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A Design of Optical Networks in Cloud Computing Services

[1]Nagul Meera Sayyed, [2]Dr. Pramod Pandurang Jadhav
[1]Research Scholar, Dept. of C.S.E, Dr.A.P.J. Abdul Kalam University, Indore- Dewas Bypass Road, Indore, M.P, India
[2]Research Guide, Dept. of C.S.E, Dr.A.P.J. Abdul Kalam University, Indore- Dewas Bypass Road, Indore, M.P, India

Abstract: Modern optical networks elastic features have been adopted quickly by the web-scale providers such as Microsoft, to keep pace with tremendous bandwidth growth. In particular, transceivers of bandwidth-variable, colorless flexible-grid reconfigurable optical add–drop multiplexers, and a variety types of service are supported to improve network efficiency for cloud network operators, the ability to choose a variety types of optical source are integral. In this analysis, for cloud services, optical networks architecture is based on novel Stateful PCE-Cloud (SPC). For improving the maximum utilization of resource and reliability to the construction of SPC, the cloud computing technologies (e.g. parallel computing and virtualization) are applied. Detailed description and design are provided to the SPC components. Relationships of different potential cooperation between Region Stateful PCE Cloud (RSPC) and Public Stateful PCE Cloud (PSPC) are investigated. Moreover, constraint-based routing scheme base on RSPC and PSPC cooperation and policy enable are presented. A design of Optical Network in Cloud Computing Services (ON-CCS) shows increases in elasticity as client number increases, storage capacity and computing capability will also increase.

Keywords: *Stateful PCE- Cloud (SPC), Optical Networks, Control Plane, Cloud Computing, Path Computation Elements (PCE)*

I. INTRODUCTION

In elastic optical networking (EON) technologies, there are advantages and in Microsoft's long-haul data center network architecture, how these developments may be leveraged are considered. Intercity network was deployed currently by Microsoft's which is based largely on traditional fixed-grid technology, and to adopt capabilities and EON features, work is under way to the next deployable long-haul generation solutions. The Elastic Optical Network (EON) architecture [1] was proposed in response to the huge capacity demand and the diverse granularity needs of current and future Internet traffic. By adjusting the spectrum allocated to the connections' needs (assigning variable sized spectrum bands to them), the EONs clearly improve in terms of spectral efficiency. Depending on its bandwidth requirements, the appropriate amount of optical spectrum is assigned to each connection.

The advent of bandwidth-variable transceivers (BVTs), colorless, and flexiblegrid architectures, and in a variety form of platforms and factors, the coherent optical sources availability like never before, provide opportunities to maximize spectral efficiency, spectral utilization, and capacity. In addition, developments brought about by the capabilities of software-defined networking (SDN) for cloud network providers will enable the full range of benefits of network elasticity to be utilized. Cloud computing has shown its potential in addressing scalability and adaptability to fluctuating user demands by introducing virtualization in its core. However, provisioning appropriate network support to embrace versatile group of cloud computing operators and networks remains an open question while the Internet is moving toward a content-centric direction [2].

The latency-sensitive computing tasks Faced with the edge applications proliferation, including smart cities, Virtual Reality /Augmented Reality (VR/AR), and industrial IoT, and at end devices, the computational intensity of a promising service model to became ease by the Multi-Access Edge Computing (MEC) and to the cloud, data transmission burden will be reduced.

In edge infrastructure construction, the capital expenditures are considered, compared to cloud servers, fewer com-putting capacities are often owned by the edge servers. At the edge, with com-putting capacity limitation to cope, to handle the services bitterly, edge-cloud collaboration (ECC) becomes a necessity: To several heterogeneous computing tasks, Edge-Cloud Collaborative (ECSs) are splitted, where to edge servers they are offloaded, while the latency-insensitive are computing tasks and cloud data centres (DC) serves the computational-intensive. For heterogeneous servers (cloud server or edge) and heterogeneous computing resources (FPGA storage, GPU, CPU, etc.), the requirements are reflected by the hetero-geneities tasks in ECS [3]. In ECC, for task placement the scenarios of recent works have focused on i) hierarchical functional division, ii)

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resource auction and procurement, and iii) partition of computing job. In services as virtual links (VLs) represented for data exchanges in the resource allocation aspect among the tasks in ECS, in the underlying optical network, these works neglect the physical transmission effects and resource granularity but it only consider the allocation of band width-level[4]. However, high- dimensional resources to be allocated with fine-granular bandwidth, traffic aggregation, sliceable spectrum, and tunable modification format, the underlying optical network, especially multilayer optical network (ML-EON) e.g., modulation format, Sliceable Bandwidth Variable Transponders (SBVTs), and frequency slots (FSs). In high-dimensional ML-EON resources and heterogeneous servers, still it is a challenge to perform computing resources of heterogeneous joint allocation. To allocate jointly, the computing resources and optical network, they have been investigated by the virtual optical network embedding (VONE) [5]. To rank the virtual nodes/substrate nodes for embedding, as criteria the virtual/substrate networks required/residual capacities were took by most of the existing works. However, in ML-EON, for ECS provisioning there exist two drawbacks in these methods: i) Thus, the different ECS is insufficient, the residual resources are considered only for substrate nodes in static ranking but it does not integrate the differences among the task, it is faced with heterogeneities of tasks. ii) In ML-EON, for VL mapping, neglected the costs for high-dimensional optical network resources, in these methods, in the virtual node mapping process due to the failure of VL mapping the ECS to be blocked [6].

The e-commerce, multimedia applications, smart applications, social networks, continuous internet growth, etc., for networks, poses a continuous challenge on keeping up with such evolution in terms of complexity, information overload, bandwidth, etc. Enterprises use a very large number of data centres such as Facebook, Microsoft, eBay, Amazon, and Google. In those centres, a huge data volume is exchanged. To divide networks logically or virtually into different slices, nodes, or clusters, virtual machines (VMs) or tenants are included by the data centres. New VMs to be created, new services may cause based on customer demand or users. VM needs particularly, to accommodate dynamically for each newly created tenant or VM, control security, resources management, etc. are all should be allocated [7].

From hour to hour or from day to day, the demands varies widely it is one of the serious challenges in the internet traffic or in the cloud computing. Manually, to manage this process it made very hard by these fluctuation. On the other hand, the reconfiguration/configuration and administration of those switches are labor intensive, and the traditional switches are vendor specific. Similarly, security control management such as firewalls, as the process it is labor intensive in those firewalls to maintain access control lists (ACLS), add, or update by network administrators, it is manually accomplished. To define interaction between switches and controller, an algorithm was developed which is known as Open-Flow [8]. Specifically, with it's OF switches, how the controller should communicate, have the detailed specifications which are included in Open-Flow (OF). Compared with traditional switches, OF switches are different, with no control function they are built to be very basic and including only forwarding elements or data. Both modes are started supporting by the most newly designed switches: OF and traditional [9]. For the administration and control of Open-Flow switches, as a network operating system (NOS), a software program acts which is known as controller. In networks, to solve the specific problems, came several initiatives by SDN. Routers, switches, or other components of network are vendor septic. To program applications, users are not allowed on top of those networking applications, the networking companies are not for technical purposes it is only for business purposes. To have an open networking architecture is one of the main SDN goals that is not specific or vendor locked-in. Further, to interact with the switches, the architecture of network should be network administrators or developers, and for example, access control algorithms or use or customize flow [10].

II. LITERATURE SURVEY

C. Song *et al*., [11] an innovative concept was proposed, a physical network to partition into different configurable slices, to meet the expected diverse requirements services in the 5G era, the network was allowed. Exclusively, the existing schemes of network-slicing focus almost on the partitioning of the radio access network or the core network. However, in service provisioning to achieve better resource utilization and greater flexibility, in the 5G optical Mobile Front Haul (MFH) network, the potential of network slicing should be jointly exploited. To enable slicing of 5G optical MFH network, a flexible architecture of hierarchical edge cloud was propose to address this challenge. Additionally, to support the requirements of various diverse resource requests of the network slices and Quality-of-Service (QoS) are proposed by a corresponding integrated scheme of network resource management. The proposed scheme was indicated by the simulation result which is able to jointly allocate the resources of bandwidth to network slices and to meet the requirements of various QoS, cloud-computing offloading was realized, and therefore, the burden of fronthaul bandwidth was reduced.

G. B. Figueiredo, D. M. Batista, B. Mukherjee, R. I. Tinini, and M. Tornatore, et.al [12], in local fog nodes it can be activated on demand which is clouser to the RRHs, to process fronthaul/surplus cloud, to replicate the processing CRAN capacity, restores to network function virtualization and to fog computing by an architecture of hybrid Cloud-Fog RAN (CF-RAN) which was proposed. Graph-based heuristics and Integer Linear Programming (ILP) are devised to decide how to dimension wavelength and to support the fronthaul, to activate fog nodes on multiplexing passive optical network of a time-and-wavelength division. Compared with traditional distributed RAN, 96% less energy was consumed by our architecture which was shown in our results, about 20 µs, latency of a maximum transmission was provided between BBUs and RRHs even in large traffic scenarios. Moreover, to achieve the same optimal ILP formulation solutions our graph-based heuristics was demonstrated but in the execution time 99.86% reduces.

M. Ruffini and F. Slyne, et.al [13] describes Network Function Virtualisation (NFV) and Software Defined Networking (SDN) has changed recently the way how network operates. By virtualizing their components and decoupling control and data plane operations, new frontiers have opened up toward reducing the costs of network ownership and improving the efficiency and usability. Recently, toward public telecommunications networks their applicability has moved, with concepts such as the Cloud Central Office (cloud-CO) that have pioneered its metro networks and use in access: the network operators interest has quickly attracted to an idea. By residential, enterprise and merging mobile services into a common framework, around commoditized data centre types of architectures was built, CO virtualization future embodiments concept could achieve operational cost savings and significant capital, to low-latency and high-capacity future applications, customised network experience has provided.

X. Yu, H. Gu, K. Wang and S. Ma,et.al [14] a scalable, lossless, optical data centre network that is high-performance, and PETASCALE are presented. Respectively, compared with fat tree topology, beyond 60000 servers, PETASCALE is able to scale, in a number of cables and switches to achieve up to 2 and 2.5 times by embedding full-mesh into a bipartite graph. To solve the packet collision, the retransmission scheme and negative acknowledgment (NACK) leverages by the PETASCALE, thus eliminating the costly and complex buffers. A state retention mechanism is leveraged in near real time, over multiple hopes the contention can be notified. To improve further the utilization of bandwidth, within the source pod to restrict the packet collision domain, an algorithm of wavelength routing was proposed. Moreover, both the wavelength routing and multi-hop NACK to support, a novel switch structure was designed. Compared with an electrical fat tree network, the latency of end-to-end reduces more than 50% by PETASCALE which was shown in our simulation results. Under uniform traffic pattern, for throughput, a non-blocking networks 89% bisection bandwidth was delivered by the PETASCALE. Compared to the other optical designs and fat tree, it can achieve higher throughput under the local traffic pattern.

H. Yang *et al.*, [15] against collapse in the optical and fog-based wireless networks, a Bandwidth Compression Protection (BCP) was proposed to improve the performance of the network and in case of collapse with digital and analog scenarios, guarantee the survivability. Appropriately, with reducing redundancy, the whole networks resource efficiency can be promoted, the level of services can be classified by the BCP algorithm and by the low level services, occupied the bandwidth of backup path which was furtherly compresses. Evaluated the proposed algorithm performance and by means of extensive simulations, with the conventional protection algorithm it was compared. Compared to other algorithms, with less average hop, lower blocking probability and higher resource utilization, the proposed algorithm of BCP can guarantee the survivability of network which was shown by the numeric results.

J. Neaime and A. R. Dhaini, et.al [16] introduces a content distribution networks are exploited by an agile, programmable, scalable, and OCLDN optical cloud distribution network to deliver killer cloud and tactile services to end users at low cost, ultra-low latency and very high speed. At central office of a next generation passive optical network, installed a software-defined-networking-based mini-cloud data centre, where a cloud based tactile steering server was included, and all cloud applications types are included with OCLDN. The Quality-of-Service (QoS) has stringent the requirements of these application and thus, mechanism allocation of effective, fast and adaptive bandwidth is required. Therefore, the tactile services of QoS requirements has met the scheme of Dynamic Wavelength and Bandwidth Allocation (DWBA) via dedicating it upstream wavelength (s), and for all services types, without impairing the QoS requirements to maximize the network throughput, the inner-channel statistical multiplexing was enabled. To outperform the existing schemes, the proposed DWBAs ability was demonstrated by the extensive simulation, and for non-tactile and tactile services, the QoS demands its effectiveness which was highlighted in meeting.

G. Landi *et al.*, [17] described the inter-DC network that was formed using the multiple or single entities with the operation of elastic optical networks (both subsea and landline) and traffic which was increasing constantly was served. In addition, for intra-DC networks, optical switching technologies are researched as it means to achieve energy efficiency and higher capacity. For realizing the network as service visions and network virtualization there was an intra-DC network infrastructures, inter-DC orchestration and joint optimization key. Intra-DC was treated by the networking orchestration platform that was defined by the presented hierarchical software and as domain there are inter-DC networks and to achieve end-to-end orchestration, inter-domain with domain specific controllers/orchestrators are cooperated. In a realistic testbed and in an emulated, the developed systems are evaluated, and with low control and dedicated capacity the dynamic end-to-end path establishment functionality are showcased.

Y. Xiong, Y. Li, B. Zhou, R. Wang and G. N. Rouskas, et.al [18] before occurs the link failure, to compute backup paths an associated trigger mechanism and the FR-TP strategy are presented. Furthermore, to improve the resource of bandwidth assignment and path computation efficiency, to change the spectrum window planes (SWPs) width dynamically a spectrum window planes layered auxiliary graph (SWP-LAG) was constructed to satisfy different service requests. Compared with the existing strategies of restoration, results of simulation demonstrated that, in studied network topologies, the proposed FR-TP strategy combined with SWG_LAG, the recovery time reduced up to 30.4% which was studied the blocking probability that was not increasing.

E. J. Dávalos and B. Barán,et.al [19] presents a survey, in the literature, found the most relevant VONE schemes. Presented, the important algorithm aspects discussion of this problem, such as possible research directions, global performance metrics and optical-layer restrictions. In addition, a new VONE approaches taxonomy was proposed, considering the static or dynamic scenarios, type of optical networks, and the method of optimization. In network virtualization, an important challenge is the assigning physical resources process to the requests of virtual network, where the IT capacities demands were represented by virtual node resources, between virtual nodes pairs, the virtual links are connected. Virtual Optical Network Embedding (VONE) is used to solve the problems, specific strategies are required for physical optical network infrastructures due to their special characteristics.

Mayoral *et al.*, [20] proposed a comprising optical circuit switching of multi-domain transport network which is consisted in international multi-partner test bed which was demonstrated experimentally by a solution and control planes of Generalized Multiprotocol Label Switching (GMPLS), infrastructure of a distributed cloud and OpenFlow/SDN controls optical packet switching domains. The network resources and dynamic IT provisioning are shown in the results and architecture capabilities are recovered.

B. P. Rimal, D. Pham Van and M. Maier, et.al [21] to the process of underlying FiWi dynamic allocation, both MEC computation offloading and centralised cloud activities are incorporated by the scheme of novel unified resource management which was proposed. By the leveraging time division multiple access, outside the FiWi traffic transmission slot the both cloud traffic and MEC are scheduled. For both broadband access traffic and cloud, developed an analytical framework to model packet delay, communication-to-computation ratio, gain-offload overhead ratio, and response time efficiency. In addition, in optical MEC and backhaul the importance of reliability was given, to assess the both MEC server failures and fiber cuts impacts, a probabilistic survivability analysis model was developed in this paper. The implementing conventional cloud feasibility was demonstrated by the obtained results and without affecting network broadband access traffic performance of MEC in FiWi access networks.

B. P. Rimal and M. Maier, et.al [22] in the envisioned network, from an end-to-end perspective a non-cooperative multi-level game-theoretic approach is used in a proposed mobile data offloading frameworks. More specifically, three-level Stackelberg games are designed, in which a multi-leader multi-follower game, a single-leader multi-follower game, and a singe-leader multi-follower game are modelled in the introduced network such that local payoff functions were optimized selfishly by individual players and problems of the large complex network- wide optimization have solved collectively. Further, to reduce the hierarchical games complexity, the distributed mobile data offloading algorithms were developed and in each sub-game, an unique Nash equilibrium condition was achieved. The results of simulation show that by reaching the condition of Nash equilibrium, the proposed solution helps interference price, processing cost, and minimize energy consumption, while maximizing player's revenues in the envisioned network. In addition, the equilibrium efficiency quantified in terms of price of stability and price of anarchy for the worst/best Nash equilibrium case.

G. Castañón, G. Campuzano, I. Aldaya, E. Giacoumidis, J. Beas, and J. Torres-Zugaide, et.al [23] described bandwidth consuming applications that was driven the High-speed demand such as cloud computing and video streaming, capacity of available network is exceeded, to implement innovative technologies by forcing operators to increase the offered throughput to end users. In particular, with a full

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duplex capacity of 10Gb/s, the Passive Optical Networks (PONs) over 40km span are shortly developed as expected. However, due to splitter losses and fiber, the systems range is penalized severely. Communications of Coherent Optical (CO) attention has regained to increase the PONs transmission distance. As a modulation format, proposed the Orthogonal Frequency Division Multiplexing (OFDM) due to its flexibility, robustness to chromatic dispersion and high spectral efficiency. However, to fiber nonlinear distortion, the OFDM signals high-peak-to-average ratio makes them very vulnerable. In this paper, in CO-OFDM PONs for the nonlinear distortion, what we believe is a novel was proposed to partially compensate low-complexity equalizer based on the inverse model of Hammerstein. When compared to linear equalization, split-step Fourier transform method is used in numerical simulations to reveal a potential link, to 20 that increases and 5km for bit rates of 40 and 10 Gb/s, respectively.

L. Velasco *et al.*, [24] connectivity of C-RAN application requirements are studied and conclude that elasticity, dynamicity and fine granularity are needed. However, those requirements are supported when there is no implementation of SBVT, and thus, based on dynamic optical arbitrary measurement/generation, we assess and propose an architecture of SBVT. Different advanced configurations of long-term evolution was considered and in terms of the operating expense and capital expense, the centralization level impact was studied. To decide which equipment needs to be installed including transponders and which Cos should be equipped, modelled an optimization problem. Compared to installing fixed transponders, the proposed SBVTs is installed for noticeable cost savings as shown in results. Finally, remarkable cost savings are shown when considered the lower centralization level compared to the maximum level of centralization.
C. Yang, Z. Wang and Z. Tan, et.al [25] the energy consume problem in a new C-RAN architecture, i.e., the ring topology Time Wavelength Division Multiplexing (TWDM) front haul enable C-RAN, Passive Optical Network (PON), requirements are considered for high energy efficiency, large transmission capacity, and appropriate utilization in densely populated cities and in large-scales. To analyze the energy problem, after bringing this optical front-haul, a network traffic modelling is provided based on queueing theory and service quality was considered. In the most energy-efficient state, to ensure the works of system the network optimization was conducted. Besides, the comparisons of energy among the ring-topology Time Division Multiplexing (TDM) PON enabled C-RAN, TWDM-PON front-haul enabled C-RAN and also have been made the ring-topology architecture of TWDM-PON-LTE. Compared with the TWDM-PON-LTE architecture, after energy optimization the new C-RAN can save up to 58.1% energy according to the numerical results and over the TDM-PON enabled C-RAN (more than 2% energy will be saved), it has slight advantage, demonstrated large potential and broad application prospects in the future.

III. A DESIGN OF OPTICAL NETWORKS IN CLOUD COMPUTING SERVICES

In this section design Optical Network in Cloud Computing Services (ON-CCS) shown in Fig.1.
For this design phone is taken as an input. After the phone is it entered into Personal Computer (PC). To converse with one another, clients are permitted by arrangement of private phone which is known as Private Branch Exchange (PBX). To arrange phone, availability was given by cooperating with diverse equipment parts. As an inner phone arrangements association, a PBX works. Rather than the telephone company, the enterprise is operates or owns a PBX, which was used as a private telephone network or business telephone system. However, service provider or supplier may be considered by the telephone company. Originally, analogy technology is used by private branch exchanges.
As shown in Figure 1, a Passive Optical Network (PON) system connects 16~256 Optical Network Unit (ONU) to an Optical Line Terminal (OLT).

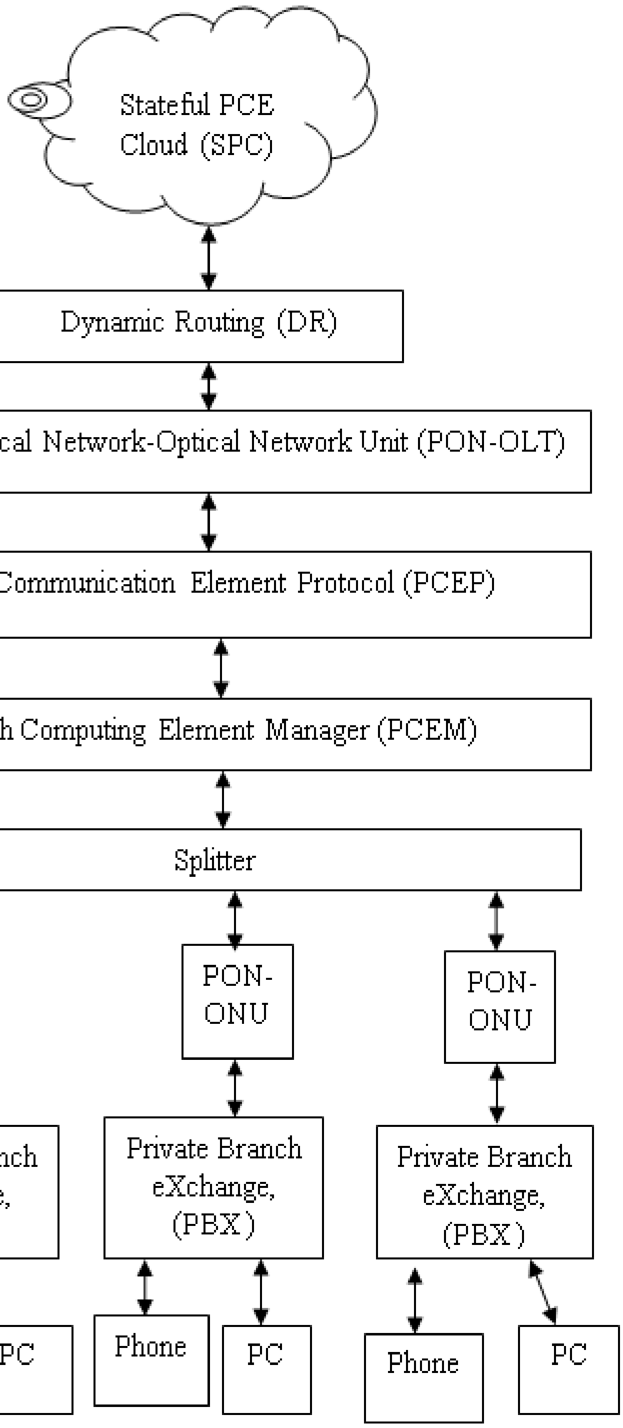

Fig.1: A Design Of Optical Network In Cloud Computing Services

The distance to a typical PON distribution is 20 km, and with reach extenders, achieved distance over 60 km. Symmetrically, in feeder fiber the transmission rate reaches up to 10 Gb/s. To share fiber resources, well defined protocols were used based on TDM technology by the mainstream PONs and various applications were supported. Therefore, to a central node, geographically distributed units are able to connect effectively by the PON. Multiple distributed ONUs workflows and resources are coordinated by the PON OLT. From a single source to multiple displays, to stream video users were allowed by the technological devices is known as splitter. This means, from multiple

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devices a video can be viewed by the users within a building, the need for everyone was eliminated that to in the same room. To multiple streams, a light beam was divided that was involved by the wave splitting. The ratio of daughter streams can be different or equal. Two or more fibers are used by the FBT splitter. Removed the layer of fibers' coating.

According to specified routing policy, for parallel computing the map-reduced operation was performed, form users the tasks were managed by the PCEM and to PCETTS, computing tasks were assigned.

The actual unit of path computing is known as PCETT. Through parallel computing technology, the path computing request was processed with each other by collaborating with PCETTs. On the Virtual Machines (VM), the OpenStack allocates the PCETT and PCEM run dynamically.

In the internal domain, the communication agent of label switching router (LSRs) delivers the communication function between the RSPC with path communication element protocol (PCEP and path communication client (PCC is known as PCEA).

From the LSR and PCC, the inter-domain information regarding network state, traffic engine, reserved resources and set of active path were collected.

Moreover, it periodically notifies the collected information to RSPC. Chassis the PON OLT and multiple OLT cards are consisted. Several OLT ports are contained by each OLT card. PON system is essentially shown a single OLT port with its associated ONUs. With storage media and general CPUs, the both ONU and PON OLT devices are equipped. In a wide range cloud computing performance was able to provide by a PON chassis, depending upon the numbers of PON rates, storage capacities, ONU and OLT processing capabilities, port splits, OLT ports and OLT cards. At a time, for a single LSP request the route was evaluated by the DR module that was expressed in terms of bandwidth requirements, destination nodes and source. Required bandwidth is available to make the higher-priority of LSP that was invoked by the BE module.

To develop SPC based GMPLS optical networks architecture, it uses disperse event simulation tool OMNet++ in the architecture of SPC. There are 46 nodes and 6 domains in the simulated network topology, and contains 16 wavelengths in each link. The Poisson process with arrival rate is supposed by the simulation to arrive the request between any pair of node. Each call holding time, with unit mean is exponentially distributed.

For all four architectures, with the increase of traffic load the path provisioning latency increases. However, when the intra-domain ratio gets better by the SPC performance and decreases the inter-domain. The reason is that SPC with virtualization and parallel computing technology makes better in computationally intensive cross multi-domain path computing tasks. According to the QoS's different services requirement, the elastic resources provision was provided by the SPC cloud and to different application scenarios it was accommodated as shown.

IV. RESULT ANALYSIS

In this performance analysis of design of optical network in cloud computing services is seen.

Table.1: Performance Analysis

Parameters	FR-TP	ON-CCS
Elasticity	89	91
Storage Capacity	91	95.6
Computing Capability	94.8	99.1

In Fig.2 elasticity comparison graph is seen between Fast Restoration Strategy with Triggered Precomputation (FR-TP) and Optical Network in Cloud Computing Services (ON-CCS). The ON-CCS shows higher elasticity as client as increases.

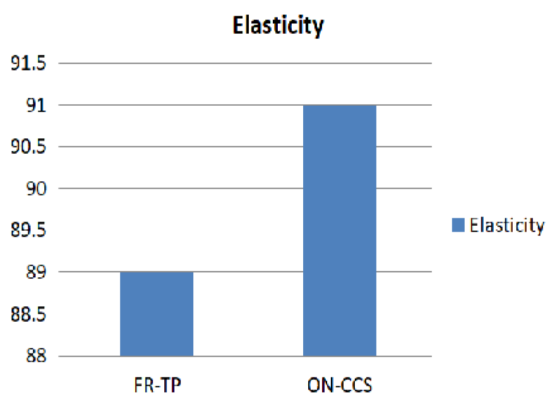

Fig.2 Elasticity Comparison Graph

In Fig.3 storage capacity comparison graph is seen between Fast Restoration Strategy With Triggered Precomputation (FR-TP) and ON-CCS. The storage capacity is higher in ON-CCS.

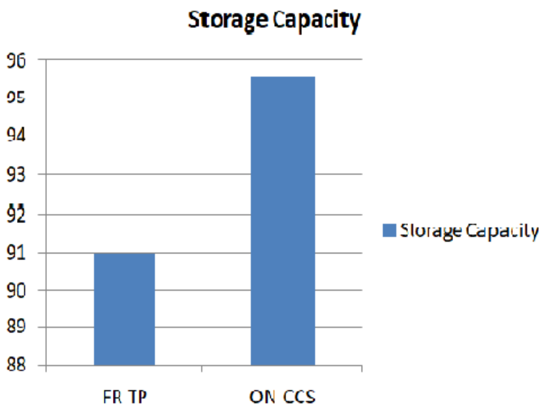

Fig.3 Storage Capacity Comparison Graph

In below Fig.4 Computing capability comparison graph is observed between FR-TP and ON-CCS. FR-TP shows lower capability when compared with ON-CCS.

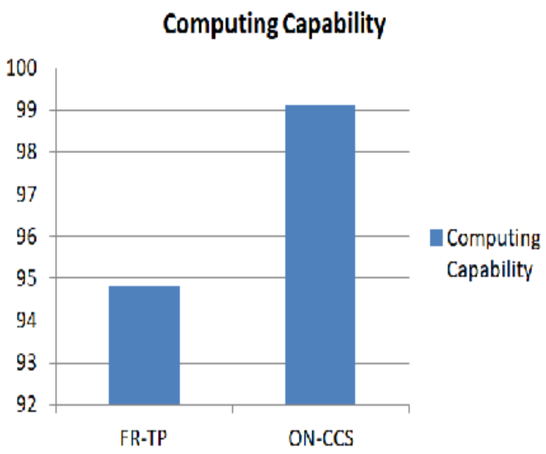

Fig.4 Computing Capability Comparison Graph

V. CONCLUSION

In this section design of optical network in cloud computing services are concluded. For cloud services, a novel stateful PCE-cloud based optical networks architecture was evaluated, designed and motivation of ON-CCS. Connectivity of End users to data center and for datacenter to data center it was described and to meet the QoS's constrained-based routing problems and address the policy enable, cloud services requirement and multi-domain optical networks are designed. Moreover, another prime design architectural target is for improving systems control plane reliability and resources utilization. It also achieves elasticity as client number increased, storage capacity and computing capability also increased.

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