# OPTIMIZING TELECOMMUNICATION NETWORK LENGTH USING GENETIC ALGORITHM

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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JUDUL : OPTIMIZING TELECOMMUNICATION NETWORK LENGTH USING GENETIC ALGORITHM

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# OPTIMIZING TELECOMMUNICATION NETWORK LENGTH USING GENETIC ALGORITHM

MOHD BRUCE LEE BIN MUSTAPA



This report is submitted in partial fulfillment of the requirements for the Bachelor of Computer Science (Artificial Intelligence) with Honours.

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

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SUPERVISOR : _____ Date : 19 Sept 2023
(DR. NORHAZWANI MD YUNOS)

# DEDICATION

I would like to dedicate this Final Year Project to all those who had supported me in completing this project, especially to my supervisor, Dr. Norhazwani Md Yunos, who had guided me along this project.

# ACKNOWLEDGEMENT

Firstly, I would like to express my highest appreciation to my supervisor, Dr. Norhazwani Md Yunos for her willingness guided me along the process to complete this project. She had provided lots of advice and suggestions to help in improve my project, without her guidance this project would not be able to be completed. Besides that, I would also like to thank to my family for supporting me spiritually throughout this project. Last but not least, I would like to thank to my friends and special person in my life also who had given me some inspiration and spiritual support for this project.

# ABSTRACT

The length of a telecommunication network significantly impacts project costs, as longer network cables increase expenses and subsequently affect user service fees. To address this issue, the project aimed to find the optimal network length by formulating it into Minimum Spanning Tree problem. The problem is solved using Genetic Algorithm where it incorporates steps like mutation, crossover, and good selection to influence the final result. The output from the algorithm provide most minimum spanning tree as a shortest path to connect all the DP. This project effectively assist related organisation in planning telecommunication network made the project more efficient and save more cost.

# ABSTRAK

Panjang rangkaian telekomunikasi mempengaruhi kos projek secara signifikan, kerana kabel rangkaian yang lebih panjang meningkatkan perbelanjaan dan seterusnya mempengaruhi yuran perkhidmatan pengguna. Untuk mengatasi masalah ini, projek ini bertujuan untuk mencari panjang rangkaian yang optimum dengan merumuskannya sebagai masalah "Minimum Spanning Tree". Masalah ini diselesaikan dengan menggunakan Algoritma Genetik yang menggabungkan langkah-langkah seperti mutasi, persilangan, dan pemilihan yang baik untuk mempengaruhi hasil akhir. Hasil daripada algoritma ini menyediakan "Minimum Spanning Tree" yang paling singkat sebagai laluan terpendek untuk menghubungkan semua DP. Projek ini secara berkesan membantu organisasi berkaitan dalam merancang rangkaian telekomunikasi, menjadikan projek ini lebih efisien dan menjimatkan lebih banyak kos.

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| FYP | - | Final Year Project |
| PSM | - | Projek Sarjana Muda |
| DP | - | Distribution Point |
| GA | - | Genetic Algorithm |

# CHAPTER 1: INTRODUCTION

## 1.1 Introduction

The field of communication networks is rapidly evolving, and it is essential to optimize the network's cost and efficiency to meet the increasing demands of modern communication. One of the critical factors affecting the performance of communication networks is the network topology. Network topology determines the routing paths of network cable and can significantly affect the network's overall cost and efficiency. Minimum spanning tree (MST) is a widely used as a model for optimizing the network topology in communication networks, see Figure 1.1.

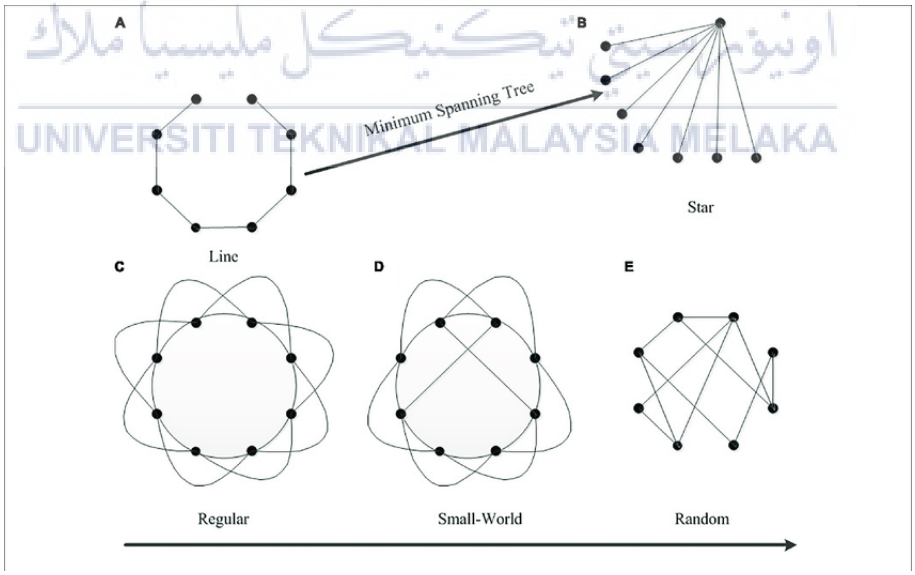


Figure 1.1: MST in Network Topology

MST problem is a problem to finds the minimum cost tree connecting all nodes in the network, which can significantly reduce the overall cost of the network specifically the total cable path. It is a popular formulation used in network

design, including in applications such as computer networks, wireless sensor networks, and telecommunications networks. In this project, we aim to analyse and design communication networks cable path planning using the MST model to minimize the network's cost in term of uses of the network cable to connect all the distribution point (DP) and maximize its efficiency by reducing the complexity of the network cable path. During this project, we target to notify which path require the most optimal cost in other word need as minimum as possible cable to connect all the distribution point (DP) and directly the cost of the cabling process will become lower and most effective

## 1.2 Problem Statement

Optimizing communication network cost and efficiency requires efficient network topology. A terrible planning of network topology will lead to a big cost in term of amount of material used, man-power, and time required to complete the project. Bad planning also will lead to more complexity networking and will cause to more error. This project aims to design a communication network using the MST model to connect all distribution points (DPs) with minimal cable usage, reducing costs and maximizing effectiveness. See Figure 1.2.



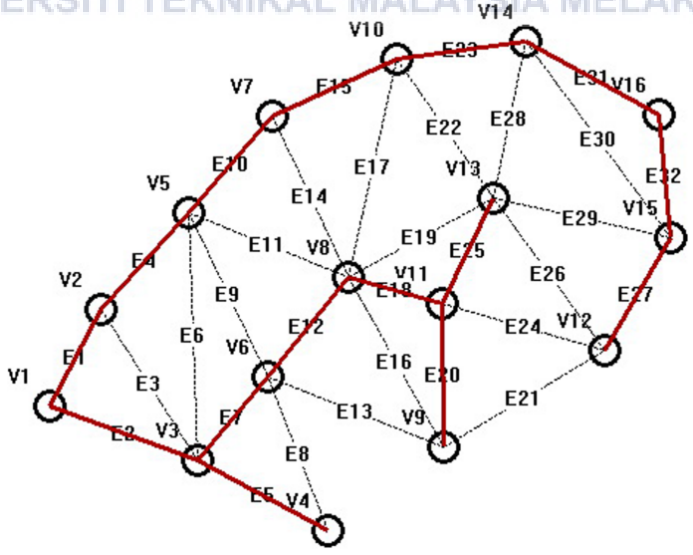


Figure 1.2: Complex network topology

## 1.3 Objective of the Study

This project embarks on the following objectives:

1. To formulate the telecommunication network length problem into Minimum Spanning Tree.
2. To design a Genetic Algorithm to solve the problem.
3. To propose an optimal telecommunication network length.

## 1.4 Scope of the Study

The scope of the study is limited with a distance graph that can apply for minimum spanning tree graph. the map of the area we want to apply this system must be converted to a distance graph that connecting all the DP.

The study also limited to optimizing the length of the cable path connecting all the existed DP. and not related to optimizing the amount of the DP need for that particular area. the study also not related with the quality of the cable and quantity capability of the DP.



## 1.5 Significance of the Study

This study focuses on optimizing telecommunication network length using a genetic algorithm. By applying a genetic algorithm, the research aims to find the most efficient network configuration that minimizes the total length of network cables. This optimization has significant practical implications, as it can lead to cost savings by reducing the amount of cable required for network infrastructure. Additionally, a more streamlined network with minimized cable length can enhance network performance and reliability. By utilizing a genetic algorithm approach, this study offers a novel and effective solution to address the challenges of network optimization in the telecommunication industry.

## 1.6 Expected Output

The expected output of this project is an optimized telecommunication network length achieved through the utilization of a Genetic Algorithm. The algorithm will be employed to efficiently determine the best network configuration, minimizing cable length while connecting all necessary distribution points (DPs). By leveraging this approach, the project aims to reduce costs associated with cable installation and maximize the overall efficiency of the telecommunication network.

## 1.7 Conclusion

In conclusion, this project focuses on optimizing the length of telecommunication networks using a genetic algorithm approach. By leveraging genetic algorithms, the proposed system aims to minimize network length while considering various constraints and factors that affect network efficiency and cost. The outcome of this project has the potential to significantly enhance the effectiveness and efficiency of telecommunication networks, paving the way for more advanced and optimized network infrastructure in the future.

# CHAPTER 2: LITERATURE REVIEW AND PROJECT METHODOLOGY

## 2.1 Introduction

Optimizing telecommunication network length is essential for ensuring efficient and cost-effective communication systems. This study focuses on utilizing a genetic algorithm to minimize network cable length, considering factors such as coverage area, cable overlap, and distance between network points. By reducing cable length, we aim to enhance network efficiency and achieve cost savings. As in Figure 4.13.

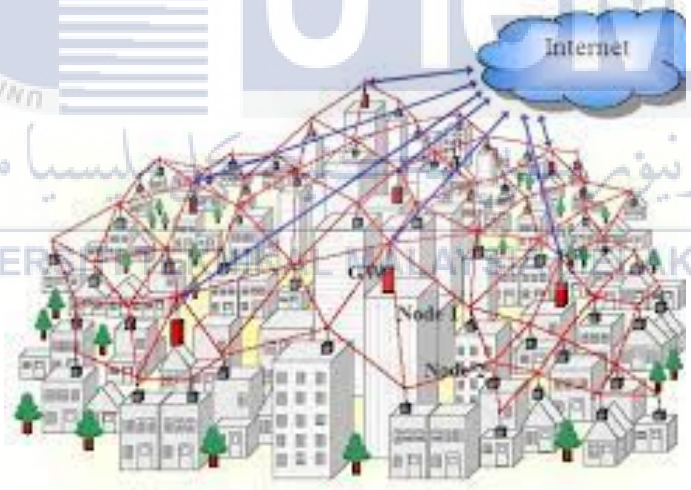


Figure 2.1: Diagram of real world network

## 2.2 Facts and findings

### 2.2.1 Domain

The domain related to this project is the field of telecommunication networks and optimization techniques. The project aims to optimize the length of communication network cables by utilizing a genetic algorithm. Various factors such as network topology, cost, and efficiency will be considered in the optimization process. This domain involves the application of advanced mathematical algorithms and optimization techniques to achieve the most efficient and cost-effective communication network possible. The project also draws upon principles from network design and telecommunications engineering to analyze and improve the overall performance of the communication network.

### 2.2.2 Existing System

In this field, to optimize network cabling length, researchers employ various techniques including shortest path algorithms, spanning tree protocols, genetic algorithms, heuristic methods, simulation and modeling, and constraint programming. Shortest path algorithms help find the most efficient path between devices, while spanning tree protocols eliminate redundant links. Genetic algorithms and heuristic methods provide iterative optimization, and simulation and modeling allow for evaluating different scenarios. Constraint programming helps define and satisfy constraints. By combining these techniques, engineers can effectively optimize cable lengths based on network complexity and requirements.

CableLengthOptimizer is a system designed to optimize network cable length planning, catering to network engineers and IT professionals. Its key features include network topology analysis, cable length calculation, constraints and customization, visual representation, cost estimation, and reporting/documentation. By leveraging these features, users can streamline the cable planning process, minimize cable waste, enhance network performance, and potentially reduce costs associated with cable

installations. Overall, CableLengthOptimizer provides a comprehensive solution to efficiently plan and optimize network cable lengths for a given infrastructure.

CablePro is a comprehensive network cabling management system that streamlines the cabling planning process by offering features such as network diagramming, cable routing planning, and cable length optimization. It assists in reducing cable waste and optimizing network performance by providing cost estimation, efficient cable management tools, and visualization of cabling layouts. CablePro also generates reports and documentation, aiding in project documentation and tracking. However, it may require initial setup and configuration, as well as a learning curve to effectively utilize all features. Regular updates and maintenance are necessary, and specialized cabling requirements may not be fully accounted for.

### 2.2.3 Technique

The are several research about the technique that used in order to optimize the network topology.



Vasko, Lu, and McNally (2022) presents a methodology for efficiently generating optimal spanning trees for the cable-trench problem in network design. Their algorithm considers cable length, cost, and trench routing, providing a valuable contribution to improving network efficiency. The authors propose an algorithm that considers different factors such as cable length, cost, and trench routing to determine the optimal spanning trees. They emphasize the efficiency of their methodology, suggesting that it outperforms existing approaches in terms of computational time and resource utilization.

Abas, Salleh, and Abd Rahim (2019) conducts a comparative study of minimum spanning tree algorithms for network optimization. Published in the Journal of Telecommunication, Electronic, and Computer Engineering (JTEC), the study evaluates different algorithms to determine their effectiveness in optimizing network performance. The authors provide valuable insights into the selection and

application of minimum spanning tree algorithms for network optimization purposes.

Al-Khateeb and Al-Sharaa (2019) investigates the concept of network optimization using the Minimum Spanning Tree (MST) approach. Published in the International Journal of Computer Science and Mobile Computing, the study delves into the practical application of MST to enhance network performance. Through their analysis, Al-Khateeb and Al-Sharaa provide insights into the benefits and challenges associated with implementing MST for network optimization. They present experimental results and performance evaluations to demonstrate the effectiveness of the MST approach in enhancing network efficiency.

Ahmadian and Shekarian (2013) presents a parallel genetic algorithm to address the minimum spanning tree problem. The study focuses on improving the efficiency and effectiveness of finding optimal minimum spanning trees using a parallel computing approach. The authors propose a genetic algorithm that incorporates parallel processing techniques to accelerate the optimization process. The research demonstrates the effectiveness of the parallel genetic algorithm in efficiently solving the minimum spanning tree problem.



In other field that similar with the project, "An Improved Genetic Algorithm for Pipe Network Optimization" by Dandy, Simpson, and Murphy (1996) focuses on optimizing pipe networks using a genetic algorithm. The study aims to improve the efficiency and accuracy of optimizing water distribution systems. The authors propose a genetic algorithm that incorporates new techniques to enhance the optimization process. The research demonstrates the effectiveness of the algorithm in achieving better solutions for pipe network optimization.

The referenced studies provide a sound approach to optimizing the placement of telecommunication devices. They utilize mathematical models and algorithms to consider multiple factors and constraints, resulting in cost-effective and efficient placement solutions.

## 2.3 Project Methodology

The chosen methodology for this project is the iterative waterfall model, which follows a sequential software development process that divides the development into predefined phases. Each phase must be completed before progressing to the next one, ensuring a systematic and organized approach. This model is particularly suitable for the project as it ensures that each process is thoroughly finished before moving on to the next, thereby maintaining control and accountability. Additionally, the iterative waterfall model facilitates feedback paths from later phases to earlier ones, allowing for adjustments and improvements based on previous stages. As in Figure 2.2.

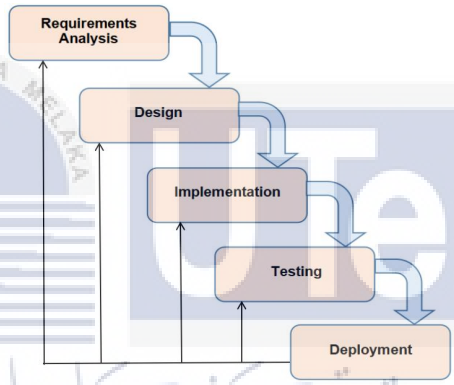


Figure 2.2: Diagram of iterative Waterfall model



### 2.3.1 Requirement Analysis Phase

The initial phase of the project involves conducting an analysis of the required specifications and researching relevant existing systems. This crucial step includes identifying the software and hardware requirements necessary for application development, as well as determining the specific functions that the system should encompass. Additionally, a thorough review of related existing systems is conducted to gather insights and ideas for the forthcoming development phase of the project.

### 2.3.2 Design Phase

During the design phase, the requirements identified in the requirement analysis phase serve as guidelines for developing the system. This involves designing the necessary functions and features of the system based on the identified project requirements, including determining the input and output specifications and defining the functionality of each system component.

### 2.3.3 Implementation Phase

During the implementation phase, the system will be constructed according to the design blueprints created in the previous design phase. This involves generating the lines of code required to build the application, with C++ being the primary programming language utilized for development.

### 2.3.4 Testing Phase

During the implementation phase, the system undergoes testing to ensure its proper functionality and adherence to the project's requirements. Each module within the system is thoroughly tested to verify that all functions are working correctly and that the system meets the specified project requirements.



### 2.3.5 Deployment Phase

During the deployment phase, the system undergoes its final stage of implementation after successfully validating all its functionalities in the testing phase.