SURVIVABLE OPTICAL NETWORK TOPOLOGY

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To my beloved family, friends and loved ones for their support and sacrifices

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ABSTRACT

The demand for increased bandwidth is on the rise given the increased need for data consumption to meet the present and future requirements for information and communication technology (ICT) deployments. Thus, requiring high capacity optical links to support this expansion. Optical networks offer high-capacity fiber links for the ICT access networks, but comes with survivability concerns. The aim of this research is to assess the best approach for improving the survivability of an optical network via topology augmentation. Networks must provide reliable important services, and these networks continuously grow to cater for the ever-increasing number of clients. To improve the availability of optical networks, this project proposed to increase the network topology by adding a link(s) of appropriate length between nodes to eliminate the problem of "trap topology" so that the failure of any link with other links can be compensated. The Suurballe's algorithm was coded in MATLAB so that we obtained the best probability for the network by finding multiple separate paths. The most important advantages of the method used is its speed in calculating availability and its effectiveness in finding the alternate line between stations in the event of a sudden cut. An optical network consisting of stations and paths is designed for the purpose of invoking them in the MATLAB simulation program and and test their paths in case the network is exposed to the most difficult conditions. The method used to develop the network, as well as the Suurballe's algorithm, contributed to raising the survivability rate to three time than the first topology design and reduce the restoration time to a minimum a less as possible. It is believed that this method can be very useful in providing optical fiber networks. The continued survivability of optical fiber networks preserves customer data from loss and helps in increasing customer numbers continuously.

ABSTRAK

Tahap permintaan jalur lebar meningkat secara berterusan justeru itu memerlukan pautan optik berkapasiti tinggi. Rangkaian optik menyediakan pautan gentian berkapasiti tinggi untuk mengakses rangkaian teknologi komunikasi maklumat (ICT). Tujuan penyelidikan ini adalah untuk menilai pendekatan terbaik untuk meningkatkan kebolehan rangkaian optik melalui pembesaran topologi. Rangkaian-rangkaian mesti menyediakan perkhidmatan penting yang boleh dipercayai, dan rangkaian-rangkaian ini terus berkembang untuk memenuhi jumlah pelanggan yang semakin meningkat. Untuk meningkatkan ketersediaan rangkaian optik, projek ini mencadangkan untuk membesarkan topologi rangkaian dengan menambah pautan dengan kepanjangan yang sesuai di antara nod-nod untuk menghilangkan masalah "perangkap topologi" sehingga kegagalan pautan dengan pautan yang lain dapat dikompensasi . Algoritma Suurballe dikodkan menggunakan MATLAB untuk memperolehi kebarangkalian rangkaian yang terbaik dengan cara mencari beberapa jalur-jalur yang terpisah. Kelebihan kaedah yang digunakan ini adalah kepantasannya dalam mengira ketersediaan dan keberkesanannya dalam mencari garis ganti antara stesen-stesen sekiranya berlaku insiden pemotongan secara tiba-tiba. Rangkaian optik yang terdiri daripada stesen-stesen dan jalur-jalur direka supaya dapat digunakan dalam program simulasi MATLAB dan untuk menguji jalur-jalur tersebut sekiranya rangkaian terdedah kepada kondisi sukar. Kaedah yang digunakan untuk mengembangkan rangkaian, dan juga algoritma Suurballe, menyumbang untuk meningkatkan kadar bertahan hidup menjadi tiga kali daripada reka bentuk topologi pertama dan mengurangi waktu pemulihan ke seminimal mungkin. Kaedah ini diyakini bahawa sangat berguna dalam menyediakan rangkaian gentian optik. Kelangsungan berterusan rangkaian gentian optik dapat memelihara data pelanggan daripada kehilangan dan membantu meningkatkan jumlah pelanggan secara berterusan

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LIST OF ABBREVIATIONS

ADSL	- Asymmetric Digital Subscriber Line
APS	- Automatic protection switching
APON	- Association Paediatric Oncology Nurses
ATM	- Asynchronous Transfer Mode
BRI	- Basic Rate Interface
BT	- Bioassay Technology
CAP	- Carrier-less Amplitude Phase
CPE	- Customer Premises Equipment
DMT	- Discrete Multi-Tone
DSL	- Digital Subscriber Line
EPON	- Ethernet Passive Optical Network
FDM	- Frequency Division Multiplexing
FSAN	- Full-Service Access Network
FTTH	- Fibre to the home
GPON	- Gigabit Passive Optical Network
HDSL	- High-bit-rate digital subscriber line
HFC	- Hybrid fibre Copper
IPTV	- Internet Protocol Television
ISDN	- Integrated Services Digital Network
ISI	- Inter Symbol Interference
ONU	- Optical Network Unit
OTDR	- Optical Time Domain Reflect
PON	- Passive Optical Network
PRI	- Primary Rate Interface
P2P	- Point-to-Point
QAM	- Quadrature Amplitude Modulation
RS	- Reed-Solomon
SHDSL	- Single-Pair, High-Speed Digital Subscriber
Line SHR	- Self-Healing Ring
SONET	- Synchronous Optical Networking

VHSD - Very High-Speed Digital

WDM - Wavelength Division Multiplexing

LIST OF SYMBOLS

ISDN	-	Integrated Services Digital Network
Avi	-	Availability for the first path
ISDN	-	Integrated Services Digital Network
Avn	-	Availability for the second path
CC	-	Cable Cut
MTBF	-	Mean Time Between Failure
MTTR	-	Mean Time to Repair
L	-	Length
N		Number of links
R		Relation

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Optical networks are types of data communication network developed using optical fiber technology [1]. The central medium of communication are optical fiber cables. They are used for the conversion of data as well as passing it as light pulses between the sender and receiver nodes. Optical networks are also called fiber optic networks or optical fiber networks or photonic networks. They are one of the fastest communication networks as their transmission medium is light. They operate on the principle of electrical signal conversion to light pulses by utilizing optical transmitter devices. The signals are then transported by fiber optic cables to a receiving device.

These light pulses may be transported over a long distance in contrast to copper-based networks, and by the use of optical repeater devices, are regenerated to sustain the signal over the long path [2]. Once delivered to their destination nodes, the signals are transformed into electrical signal through optical receiver devices before being passed to the recipient node. Moreover, optical networks are highly secured from external inferences and attenuations. They have the advantage of offering substantial higher bandwidth speeds than copper networks.

Despite the advantages of optical network, disasters are the huge problem that may give big impact towards the performance of optical networks. For example, in areas close to the sea or rivers, floods often occur due to its high vulnerability to such disaster. Consequently, many kinds of infrastructure have been destroyed by the disasters [3]. As society heavily depends on optical network, for instance telecommunication companies deploy it to transmit cable television signals and telephone signals, much must be done to prevent network failures.

However, the nodes and links of optical networks are constantly threatened due to these disasters. As the traffic volume to be transported through the network infrastructure continues to grow, the survivability and availability of the network are increasingly becoming the most important focus of researches. Survivable optical networks are designed by putting into considerations all possible failures under which the networks must survive. Generally, the possible failures are classified as link failures and node failures. While link failures are caused by cutting of the fiber cables, node failures are caused by equipment breakdown at network nodes. In addition, channel failures are also possible in wavelength division multiplexing (WDM) optical networks besides the link and node failures which are generally known failures to all communication networks.

Channel failures are typically due to the breakdown of transmitting/receiving equipment operating on that channel. Most works on survivability in WDM optical networks mostly focus on recovery from a single link or node failure owned to two main factors. First, planning, for the breakdown of one piece of equipment at any given time, is easier and secondly, link failures in optical networks are characterized by cable cuttings. Natural phenomenon which are quite uncontrollable (e.g. floods, landslides, earthquakes etc.) as well as some human errors can cause equipment breakdown, and hence, node failures.

Although channel failure scenarios have only received little attention, it must be understood that even a single channel failure could lead to equal losses as a single fiber failure in a non-WDM system. To manage any of the expected resultant failure, shortest paths are always considered between communication

1.2 Choosing the Shortest Paths

The choice of shortest paths between nodes is crucial as it helps to ensure the network can recover should any breakdown occur at any point between any two nodes [4]. This is configured to redirect the network through a provisioned backup path. To achieve this, disjointed paths are chosen between the contracts except at termination points since it is not easy to find disjointed paths at this point. Therefore, the choice of such shortest paths is to aid the algorithm for ease of redirecting and generating more disjointed paths in the event of breakdown. In finding the shortest paths, a phenomenon known as trap topology may occur if not properly designed.

1.2.1 Trap Topologies

Some paths on the network may represent the phenomenon of trap topology. If this path is interrupted, this malfunction causes the network to be divided into two separate parts, after which no other communication path can be found between the two parts, causing the network to collapse rapidly. Figure 1.1 demonstrates a typical example of trap topology in a network.

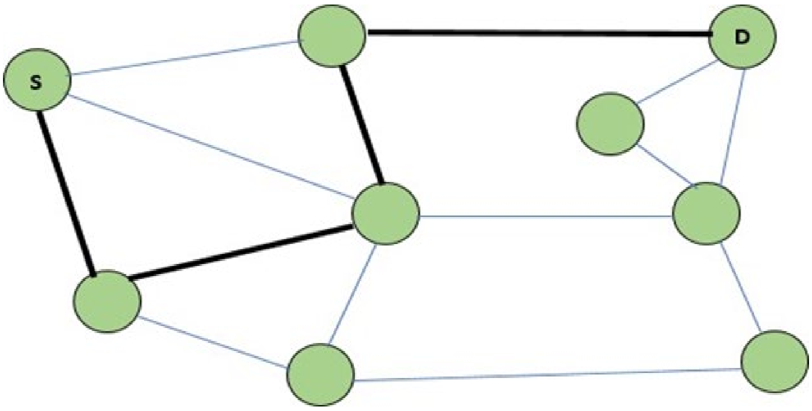

Figure 1.1 An example of trap topology in network

1.3 Problem Statement

Network developments provide important, reliable services, and continuous growth to cater for the ever-increasing number of clients. Bandwidth demand is continuously increasing and therefore, necessitates planning for more capacity of optical links. The aim of this research work is to assess the best approaches for improving the survivability of an optical network via topology augmentation. The network survivability can be improved by adding network links between appropriate network nodes such that the failure of any network link can be compensated using other network links.

1.4 Research Objectives

i. To compute the connection survivability between all network nodes pairs in each network topology using the new availability algorithm.

ii. To analyze the connection with the lowest survivability and propose the addition of network link(s) to improve the network survivability.

1.5 Scope of Work

The main scope of work in the project, network development by adding a link (s) between some nodes. In addition to implementing appropriate algorithms to find the ideal path that supports availability as well as finding K disjointed paths between all nodes on the network. To support availability with minimal connectivity. In addition to increasing the ability of the network to recover from failure with the lowest possibility. This project was built since implementing an algorithm to find the best path between all the nodes.

1.6 Thesis Organization

This thesis contains five chapters. In the first chapter the general background of the study, the problem statement, research objectives and scope of the study are elaborated on. In the study chapter, the literature review is listed. In the third Chapter, the research methodology is elaborated. The fourth chapter focuses on the results of the experiment and inspection, with a discussion performed at the end of the chapter. Finally, in the fifth chapter, the study is concluded and recommendations are given for future work, as well as a reflection of the work that has been thus far completed.

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