Towards a resilient and programmable optical network with dynamic lightpath as a service

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Abstract—**With the growing adoption of programmable networks, the protection and restoration schemes for optical networks needs to be thoroughly looked into so as to guarantee efficiency and resiliency for the new Software Defined Network (SDN) architectures. This paper presents a work in progress for the design of a software defined wavelength division multiplexing (WDM) optical network with dynamic lightpath as a service. The main aim of the study is to fully understand the effects of incorporating optimization algorithms within SDN-based switch to ensure a resilient data plane of the programmable network.**

***Keywords*— software defined network (SDN), Wavelength Division Multiplexing (WDM), lightpath, Restoration, Protection, OpenFlow (OF).**

I. INTRODUCTION

The ever increasing high demands for bandwidth services such as, video on demand services and high definition television, has seen the telecommunication service providers roll out fibre networks worldwide in order to meet and satisfy these demands. Fibre is opted for because of its large bandwidth, low error rates, and reliability [1]. Fibre is also less lucrative for criminals who prey on copper cables. There are many multiplexing technologies that can be coupled with an optical network, for example, OTDM (optical time division multiplexing), WDM (wavelength division multiplexing) to experience the huge bandwidth offered by fibres. However, WDM is the widely used because of its flexibility and cost effectiveness.

A lightpath is an optical communication path established between two nodes without any conversion of electronic to optical and vice versa on the intermediate nodes [3].In WDM network, dynamic lightpath refers to lightpath requests that are not known in advance and hence have to be accommodated by using available network resources. Lightpath connections are often used to carry critical and large customer data and as such, reliability and availability of the WDM optical network are the most critical elements required by network operators in order to serve the user demands and meet service level agreements that have to be fulfilled despite network failures. Design of networks that are able to survive network failures is of critical importance. Such networks are called survivable networks. In lightpath, survivable lightpath routing is the ability of a network to continue routing lightpaths during and after a network failure. Survivable lightpath routing in WDM networks have been studied extensively, for example in [4]-[5], and it comes with extra cost when deploying the WDM optical network.

The design of survivable networks requires protection and restoration mechanisms. These are recovery mechanisms employed by a network to try minimizing the total network downtime due to failures. Protection is a process performed in advance of a failure incident which is intended to protect the network against a possible interruption. Restoration is a process performed after a failure to recover affected traffic and restore service continuity.

Internet has been facing different technical difficulties such as rigidity to meet the ever changing requirements. Some of these difficulties as faced by the network operators include management of varying vendor equipment that forms part of the overall network. These equipments usually require different network management systems per each vendor. In order to resolve these challenges, various research initiatives such as clean slate internet program and others have been initiated [6]. A major achievement of this initiative is the software defined networking (SDN) which introduced the concept of programmable networks.

SDN provides a framework for decoupling the data plane from the control plane. As per the survey study conducted by Juniper Networks [7], the information technology decision makers foresee better opportunities with SDN in simplifying network operations and reducing cost of operations

This study aims to focus on the dynamic lightpath restoration on an SDN OpenFlow-based optical network.

II. AIM AND OBJECTIVES OF THE STUDY

The primary aim of this work is to study the SDN optical network using OpenFlow protocol for efficient network restoration after failure with dynamic lightpath provisioning and routing. Study of literature review and lab experiments will be used to identify, develop and evaluate a set of possible optimization algorithms that can be used to optimize the network after a failure. The following are some of the objectives to be addressed by this study:

- To investigate the impact to the SDN based control plane on finding optimal routing for dynamic lightpath after failure.
- To determine improvement for the restoration of dynamic lightpath provisioning and routing using

the SDN based network and optimization algorithm.

- To investigate the effectiveness of solutions offered by OpenFlow based SDN controllers by looking at the time it takes to find and provision optimal routes in case of failures (either in the control plane or the data forwarding plane).

III. Review of Related Work

Protection and restoration mechanisms play a vital role in providing reliability solutions for telecommunication operators and also in meeting the high quality of service demands even after network failures. The restoration mechanisms have to ensure efficiency and fair network capacity utilization after network failures. Protection and restoration schemes for optical networks have been studied extensively in the past. However, for the new SDN architectures, this is still an open research area [8]. Yang et al introduced a protection scheme applicable to OpenFlow based SDN network [9]. In their work, a multipath protection scheme is developed and applied on to an SDN-based elastic optical network. Their proposed method is developed by extending the OpenFlow protocol in order support the multipath in the elastic optical network. However, this study looks only on protection and not restoration.

IV. Methodology

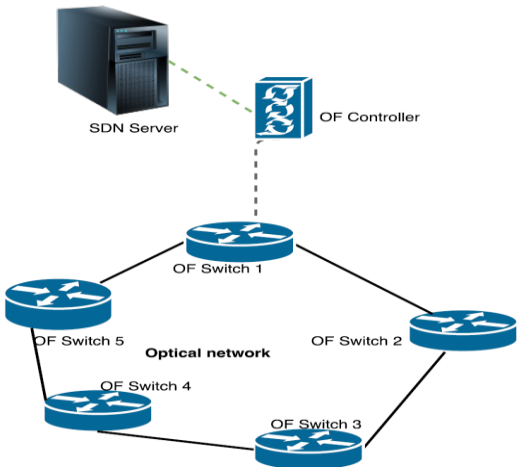

Figure 1: The planned lab setup for the study

As depicted in Figure 1, the study is planned to be conducted on a testbed made up of several OpenFlow (OF) edge core switches which are connected to a single centralised OpenFlow controller. The controller is connected to an SDN-based server. The switches are connected by a single mode fiber with a couple of WDM channels. Both the switches and the controller will support OpenFlow version 1.4.

The SDN based network will be used to gather facts on how the SDN-based network handles and recovers from network failures. This will be done by monitoring and generating different types of network failures, such as link failure, OpenFlow switch failure and the switch's group flow table failure. A critically informed list of testing parameters to improve the restoration process will be developed. The list must be flexible to allow adaptation of unforeseen effects or constraints. An optimization algorithm is planned to be incorporated into the OpenFlow network so as to improve the restoration process. In essence, the optimization algorithm will be used for lightpath optimal routing and to ensure that load is shared fairly amongst the available working resources after a failure. Limitations and strengths will be observed and recorded for further investigations. This will include identifying general findings and working upon them with the goal of making the problem clearer and improving the outcome of the solution.

V. Expected Outcomes

The results of this study will be mainly from experiments conducted on the lab testbed. We plan to experiment, document, publish processes, lessons learnt and challenges for designing an SDN-based optical network restoration process. The research work is expected to contribute to theory on restoration of SDN based optical network. We also expect to draw lessons from our design process, particularly the strengths and weaknesses of our methodology and study strategy.

VI. Summary

The preliminary literature review identified that there is a need for research on protection and restoration mechanisms for the new SDN architectures. This paper introduced the idea of designing a network failure tolerant SDN based optical network. It then discussed the methodology and the expected outcomes of designing such a network.

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