VoD,etc.).There will be presented two very important costs that belong to the cost of the network [12]:

1. Unit service cost scalability – it evaluates the performance cost of a service unit within a technological network that receives continuously demands from end-users to deliver the services. This cost will also be calculated in cases where the network is overloaded.
2. Cost-to-service - which economically contains the cost of introducing a new service within a network technology.

The CapEx and OpEx costs will be used to determine the unit cost for a service referred to the QoS parameters of a network. We will only consider bandwidth as QoS parameter for service requirements.

Case study 1: Quantifying the cost of providing IPTV Service from traditional network

Until a few years ago, IPTV service was provided only by Internet service providers (ISPs), which used to offer this service in a limited and monopolized manner along with other streaming services such as VoD and VoIP. The service delivery cost scheme for each end user according to their hardware network is Cost-Server (Content) and Cost-Network. To quantify the cost of providing IPTV service to any user under the traditional network, we used the real SMC IPTV ISP data center, which currently provides IPTV service to 300 active end-users. Table no 1 shows the cost calculation divided into two parts: Network Cost and Cost of Content delivery (Which is Dynamic).

Table no 1: Cost evaluation of providing IPTV service according to the traditional network

The types of costs	Network Elements	Calculation of the cost for each element
The network cost for each end-user	IPTV Server 1 Gb Upload /Adequate for 500 end-users	2000 Euro / 4 Euro for each end user
	STBox Max 250	75 Euros (during the first installation)
	Cost per client added to the ISP network	2 Euros per month (DSLAM Ports, Switches,etc)
The content cost for each end-user	For example, like Content Source is takenDigitalb	5 Euro per month for each end user

Based on the CapEx Cost Calculation Equation (Equation 1) and Real Data received by the SMC IPTV ISP Provider in Table no 1, the CapEx monthly delivery cost of the IPTV service for each end-user is:
$CapEx_{Monthly}/_{1\ IPTV\ end-user}$ = 11 Euros (+ STBox Cost during the first Installation which is average 75 Euros)

In the IPTV service cost evaluation, the scalability of the system, as well as the cost of profiting a new service (cost-to-service), will be taken in high consideration.

The cost of scalability of the service unit - As it is mentioned above, the cost of scalability of the system will include network load and various other costs that will be spent to keep the service QoS at the same level for any request that comesto the network service. In the case of the traditional network used for providing IPTV service, this scalability cost will be called Scalability Cost. In the concrete case of subscribers who are clients of SMC IPTV ISP, the relative values of this cost are calculated in two situations:

- for clients who, besides IPTV service, also receive Internet service, this cost is relatively low because the bandwidth scalability and service quality is provided with high efficiency by the service provider itself
- For customers who receive the Internet service from another ISP, it is not guaranteed the security and provisioning of the delivered IPTV Service at the required QoS level. In this way, the quality and scalability of the IPTV service are not delivered at the required level, which normal is translated into an increase of scalabilitycost.

The cost of profiting a new service - as it is explained above, this cost is the total cost of service implementation/design, cost of service testing, and the cost of the problem-solving / correction process that were discovered during the test phase. In the case of the traditional IPTV service network, this cost is evaluated with a high priority because its values are part of the final cost calculation of providing IPTV service to the end-user. For example, if you need to add a network channel (for example,a Sports channel because itis tremendously needed from the end-users), then the following costs will be added to the final cost calculation:

1. The contract cost that the provider IPTV SMC ISP signs with the provider of this channel (the source of the content).
2. The cost of physical connection; from the source of the content to the IPTV service provider
3. Cost of converter for converting content into IP.
4. The cost of adding a channel to the IPTV server, along with the necessary settings.

The same procedure is also usedfor adding services to the VideoClub Server.

So it seems clear that any IPTV service provider using traditional networks for streaming services faces a huge challenge like the relatively high cost of service delivery. This is also the essential reason that ISPs offer IPTV service only to the end-users who also receiveat the same time other services such as the Internet, VoIP or VoD. In order to solve this major issue, there is a need for innovation and technological networking, absolutely an SDN solution which, through virtualization and networking software, enables the delivery of IPTV not monopolizing, geographically unconditional, withlow cost and high quality. One of the biggest economic benefits that SDN technology brings to Business Services in delivering streaming services is the delivering of these services with low cost. Through the SDN, it is possible to automate all the processes needed for providing IPTV service and increasing the new services delivery. It decreases hardware complexity as it is already working on virtual machines, reduce installation time on the network and realized with high efficiently upon the end –users requests high scalability of the bandwidth in real-time.

IV. Case study 2: Quantifying the cost of providing IPTV Service through SDN Solution

The development of SDN technology brings huge technological innovation in Networking. This smart solution performs network control through an SDN controller that successfully meets all of the growing demand of the end-user for real-time streaming services. The two features of this technology are Softwarization and Virtualization of Network Elements, which simplify and globalize the delivery of SDN services. Providing streaming services through SDN solution all over the world, with no geographical condition, is a big revolution in Networking. Nowadays, IPTV service can be delivered from any end-user anywhere around the world and can be offered by any SDN provider. Also, providing IPTV service through SDN technology brings great economic benefits to businesses. Through SDN, IPTV service is offered to any end-user with lowerCapEx costs compared with the CapEx cost offeredby traditional networks. Also, the cost of service provision and service management is very low because the SDN solution itself enables automatic network configuration. In this way, through SDN technology, IPTV service is offered at a low cost andalso high QoE / QoS.

In the case of the IPTV SMC ISP data center, the CapEx cost scaling scheme for providing the IPTV service through the SDN solution is SDN Cost-Content cost (which in case of SDN technology is dynamic too). The monthly CapEx cost calculation for each end-user will be based on Equation 1.

Table no 2 shows in detail the types of costs taken into consideration and Calculation. We have chosen the best purchase price of the Virtual Hosting server and the best possible alternatives prices for purchasing the Container. Also, there are performed correctly all the adequate evaluations of the CapEx cost of delivering monthly IPTV Servicefrom two networks overview; Traditional Networks and SDN Network.

Table no 2: Cost evaluation of providing IPTV service through SDN network

The types of costs	Network Elements	Calculation of the cost for each element
SDN Cost	First case: 3 Virtual Hosting Servers 1 Gb upload / Download (a host can connect 418 end users)	500 Euro per month / Host 1.19 Euro/month for each customer
	Second Case: If an ISP offers SDN providers for their purposes a free Virtual Hosting Server	The cost of service delivery for each customer is reduced from 1.19 Euro monthly to 0.7 Euro
The Content Cost	First case: Purchase of container 1000 euro/month	The monthly container cost for each end-user is 0.6 Euros
	Second case: If the channel exchange process is realized between the various SDN providers	The monthly container cost for each end-user does not change

Monthly CapEx cost Evaluation for each end-user according to the SDN solution will be made based on the respective cases given in Table No 2.

First case: If we use 3 Virtual Hosting Servers 1 GB upload / Download (a host can connect 418 end users) and the monthly cost of the container is 1000 Euros, then the monthly CapExcost for delivering IPTV service based on SDN resolution is:

$CapEx_{Mont\,hly}/_{1\ end\ -user}$ = 1.19 Euro Monthly (Based on SDN Network Cost) + 0.6 Euro Monthly (Based on Cost of Content for each Client) = 1.79 Euro

Second Case: If an ISP offers to SDN providers for its purposes a free Virtual Hosting Server and the monthly cost of purchasing Content is again 1000 Euros, then the monthly CapEx cost of IPTV service delivery based on SDN Solution is:

$CapEx_{Mont\,hly}/_{1\ end\ -user}$ = 0.7 Euro Monthly (Based on SDN Network Cost) +0.6 Euro Monthly (based on Cost of Content for each end-user) = 1.3 Euro

Based on the second case of the content cost, the CapEx monthly cost of providing the IPTV based service on SDN does not change, but through the Exchange Channel functionality provided by the SDN controller, we increase the number of channels that each end user receives at low cost, increases uptime for each channel source at 99.99% and reduces channel loss time to <0.1 seconds.

SDN technology offers big chances for the service providers (which provide real-time streaming service)to increase their benefits by reducing the cost of offering them. This network technology is highly scalable, capable of supporting the high workload in the network, gives the possibility to reducedeeply the IPTV Service scalability cost (≅0). SDN enables the automation of all the processes required for providing IPTV, decreases the complexity of the hardware because it is already working on virtual machines, decreases the installation time of the devices in the network and insures in high-efficiencyreal-timebandwidth scalability upon the end user's requests.

As it is shown in Figure 1 below, CapEx's cost of providing IPTV services using SDN solutions, compared to the traditional delivery networks of this service has been significantly reduced.

Specifically, CapEx's cost of providing IPTV service under the SDN solution basedon the first case was reduced by 83.72%, and the CapEx cost of IPTV delivery under the SDN solution based on the second case was reduced by 88.18%.

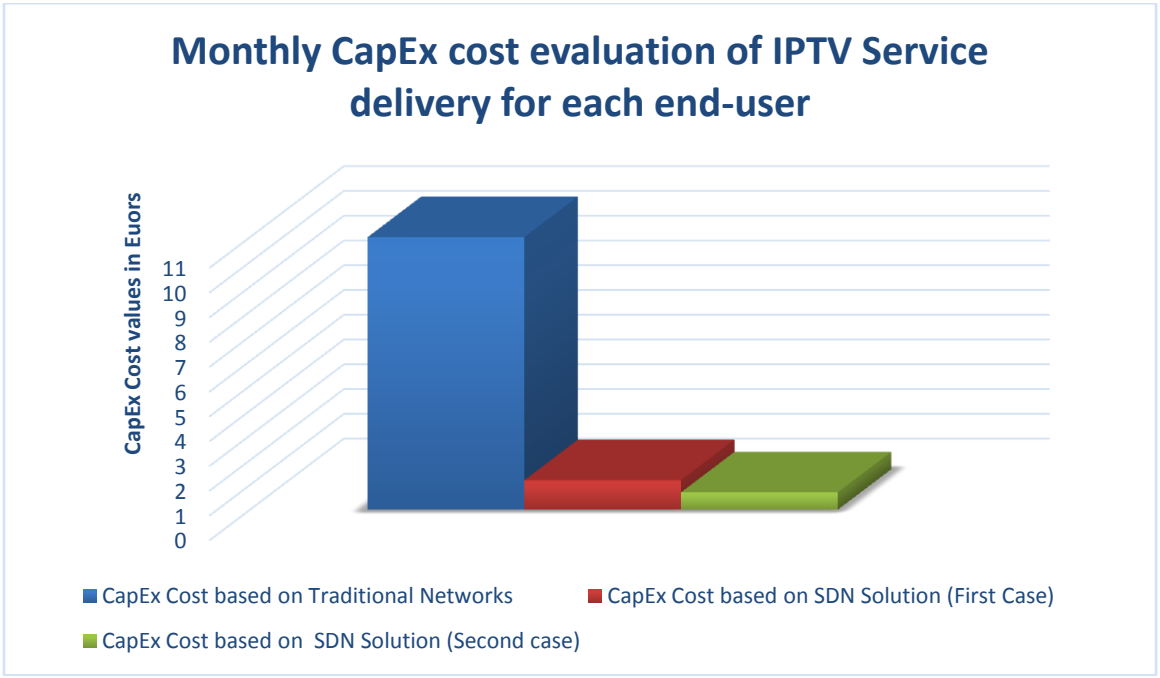

Figure 1: The Comparison of the CapEx Cost of IPTV Service delivery based on traditional and SDN Networks

V. Conclusion

In this paper, we introduced a techno-economic evaluation that takes in high consideration the SDN Principles in order to achieve the delivery of IPTV Service with low cost and high QoE/QoS. It is described in detailed a CapEx and OpEx Cost model because the study is focused on CapEx cost quantifications of IPTV Service delivery. Also, we have performed a real calculation of Monthly CapEx cost spent from the Streaming Service Providers to provide IPTV service to end-users in two manners; through Traditional Networks and SDN.

It is well known that SDN technology offers big chances for service providers which providereal-timestreaming services to increase their benefits by reducing the cost of offering it. This network technology is highly scalable, able to support the high workload in the network, leads directly to a big reduction of IPTV Service Scalability Cost (≅0). SDN network enables the automation of all the processes required for providing IPTV by decreases the complexity of the hardware,and it ensures the real-time bandwidth scalability with low cost.

Based on the above results we come to a conclusion that, by using SDN solution we successfully solve one of the biggest challenges of IPTV service providers, which is the high cost of service delivery.

As it is shown by the Figure 1, it is very clear that through SDN implementation, the Monthly CapEx Cost of IPTV service is significantly reduced. From the calculation, it is observed that CapEx cost of providing IPTV service under the SDN solution based on the first case was reduced by 83.72% and based on the second case was reduced by 88.18%.

The real values are studied and received from IPTV SMC ISP data center

The purpose of this real-case study (***costs taken in calculation are relative***), based on the CapEx cost analysis of the IPTV service is to strongly emphasize that SDN Solution brings not only huge operational benefits for the Services providers with the aim of increasing their Revenue but also for the end-users who received the IPTV service with low cost, high performance and high QoE/QoS.

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