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PCE BASED PATH COMPUTATION ALGORITHM SELECTION FRAMEWORK FOR THE NEXT GENERATION SDON

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ABSTRACT

The network operators are striving for the optimization of transmission resources while achieving network performance and efficiency. The current optical networking is rolling out towards the next generation intelligent optical network to offer high capacity and better quality according to the attribution of the service. One of core problems in optical network is path computation which involves finding the route between source to destination with appropriate wavelength. The constrained optical path computation involves finding the route with appropriate wavelength while optimizing one or more criteria (ex: less congestion). At present scenario, the centralized PCE with GMPLS control plane could control the optical network with traffic engineering. This approach may be incapable or costlier for the next generation voluminous and dynamic application needs with range of QoS gurantees. The PCE has to rely on a certain routing protocol along with some path cost measures, may not explore the required optimal solutions space, and end up with the best effort path most of the time. Moreover the traffic engineering can potentially add additional cost while maintaining the quality of the path. This article intends a path computation algorithm selection framework amenable for the next generation software defined optical network to solve the problem of QoS constrained path computation. The framework exploits the right proportion of enabling technologies to realize the constrained optical flows in a cost effective and optimal manner. The simulation study was performed to analyze the characteristics of the PCE based algorithm selection model in the SDN based optical network.

Keywords: *Bit Error Rate (BER), Path Computation Element (PCE), Generalized Multi Protocol Label Switching (GMPLS), Quality of Service (QoS), Software Defined Optical Network (SDON).*

1. INTRODUCTION

In telecommunication networks the role of optical networks [1] is crucial, in providing the fully transparent high capacity and fast transmission link. The key features of such high speed communication infrastructure are the effective optimization of the used resources and the faster reaction to user events. In optical network, the virtual topology is a set of optical light path channels between nodes, which carries traffic from source to destination [2]. Hence the lightpath is the basic element in optical networks, which can be established through the shortest path and in a particular wavelength between two nodes, by obeying the constraints of the wavelength. Such lightpath must satisfy or optimize several QoT (Quality of Transmission) parameters (like less congestion, delay etc.,)[3]. The collection of such lightpaths between all the available nodes will comprise the virtual topology. Hence it becomes obvious that the well optimized virtual topology can accommodate the present as well as future demands in a resource and cost effective way. And moreover, such virtual topology must be dynamically reconfigured to adapt with the evolving traffic demands or node/link failures through a topology reconfiguration process [4][5]. The optical path computation, which is otherwise called Routing and Wavelength Assignment (RWA) is an important process which needs to be optimized for the global wide network performance. There have been several algorithms/heuristics proposed in literatures to solve the RWA problem (NP Hard problem) in a reasonable time. The PCE based optical control plane uses a single path computation algorithm to find the optical paths.

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Such single algorithm may only provide a limited functionality. As a consequence, additionalnetwork support in the form of traffic engineering (TE) was needed, for the network re-configuration, fault management and performance optimization via policy control. To take advantage of SDN and the strengths of variety of RWA algorithms/heuristics a novel framework was proposed and claimed as a viable solution for the next generation intelligent optical network.

The following sections are organized as follows.

The various attributes of the RWA problem is given in section.2 In section.3 a brief survey analyzes the cognitive and machine learning based approaches to solve the optical routing problem. The survey ends with the use of algorithm selection technique in similar NP hard problems. The section 4 explains the background enabling technologies. The proposed framework with the algorithm is given in section 5. The simulation setup and the experimental validation study is given in section 6.

2. ROUTING AND WAVELENGTH ASSIGNMENT IN OPTICAL NETWORKS

The arbitrary/logical/virtual topology shall be characterized by variables, constraints and objective functions (to maximize some value(s) or to minimize some value(s)). To find a virtual topology the RWA problem has to be solved efficiently.

2.1 Formulation of The RWA Problem

The RWA problem has been considered as a multi objective optimization problem. The following section describes the various attributes of the problem [6][7][8].

2.1.1 Given

- Physical topology (i.e., the set of nodes and the physical links that connect the nodes)
- The average traffic rates between each node pair
- Maximum number of lightpaths which can be established on a node (the number of transceivers per node)
- Number of wavelengths per physical link
- Lightpath bandwidth capacity

2.1.2 Find

- The route of each lightpath over the physical topology
- The proper wavelength of each lightpath

2.1.3 Objectives to optimize

- Minimize the resource usage of the network, i.e., the total number of wavelength-links used or the total number of transceivers used in the whole physical topology.
- Minimize Congestion/Delay
- Minimize Blocking probability
- Maximize the provision for future expansion

3. LITERATURE SURVEY

In this section we have analyzed the different approaches followed in solving RWA problem, for a static and dynamic scenarios with single as well as multi line rate abilities. As we proposed to design an intelligent algorithm selection model, we have confined this survey on the cognitive and machine learning based approaches applied to the next generation optical networks. At the end of this section, the suitability of algorithm selection technique applied to various optimization problems was also analyzed.

Using hyper heuristic technique (heuristic to select the heuristic) the RWA problem was solved effectively. The hyper heuristic technique is about selecting the best heuristic or set of heuristics according to the problem instance. Since the algorithm selection technique was applied in various NP hard domains, it can also be applied to solve the RWA problem (NP hard). In [9] they have proposed a hyper heuristic (HH) search technique. A HH is a search process which manages low-level heuristics (LLH) at each step of an optimization process. Solving the RWA problem was considered as a step by step optimization process. The basic idea was to combine goodness of all the heuristics with respect to the varying traffic conditions. This HH method has combined the strength and compensating the weakness of known heuristics through the nature inspired heuristic search technique. Some of the nature inspired HH search techniques are simulated annealing, evolutionary algorithms, ant colony optimization.

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There are plenty of heuristics and algorithms available to solve the RWA problem. But each of them differs in minimizing or maximizing some of the objectives and not all of them simultaneously at the same time (No free lunch theorem). The "No Free Lunch" (NFL) theorem (Wolpert& Macready, 1997) [10] states that no single algorithm can perform best across all the possible instances and on average all the algorithms perform in the same level. Hence each RWA algorithm has its own strengths and weakness. The Algorithm Selection Problem is about selecting the best algorithm to solve a given problem instance on a case-by-case basis. Many NP-Hard problems like GCP (Graph Coloring Problem) [11], SAT (Satisfiability) problem and CSP (Constraint satisfaction problem) [12] have been solved effectively using the concept of algorithm selection. In [13] the different hyper heuristic based routing and wavelength assignment techniques were analyzed elaborately.

In [14] the Cognitive Heterogeneous Reconfigurable Optical Network (CHRON) project was proposed. The CHRON implements the cognitive processes to perceive the current network conditions, and then plan, decide, and act on those conditions. Such network can able to learn from past adaptations and use them to make future decisions, while taking into account end-to-end goals. The CHRON project deliverables have proven the effectiveness of various soft computing techniques in solving the problem of RWA. The project has also explored the interconnection between the various service classes, traffic types with the cognitive solutions for to exploit the effective control and management flexibility.

The CoSDN (Cognitive Software Defined Networks) project [15] has explored the idea of programming the network behavior through SDN. The project has enabled the personalized QoS based network services and security on per flow basis. With its real time learning and reconfiguration ability the approach has given the better user experience with proactive fault management mechanism. In the next generation optical networks, the optical technologies and its associated control algorithms will play the major role. The Autonomic Network Management (ANM) proposes the automatic selection of required algorithms according to the use cases [16].

In [17] the machine learning was applied for the effective control and management of SDN. A programmable cognitive and autonomic architecture, GARSON was proposed. The ALTO (application-layer traffic optimization) was proposed in [18]. The multi objective optimization ability of genetic algorithms was also used to solve the RWA problem. The P-SC-IA-GAPDELT (Power optimized-Simple Cognition-Impairment Aware-Genetic Algorithm to Provision and Design the Logical Topology) has solved the RWA problem in an optimal way [19]. This method has obtained the Pareto Optimal Set (POS), i.e., a set of solutions where each solution has different tradeoffs as all the solutions cannot be simultaneously improved in terms of all the optimization objectives. As by the fact in multi objective optimization, an objective cannot be improved without worsening the others. The use of artificial intelligence techniques in provisioning the network with user preferences was proposed in [20].

The meta learning techniques were applied successfully in various domains, for the selection of suitable algorithms [21]. The algorithm selection technique (JR Rice 1976) was used in solving many NP hard problems like graph coloring problem etc.,[22][23]. The concept of algorithm portfolio was proposed in solving the combinatorial search optimization problem [24][25]. In [26], the ranking of algorithms according to their performance has proposed.

From the survey we had summarized the goals of the various next generation optical network frameworks. At the same time the use of machine learning techniques in the aspect of algorithm selection was considered in various domains.

4. BACKGROUND

In this section, the network enabling technologies that were exploited to derive a path computation algorithm selection model is given.

4.1 Generalized Multi-Protocol Label Switching (GMPLS)

GMPLS provides the label switching ability to the Label Switched Routers (LSR). GMPLS packets are forwarded in a connection oriented manner through Label Switched Paths (LSP). Normally such LSP will be computed for the packets belonging to the particular class of service. At each node the packets will be

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assigned a label which determines its forwarding rule. Resource Reservation Protocol (RSVP) is a signaling protocol/mechanism which manages the forwarding table entries of the LSR.

4.2 MPLS-TE Metrics Based LSP Creation

The metrics of the IGP routing protocol can be advertised for the constraint based routing of MPLS traffic engineering (TE) tunnel [27]. Such tunnels can be found according to the required optimization metric (eg., bandwidth, propagation delay etc.,). The objective of TE, is to optimize the resource usage and enhance the performance of the resources, wherever possible. Finding the optimized TE tunnels through the constraint based path computation is the way of performing traffic engineering.

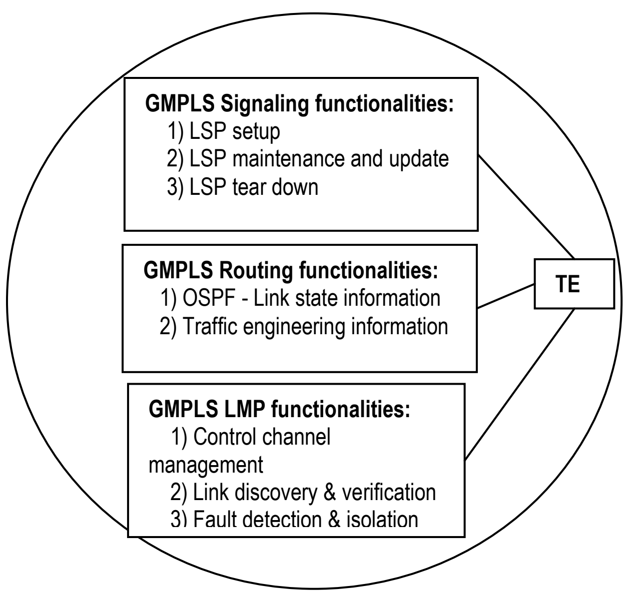

Figure :1 GMPLS Functional Blocks

The various functionalities of GMPLS protocol are given in the above figure (Ref.Fig.1).

The present implementation of the head-end label switched router (LSR) is also having such provision to mention about the metric to be followed during the constraint based routing. For every TE-LSP calculation either the metric of the IGP or the metric of the TE can be advertised for the knowledge of constraint based path computation algorithm. For the single autonomous system, IGP metric can be used whereas in the multiple autonomous system with end to end path computation TE metric can be used. Hence the use of TE metric was exploited in the proposed framework for the right selection of path computation algorithm.

The traffic engineering (TE) metric is a preferred minimum or maximum value of the link attributes to drive the path selection with required QoS guarantees. GMPLS TE-Metrices are namely: economic cost, bandwidth in Mp/s, delay in micro/milli seconds, required loss probability (BER), preferred hop count, administrative weight (combination of more than one optimization parameter) [28]. Hence according to the TE Metric the LSP can be computed on demand with specialized path computation algorithms which are available in the algorithm portfolio.

4.3 Path Computation Element (PCE)

The path computation element (IETF RFC 4655) is an entity which computes the paths given a physical topology and an evaluation criterion. The centralized PCE can control the entire autonomous system (AS). The path computation request message can contain the SD (source, destination) details of the path and optionally the metric to be optimized during path computation. The PCE can manage the GMPLS enabled optical circuit switched network. The GMPLS and PCE have known for its control/management ability and path computation ability respectively. The PCE will refer the network topology structure through the Traffic Engineering Database (TED). The TED will be maintained and referred by the GMPLS protocol in real time. Upon the arrival of path computation request the PCE will refer the TED and LSP database during the path computation.

4.4 Software Defined Network (SDN)

In SDN the control plane will be decoupled from all the network elements and managed by a centralized controller. The controller can collect the required details like physical topology, node or link information from the elements via the control plane protocols. The Openflow is a proprietary protocol for configuring the forwarding table of the nodes. And the controller can change the network configuration through GMPLS protocols, to realize the new network path (flow) explicitly by appropriately modifying the forwarding table entries along the path. Through the controller the network can be dynamically initialized, controlled, manipulated with the open interfaces.

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The controller can delegate the control actions or predefined rules (via OpenFlow) to the network elements. The SDN application layer consists of network applications and services like topology discovery, network provisioning and survivability. Such SDN applications can coexist on a same controller. This network programmability of SDN can be exploited to provision and manage many virtual optical networks simultaneously [29] and achieve scalability.

The interface which connects the SDN controller with the data plane is called South Bound Interface (SBI) ex: PCEP. The PCEP protocol as a SBI, offers communication between PCE and PCC. The PCE can centrally compute the paths based on the constraints that were arisen from the network elements. The interface which connects the SDN controller and the software entity running on the application layer is called North Bound Interface (NBI). (Ref.Fig.2).

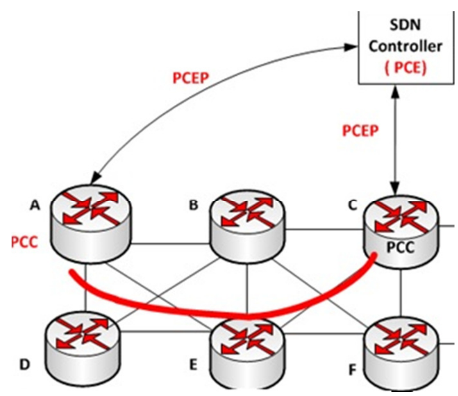

Figure :2 PCEP as a SBI interfacing PCE and PCC

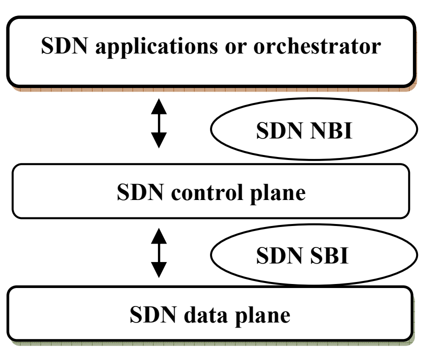

Figure :3 SDN Architecture

The application layer's network applications like topology discovery, provisioning and fault tolerance can be executed on the SDN controller with sophisticated algorithms. The REST (REpresentational State Transfer) is a North Bound API which allows multiple heterogeneous SDN applications to coexist on the same SDN controller [30][31].(Ref.Fig.3).

4.5 Hybrid GMPLS/PCE And SDN

The centralized PCE will have many similarities with SDN. And they both can create a better hybrid control [32] architecture. The software entity which implements the SDN controller is called Network Operating System (NOS) ex: ONOS (Open Network Operating System) [33]. For the creation of SOX controller ONOS can be used. The PCE is available as a SBI inside the ONOS (Ref.Fig.4 & 5).

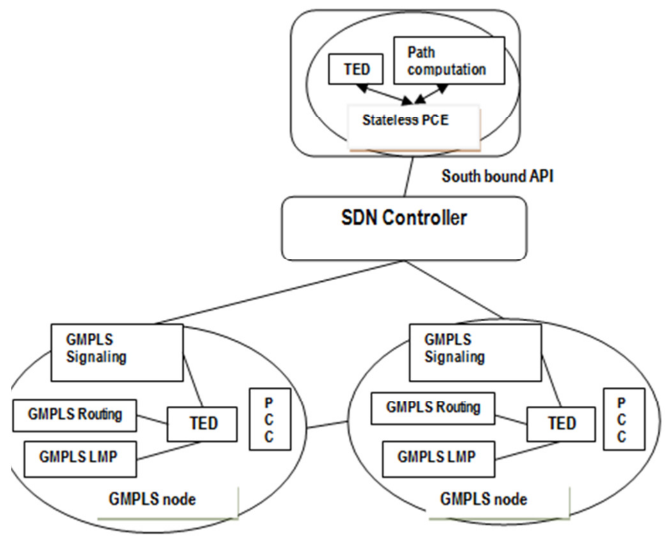

Figure: 4 Stateless PCE as an SDN application external to SDN controller

The SDN provides the higher level functionalities above the PCE and can control and orchestrate many cooperating PCE's. (Ref.Fig.4). The SDN controller can get advantage of PCE for its path computation abilities while the SDN controller manages the low level configuration of network elements to realize the path using the SBI protocol (ex: Openflow). The low level Openflow messages can be sent from the controller to update the forwarding table of the networking devices to realize the computed VN's. By sending messages the controller can add, update or delete entries in the forwarding table according to the requirements. In this way Openflow paths will be updated and maintained by the controller for

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every flow basis. In [34] they have given a qualitative comparison between GMPLS with the hybrid GMPLS/PCE and SDN to control the wavelength switched optical networks. While the GMPLS/PCE follows the centralized path computation with distributed path provisioning, the SDN provides the centralized path provisioning ability. From the above mentioned literature survey it become evident that the openflow was able to provide the higher wavelength utilization with low average path set up time.

5. PROPOSED FRAMEWORK

To achieve fine grained resource optimization, traffic engineering at per-class level is preferred rather than the aggregated management of all different service classes in the same manner. We have proposed a novel framework to compute QoS constrained optical paths which is otherwise called constrained Label Switched Paths (LSP's).

We have considered the following network scenarios: i) network with high amount of bandwidth scarcity ii) network with frequent significant amount of delay sensitive traffic iii) network where the proportion of the class of service for the traffic is not uniform iv) network with frequent elephant flows with guaranteed QoS requirements.

In practice the traffic can be grouped according to the service classes and transported over different LSP's. Such LSP trunks between the two nodes can potentially follow various routes which are optimized according to the quality of service requirements of the traffic. This work exploits the different QoS requirements and the traffic conditions to select between different path computation algorithms in an automatic manner. And this model could be a viable solution for the next generation optical network which essentially would require the cognitive/automatic ability of selecting between various alternative algorithms/procedures.

The algorithm selection model (explained in the next section) running inside the PCE under the control of the ONOS (Open Network Operating System) controller, will map the traffic demand with the appropriate path computation algorithm to find the optimal VNs (Virtual Networks) otherwise called LSP's (Ref.Fig.1). An ONOS based SDN Controller was considered with PCE as a south bound API to compute QoS driven (Ex: low latency, low BER etc.,) optimized LSP's.

We considered the centralized PCE executing different path computation algorithms for the control of single autonomous system. The packets will be segregated in-terms of its class of service category in the LSR. The LSR will send a PCC request to PCE along with the required TE parameters to be optimized. (Ref.Fig.5). Inside the PCE, the QoS metric will get mapped on to the appropriate path computation algorithm. For every path computation algorithm a new child PCE instance will be generated under the control of the parent PCE which orchestrates all the available co-operating child PCE's. For example, it may be preferred to minimize the economic cost of a path for one LSP while for another LSP the optimization criteria may be minimizing the end-to-end delay.

Hence executing the appropriate path computation algorithm according to the QoS specification of the LSP request will make the overall network control and management much simpler (Ref.Fig.3). With the plug and play ability of PCE, the effective set of path computation algorithm portfolio can be maintained with the PCE.

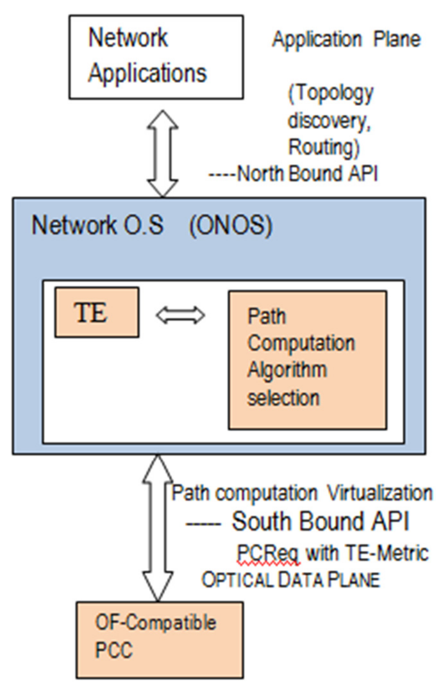

Figure :5 PCE & SDN based Optical Path computation by Algorithm Selection Model

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The following are the algorithmic steps involved in the proposed framework:

1. The head end LSR which is otherwise called path computation client (PCC) will send the *PCReq* message with source IP, destination IP, required bandwidth, setup/holding priority, request priority (1 to 7) and TE-Metric to the path computation element (PCE) server.
2. The parent PCE running inside the SDN controller will find the satisfactory path as a best effort manner.
3. The Algorithm Selection Model running inside the SDN controller will map the TE-Metric with the specific path computation algorithm. And a new child PCE instance will be generated to compute the optimized LSPs. According to the request priorities (ie., service classes 1 to 7) the LSP's will be responded in order to ensure the QoS.
4. IF the computed LSP path is optimal than the best effort path, the optimal LSP will be updated in the flow tables of the PCC along the path down to the destination with the ability of the Openflow protocol by modifying the flow table entries along the computed path.
5. ELSE the best effort path will not be reconfigured, and the best effort based service will be continued. The computed path will be kept as a backup path.

Hence the controller can derive the desired forwarding table for the particular type of traffic trunk by executing the appropriate path computation algorithm as the child PCE instances. In this way the different service classes of traffic could get mapped onto different LSP's according to their required level of TE-Metric values under the control of different co-operating child PCE's. The optimal solutions could be stored in knowledge base for the easy future reference and reuse with minimal reconfiguration. (Ref.Fig.6).

5.1 Model Used In The Proposed Framework

The proposed framework was inspired by the concept of ASP (Algorithm Selection Problem) which has been successfully applied to solve various NP hard problems in various other domains like graph coloring problem and other multi objective or combinatorial search problems.,

The ASP framework was proposed by Rice.The formal definition of the ASP is:

"For a given problem instance x∈P, with features f(x) ∈F, finding the selection mapping S(f(x)) into algorithm space A, such that the selected algorithm α ∈A maximizes the performance mapping y(α(x))∈Y".

The ASP relies on P,F,A,Y (problem space-P, feature space-F, algorithm space-A and performance measure space-Y). The PFAY of the RWA problem is described in the following section.

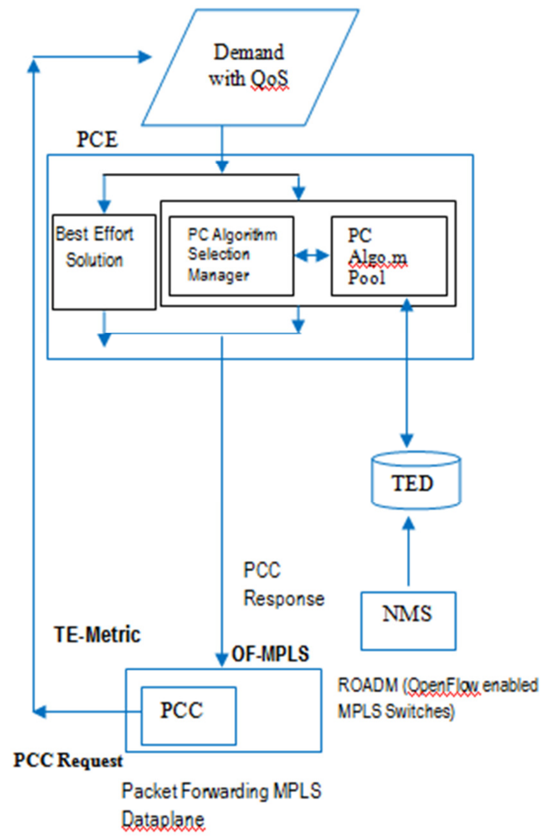

Figure :6 Flow diagram of the proposed solution

5.1.1 P F A Y of the proposed system

P - The problem space P refers the set of all instances of a problem class;

F - The feature space F refers the measurable characteristics of the instances generated by a computational feature extraction process applied to P;

A- The algorithm space A is the set of all path computation algorithms; (Ex: delay optimized path computation, Congestion optimized path computation etc.,)

Y- The performance space Y represents the mapping of each algorithm to a set of performance metrics;

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The following sections define the PFAY for the proposed system.

5.1.1.1 Problem space (P)

The PCC request instance and the TED instance will jointly constitute the problem space (P).

5.1.1.2 Feature space (F)

The various features characterizing the PCC request and the TED jointly, known as the feature space. We can otherwise call it as "task features".

i) The PCC Request will contain the information like source, destination and TE-Metric (required level of QoS ex: OSNR). MPLS-TE metrics are given in Section 4.3. We herein call each of this PCC request as a request instance.

ii) The TED (Traffic Engineering Database) will maintain the updated information about the physical topology, average traffic rate between node pair, maximum number of light paths that can be established on a node (number of transceivers per node), number of wavelengths available per physical link, light path bandwidth capacity. The TED information will serve the needs of various path computation algorithms which are available in the portfolio of PCE. And various values of this TED attributes will characterize the TED instance.

5.1.1.3 Algorithm space (A)

The algorithm space will contain a portfolio of path computation algorithms. They were divided into routing heuristics and wavelength assignment heuristics. In routing the node selection heuristics can be also be used (For ex: TSBS_FS-Traffic Sorted By Source and routed on the First Satisfactory path available, TSO-SP-Traffic Sorted Overall-routing on the shortest path). For wavelength assignment variety of heuristics with different strengths and weaknesses has been considered.

5.1.1.4 Performance space (Y)

The SDN controller can collect the following information from the underlying infrastructure.

- Topology information
- Flow statistics
- Neighbor relations
- Link status

From the above network statistics the performance metrics can be calculated. The following performance metrics of the RWA algorithms will constitute the performance space. i)Connections served until the first N blocking, ii) Connections blocked iii) Capacity transported until the first N blockings Capacity blocking rate iv) Setup time of the connection v) Number of re-routings encountered per connection. Hence based on the PFAY mapping, we had generalized the mapping function with different type of traffic demands in different network state. After the enough generalization the model was able to map the traffic demand with the appropriate algorithm. (Ref.Fig.7).

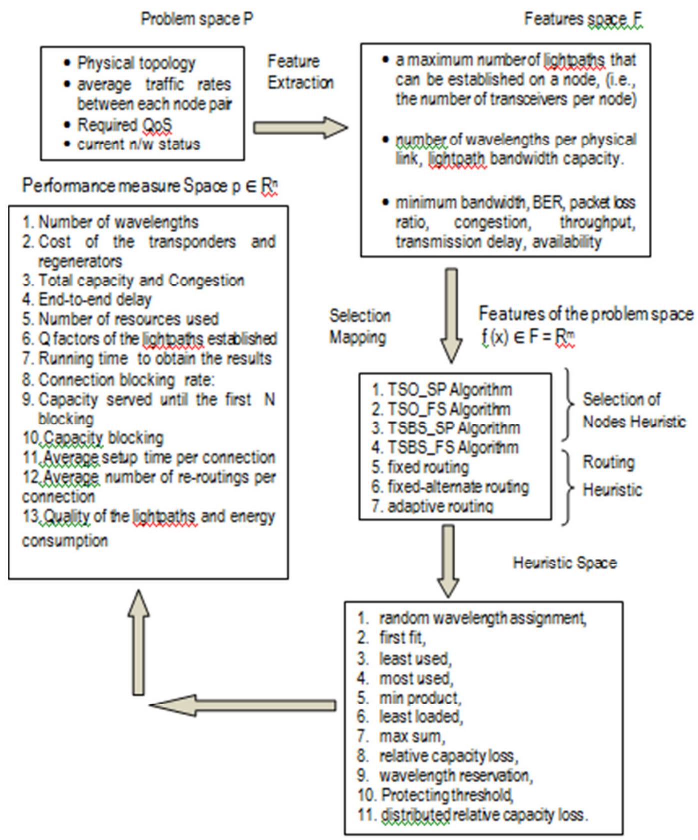

Figure :7 The Problem space, Feature space, Algorithm/Heuristic space, Performance measure space of the optical routing and wavelength assignment Algorithm Selection Framework.

6. SIMULATION ENVIRONMENT SETUP

Requirements : linux o.s (Ubuntu), ONOS Controller environment, mininet, wireshark packet analyzer.

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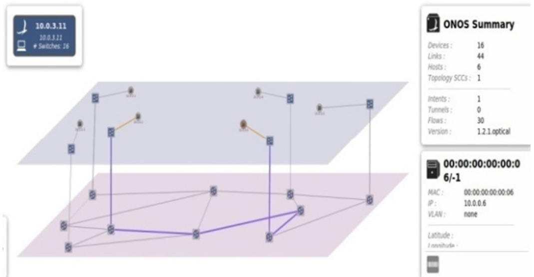

Figure :8 ONOS environment -Packet and IP layers

We have analyzed the proposed concepts through simulation to study the characteristics of switching between different algorithms/heuristics. In ONOS the data plane elements for optical layer and packet layer are emulated. (Ref.Fig.8). We have written the python scripts to implement various constrained path computation algorithms. In SDN context, the request will be a in the form of the JSON notation in which the constraints parameter will specify the desired range of bandwidth and other optimization parameter like latency etc., When no constraint is requested by the user, the system will default to offering a best effort end-to-end route using Dijkstra shortest path. Otherwise the system will map the LSP request with the appropriate path computation algorithm. We have simulated the simple 14 node Deutsche Telekom (DT), German national level reference network through mininet in ONOS. The characteristic parameters of this network are openly available. The packet nodes are emulated using OVS switches and the optical nodes are emulated using lincOEs through JSON.

We have created a GUI to specify various connection requirements. For the experiments, we have used 30 different traffic matrices, randomly generated according to a poission process model with the exponential distribution of the inter arrival time. The sample demand patterns are given in table.1. The lightpath channel capacity was kept as 30 Gb/s. The capacity could be groomed or treated individually according to the state of the network. The ONOS will pass the connection requirement object to the PCE API which will match the demands with the appropriate RWA algorithm to find the optical circuit.

From the experimental results it is evident that the proposed model can tradeoff the power of different algorithms in a mutually complimentary way and will enhance the network wide performance. We have written python scripts to simulate the behavior of switch and the controller. And we have programmed the controller to schedule the packets according to its Qos level (ie., the priority based connection provisioning). We connected the network with the controller. We start pinging the switches from the mininet. The wireshark analyzer was used to analyze the packets sent between the nodes.

Table.1. Examples of demands in DT Network

Arrival time	#Source	#Des.n	Capacity (in Gbps)	Duration (in min.s)
1.4	2	13	23	85
2.2	2	9	8	120
4.1	3	12	16	140

6.1. Use Case: Constrained Path Computation

We have considered the scenario of "constrained path computation" in our simulation as a proof of concept to the "PCE algorithm selection". Using ONOS-CLI the user defined java routines can be executed on top of the controller. The real time switch updates has been gathered in TED and LSP databases.

The PCC requests were generated with different QoS requirements such as cost, minimum bandwidth, energy, congestion and delay. These requirements were generated with the user defined python script.

The fields of the PCC request and response is given below:

- PCC Request contains the following fields: Flow ID, APP ID, Group ID, Table ID, Priority, Timeout Permanent, State, Packets, Bytes.
- PCC Response contains the following fields: RP, ERO,LSPA, BANDWIDTH, METRIC, IRO

Once the PCC generates the PCC-request with the particular constraint, the parent PCE (PFAY based Algorithm selection agent) will map the request with the appropriate algorithm with the requested performance. Since the PFAY mapping module continuously monitors the performance metrics of the algorithms which are currently running, the algorithm with the required performance can be selected easily.

The ONOS BGP and PCE modules were started to initiate the protocol related

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variables. The PFAY java based algorithm selection module was executed next.

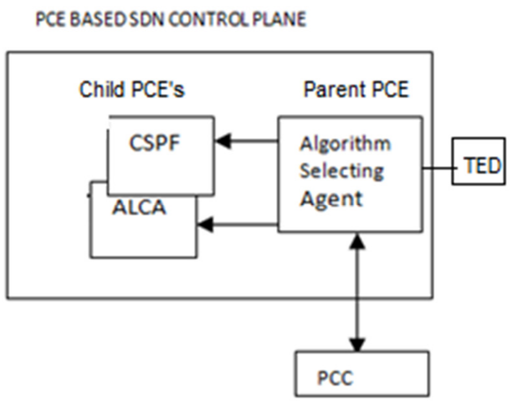

Fig.9 Selection of PCE replicas based on the PCC constraints

The flow table contains the following fields: Flow ID, APP ID, Group ID, Permanent, State,

Table ID, Packets, Bytes Priority, Timeout,

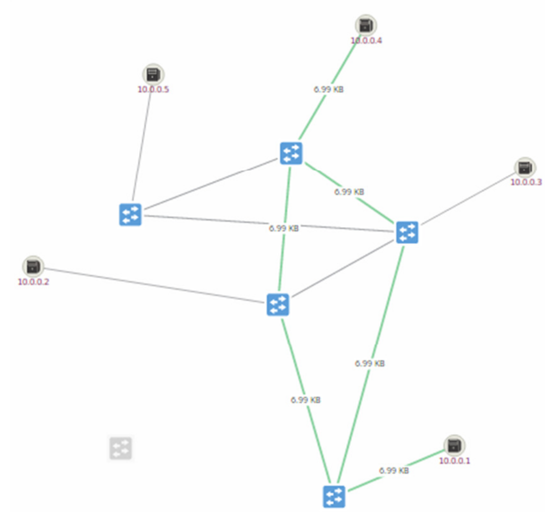

Fig.10 Six Node custom optical topology view in ONOS GUI

These above mentioned flow table data can be accessed using the ONOS flow related API's. Every LSP was monitored for its transmission ability and flow statistics were maintained.

7. EXPERIMENTAL RESULTS AND DISCUSSION

The simulation explained in the previous chapter was setup to measure the availability, performance and quality of the proposed network model. With that aim we made frequent requirements with delay, backup, blocking probability requirements. The status of the network under steady state traffic load was analyzed by accounting the percentage of the frames transmitted successfully. This packet loss rate measurement is an useful indication of how a network behaves under unexpected conditions. We had also created the mixture of traffic demands with delay sensitive and tolerant. Given the physical topology, traffic demands optimizing the network delay is governed by the set of constraints. We have considered the delay optimizing algorithm to compute the path with very minimal or acceptable delay. We have analyzed the latency (delay in ms) as the variability of latency is a serious problem in the real network. We had measured the transmission time as the time interval between the transmission of last frame in the input ports and the receiving of first frame in the output port. On an average the delay sensitive path computation algorithm was able to find the number of optimized paths in an acceptable time limit regardless of the traffic type. This added capability was enabled by the algorithm selection model, running inside the PCE by the selection of appropriate delay optimized algorithm for those demands which are sensitive to delay.

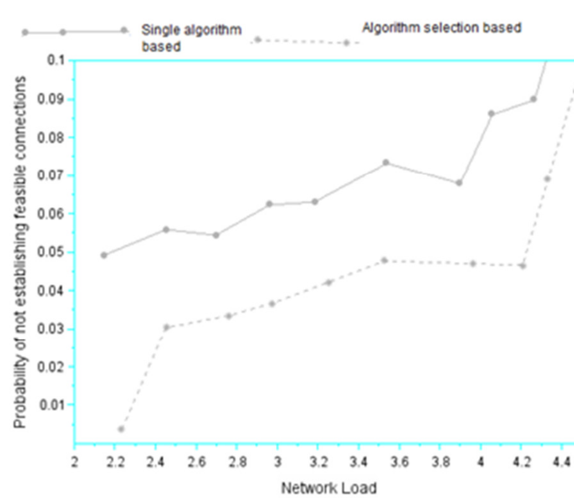

Figure :9 Network Load Vs Probability of not establishing feasible connections

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The availability is calculated in percentage of time that a network is operational. To study the availability, some paths had been removed intentionally to divert the flow in another direction through the backup paths. The measures of mean time between failures and the mean time to repair the failure were estimated according to the different traffic types. This mean time to failure recovery shows the robustness of the model in provisioning the backup paths. The survivability can be enabled by the appropriate selection of reactive or proactive path computation algorithms according to the type of service. From the experiments it is evident that the proposed algorithm selection model was better than the conventional approach of optical path computation in-terms of the less blocking probability (which is calculated as the probability of not establishing feasible connections. (Ref.Fig.9)) and less delay.

8. CONCLUSION

An algorithm selection model was proposed and claimed as a viable solution for the next generation software defined optical network. With the evolved improvements in the fields of SDN, PCE and GMPLS, every optical flow can be provisioned and managed individually. The PCE can able to execute different RWA algorithms as separate instances in parallel according to the QoT requirements of the demands. There are many heuristics based solutions available to compute the RWA. But each will have different capabilities in exploring the different portions of the search space of the problem. So choosing the appropriate heuristic/algorithm according to the type of the request, could correct the inefficiencies associated with the static choice of a single heuristic on an order large enough to live through significant variations of the upper layer demands. The algorithms will mutually complement the other with their search ability in identifying the optimal paths. We considered the case of guaranteed QoS requirements with delay, backup, blocking probability requirements to prove the efficacy of the model.

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