SURVIVABLE BICONNECTED TOPOLOGY FOR YEMEN'S OPTICAL NETWORK

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DEDICATION

I declare that this project report entitled, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

Optical fiber has transformed the telecom landscape in the world in the last three decades due to its overwhelming advantages over the other transmission mediums. Optical fibers offer low loss with high bandwidth and long lifespans. There are two challenges for providers of optical fiber technology, namely, the high cost of the optical network infrastructure and equipment and the importance of ensuring network reliability. These issues need to be considered during the deployment of the optical network infrastructure and when we need to expand the existing network. One of the requirements to provide reliability for network traffic is that a network must remain connected in the event of any single node or link failure. The network operators must be able to continue providing reliable important services through their existing network infrastructure and cater to the ever-increasing number of clients. Despite all the benefits of optical communication, many countries are still in the emerging phases in deploying optical communication networks due to the incurred cost. Hence, this study is conducted to assess the best approaches for deploying and expanding an optical fiber network that will lead to better network connectivity, thus help in ensuring the reliability of network services by designing a configuration that meets the desired requirements (e.g., biconnected network) while reducing the overall expenses (e.g., fiber deployment cost). The optimization will be conducted using the CPLEX software.

ABSTRAK

Serat optik telah mengubah landskap telekomunikasi di dunia dalam tiga dekad kebelakangan ini, kerana kelebihannya yang luar biasa berbanding media penghantaran yang lain. Gentian optik menawarkan kehilangan rendah dengan lebar jalur yang tinggi dan jangka hayat yang panjang. Terdapat dua cabaran bagi penyedia teknologi gentian optik, iaitu kos infrastruktur dan peralatan rangkaian optik yang tinggi, dan pentingnya memastikan kebolehpercayaan rangkaian. Masalah-masalah ini perlu dipertimbangkan semasa penyebaran infrastruktur rangkaian optik dan ketika kita perlu memperluas rangkaian yang ada. Salah satu syarat untuk memberikan kebolehpercayaan untuk lalu lintas rangkaian adalah bahawa rangkaian mesti tetap terhubung sekiranya terdapat kegagalan satu nod atau pautan. Pengendali rangkaian mesti dapat terus memberikan perkhidmatan penting yang boleh dipercayai melalui infrastruktur rangkaian yang ada dan memenuhi jumlah pelanggan yang semakin meningkat. Di sebalik semua manfaat komunikasi optik, banyak negara masih dalam fasa baru dalam mengembangkan jaringan komunikasi optik kerana biaya yang dikeluarkan. Oleh itu, kajian ini dilakukan untuk menilai pendekatan terbaik untuk menyebarkan dan mengembangkan rangkaian gentian optik yang akan membawa kepada penyambungan rangkaian yang lebih baik, sehingga membantu dalam memastikan kebolehpercayaan perkhidmatan rangkaian, dengan merancang konfigurasi yang memenuhi keperluan yang diinginkan (mis. rangkaian) sambil mengurangkan keseluruhan perbelanjaan (contohnya, kos penggunaan serat). Pengoptimuman akan dilakukan dengan menggunakan perisian CPLEX.

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LIST OF ABBREVIATIONS

WDM	-	Wavelength-division multiplexing
DWDM	-	Dense wavelength division multiplexing
CWDM	-	Coarse Wavelength Division Multiplexing
SMF	-	Single-mode fiber
MMF	-	Multimode fiber
POF	-	Plastic optical fiber
MASER	-	Microwave amplification by stimulated emission
ROW	-	Right of way
SONET	-	Synchronous Optical Network
ANSI	-	American National Standards Institute
ITU	-	International Telecommunication Union
LED.	-	light-emitting diode
OC	-	Optical Carrier
EDFA	-	Erbium-Doped Fiber Amplifier
AON	-	All-Optical Network
CLMV	-	Cambodia, Laos, Myanmar, and Vietnam
MENA	-	Middle East and North Africa
OPL	-	Optimization Programming Language

LIST OF SYMBOLS

N	-	Network
U	-	Source node
v	-	Target node
L	-	Length between nodes
δst	-	Total number of shortest paths
s	-	Is the source of shortest paths
T	-	Is the target of shortest paths
δst (v)	-	Number of those paths that pass-through v

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

Optical fibre technology is a kind of communication type that is used most often as a means to transmit the data (information) by light between the two nodes of the transmission along a glass or thin plastic strand (core) with add cladding to refract light and a protective layer(coating), that which called optical fibre cable.

So, the transmission is done in the Optical networks by the refraction of light pulses inside the optical fibre cables; thus, it transmits data at the speed of light. With Support larger bandwidth and provides high bit rate transmission. Unlike other transmissions, fibre optics is not electrical in nature. All these advantages allow fibre optics are used for long-distance and high-performance data networking.

There are some components to transmit the signal to the longest distance with maintaining high performance of communication such as repeater and amplifier as well as advances in optoelectronic components that allowed the design of systems that multiplexes several optical carrier signals onto one single optical fibre by using different wavelengths significantly increasing the capacity. Thus, WDM was born. Multiple high-bit-rate data streams[1] after that DWDM and CWDM introduced.

We observe the exponential growth in optical fibre communication networks over the past three decades because of its overwhelming advantages over the other transmission mediums. Today optical fibre technology has become an essential part of many other sectors of our economy's operating system. So, we can see it in sensitive places such as airports, health services (emergency services), power industry (nuclear power facility), banking industry (mobile financial services), etc., are interrupted[2].

For this reason, the requirements to provide reliability consider the priority for network traffic. This means a network must remain connected in the event of any single node or link failure.

The high cost of the optical network infrastructure and equipment still consider the main challenge for many countries. Different factors play in determining optical network cost. Usually, the planning of optical fiber networks leads to the design of a configuration that meets the specific (desire) requirements and optimize (minimize) the overall expenditure[3].

For network topology, since the optical network is expensive and is so complicated to calculate the cost for all parameters that are related to create a new network or expand exists network. Furthermore, the cost for deploy the same kilometers of fiber optic is different from one country to another, so providers have to investigate an optimal network design as can as possible for given node locations based on a traffic forecast. This is one of the main solutions to minimize cost and maximize robustness. These different communication networks can be configured in many topologies. These physical topologies determine the attributes of a network [3]. Network topology is the study of the arrangement or order of the components (links, nodes, etc.). There are some standard topologies, such as bus, ring, and star[4]. On the other hand, we can design different kinds of topologies, for example, 2-connected or biconnected topology. This is not a standard topology. In this topology, each node is connected with at least two other nodes to ensure the connection, and one failure does not affect the robustness of the network. This is used to optimize the cost by selecting the shortest two paths surrounding each node.

1.2 Problem Statement

The complexity of laying up fibers is considered the main challenge of an optical network that includes the price and rules constraints to deploying. For this reason, there are many countries still in the emerging phases in deploying optical communication networks despite all the benefits of optical communication. In other countries, optical networks continuously grow to meet demand. Hence arises the need for agile methods that assess best approaches (optimization) for deploying and expanding an optical fiber network, which leads to improved network capacity to reach the increasing number of clients without losing or reducing reliability problem statement.

1.3 Research Objectives

The objectives of the project are:

1. To optimize the deployment of a biconnected optical network in terms of fiber deployment cost and betweenness centrality.
2. To propose a suitable biconnected network with minimum extra links that connects the governorates of Yemen.

1.4 Scope of Work

This study is conducted to optimize the optical network by reducing deployment costs especially underground cables, and ensuring the reliability of network services. In this study, Yemen is chosen to achieve the aim of the study, all the centers of cities of the Republic of Yemen were connected in one biconnected network. The advantage of this research is to compare the network connected by mesh topology and connected by biconnected topology that will simulate it into IBM ILOG CPLEX.

1.5 Significance of the Study

The importance of this study through gives some solutions for the providers of an optical network to reduce the cost of the network, which usually they suffer from challenges of this network especially in the developing country and when bounded by limitation of geographical condition. So, hopefully, this study creates competition in those countries and gets some solutions for the limitation of geographical conditions.

1.6 The Project Contribution

The proposed method of this project that is based on betweenness centrality is one of the methods that are easy to use in practice instead of ILP Integer Linear Programming, which is sometimes considered complex and consumes a long time.

1.7 Organization of the Study

This thesis consists of five chapters beginning with an introduction to the overall review of this research background and study undertook. This chapter includes a problem statement, research objectives to fulfill the problem, the scope of the study, and the significance of the study to give the advantage of this work in our real life. Following the introductory chapter, chapter 2 gives some literature review with related works (optimization, robustness, and optical networking situation in Yemen). In the third chapter, the research methodology is elaborated that used to develop the optimization and robustness of the scheme followed to meet our objectives. Chapter 4 discuss the result and observations after performing testing and simulation activities. In chapter 5 the summarize is given the outcomes and a highlight of the main contributions.

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