CHAPTER I
INTRODUCTION

1.1 Background

The port is a facility where ships can load and unload cargo, passengers, and other goods. Port is essential for maritime transportation, facilitating the movement of goods and people between different domestic and international locations. With its extensive coastline and archipelago, Indonesia has numerous ports that serve as vital hubs for trade and transportation throughout the country. Every year, logistics flows are increasing, and the port is predicted to become one of the world's largest loading and unloading industry centers. Industrial competition in ports is increasing, and ports worldwide are transforming towards smart ports.

Ports in Indonesia managed by PT Pelabuhan Indonesia (Pelindo) are container terminals with the 23rd most dense traffic in the world. Container traffic at Tanjung Priok Port from 2019-2022 shown in Figure. 1.1. PT Pelabuhan Indonesia (Pelindo) has started implementing a smart port at Tanjung Priok Port which will later become a Benchmark for smart port development in Indonesia. Figure. 1.2 shows the density of container traffic at Tanjung Priok Port. Smart port development aims to improve connectivity in the port area and support the implementation smart transportation systems. Tanjung Priok has now transformed into a digital

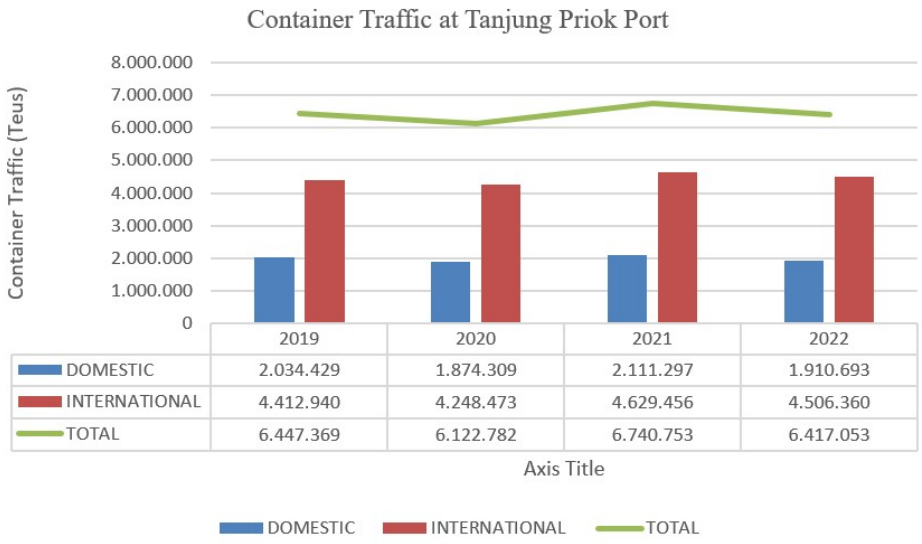

Fig 1.1 Container Traffic at Tanjung Priok Port From 2019-2022.

Fig 1.2 Tanjung Priok Port.

port and has implemented several automated systems to become a Smart Port. Several automated systems for Smart Ports, such as Buffer Area System, Car Terminal Operating System, Reception Facility, Non Container Terminal Operating System (NPKTOS), Terminal Operating System (TOS), Auto Tally, and Container Freight Station (CFS). The implementation of Smart Port to improve the quality of Tanjung Priok port services is stated in ”Keputusan Kepala Kantor Otoritas Pelabuhan Utama Tanjung Priok No: HK.206.2/11/OP.TPK-2021 Tentang Rencana Strategis Kantor Otoritas Pelabuhan Utama Tanjung Priok Tahun 2020-2024.”

Digital transformation at ports aims to increase automation and digitization, the key to the Industrial Revolution 4.0. The Industrial Revolution 4.0 enables widespread connectivity at the industrial level. By embracing Industry 4.0 technologies, smart ports can revolutionize traditional port operations, enhance competitiveness, and provide more efficient and sustainable solutions for the global supply chain. The integration of advanced technologies in the maritime industry is expected to continue transforming how ports operate and contribute to international trade and commerce growth. With widespread connectivity, existing machines, sensors, and systems will be even more efficient. The Wi-Fi network that is currently used is no longer compatible to facilitate this automation and digitization. Wi-Fi cannot accommodate many users because its anti-interference and coverage capabilities are insufficient to meet smart port requirements. System-level compromises in the overall system design are required for transmission via waveguides, leaky cables, and optical fibers. For instance, the safety distance must be shortened, and the device’s moving speed must be decreased. So it is time for the 5G private network

to be implemented for the industrial class.

Implementing a 5G private network in a smart port can offer numerous benefits, enhancing the efficiency, safety, and overall performance of the port's operations. 5G technology brings high-speed connectivity, low latency, and increased capacity, making it suitable for various smart port applications. By integrating a 5G private network into a smart port infrastructure, port operators can unlock the full potential of various Industry 4.0 technologies, leading to a more connected, efficient, and sustainable port ecosystem. A 5G private network can be described as a Local Area Network (LAN) network that uses 5G NR technology for dedicated connectivity in certain areas. 5G private network can be used for various industrial applications. Private network are also called Non-Public Networks (NPNs) in 3GPP. Some of the advantages of a 5G private network are dedicated coverage, exclusive capacity, intrinsic control, customized service, and dependable communication. 5G private network can be used for various industrial domains such as industrial automation, warehouse operations, utility networks, industrial remote operations, mining operations, to railway networks [9].

Several studies discussing the 5G private network as a technology candidate that can replace Wi-Fi in the port industrial area have been described in [10] and [11]. Several telecommunications companies have also issued prototypes for implementing smart port and 5G private network, such as Huawei on [1] and Nokia on [12]. The 5G NR network planning for industrial areas using different frequency bands and in different industrial areas has been described in [13] and [14]. Studies on techno-economy have been explained in [15], [16] and [17].

Based on previous research, this thesis will design and simulate a 5G private network based on coverage and capacity and then analyze the feasibility from an economic and regulation perspective for using a 5G private network in the port industrial area. The results of this thesis are expected to provide recommendations for telecommunication operators who will deploy a 5G private network in the port industrial area.

1.2 Problem Identification

This research focuses on research and analysis related to the implementation of 5G Private Network in Indonesia. Identification of the problem in this research is:

1. The existence of a smart port requires a communication system that supports low latency, high bandwidth and high reliability. Several studies show that 5G private networks have the potential to be implemented in industrial areas.

So further research is needed to implement smart ports in Indonesia.

2. There is a need to analyze technical research related to the implementation of 5G private networks to determine the optimal gNodeB in the port industrial area.

3. There is a need to analyze economics and sensitivity studies regarding the implementation of 5G private networks in port industrial areas to determine the feasibility of this technology.

4. There is a need to analyze existing regulations in Indonesia related to the implementation of 5G private networks.

1.3 Objective

This thesis aims to test the feasibility of a 5G private network in the port industrial area. The analysis divides into three parts, namely technical analysis, economic analysis, and regulation analysis. Technical analysis is divided into coverage and capacity analysis and then simulated using Forsk Atoll. Business feasibility and sensitivity analysis are calculated for economic analysis, which is expected to produce a recommendation for telecommunications operators that will deploy a 5G private network in the port industrial area. On the other hand, regulatory analysis is also provided in this thesis.

1.4 Scope of Work

To make the discussion more oriented, the limitations of the problem in this study are as follows:

1. The port used as the object of research is the Port of Tanjung Priok, North Jakarta.

2. This thesis uses a millimeter wave frequency at 26 GHz and bandwidth at 100 MHz.

3. This thesis uses the Outdoor to Outdoor (O2O) for uplink and downlink, Line of Sight (LOS) scenario, and Urban Micro Cell (UMI) propagation model.

4. For 5G network planning, this thesis uses coverage and capacity planning.

5. This thesis designs and analyzes network planning for IoT devices only.

6. The simulation was carried out using the Atoll network simulator considering the results of SS-RSRP and SS-SINR.

7. The forecasting is done with five years from 2023 to 2027.

8. For economic analysis, this thesis uses a business feasibility and sensitivity analysis with testing parameters of revenue, OPEX, CAPEX, NPV, IRR, PBP, and PI.

9. This thesis used two scenarios. First, The 5G Private Network is self-organized by the Port, and second, the 5G Private Network network is organized by Cellular Operators and rented by the port.

1.5 Research Methodology

This thesis is divided into three Work Packages (WPs) to produce results and recommendations in techno-economic studies for telecommunications operators.

1. WP1: Determine planning area, parameters, and collecting data
   In this WP, this thesis selects the port to be studied and selects parameters such as frequency, propagation model, research scenario, etc. This WP also collects data that will be used in the next WP.

2. WP2: 5G NR technical planning for determining the number of sites
   In this WP, this thesis calculates the number of sites by considering capacity and coverage area. The final number of sites is obtained by selecting and comparing the number of sites from coverage and capacity planning. After that, a simulation was carried out using the Atoll network simulator.

3. WP3: Result validation and recommendation use economic analysis
   In this WP, this thesis uses a CAPEX OPEX analysis, feasibility analysis, and sensitivity analysis model to test the feasibility of implementing a 5G private network from an investment perspective. Revenue, CAPEX, OPEX, NPV, IRR, PBP, and PI are the parameters used.

4. WP4: Regulatory analysis for the implementation of 5G private network
   In this WP, this thesis analyzes the regulation study of 5G private networks in Indonesia.

1.6 Hypothesis

Based on research at [9], the 5G private network has significant potential compared to several other technology to be applied in industrial areas during the Industrial Revolution 4.0 era. For the port industry, this is reinforced by the white paper published by Huawei regarding smart port at [1]. The 5G network planning research scheme and techno-economic analysis in this thesis refer to [15] and [16] references indicating that the proposed technology is feasible to implement. So that the expected hypothesis in this thesis can be implemented in terms of network planning, economic planning, and regulation planning, it is hoped that this thesis can provide recommendations for implementing 5G private networks even though there are differences in characteristics and parameters from previous studies.

1.7 Structure of Thesis

This Thesis is organized as follows:

- CHAPTER 1: INTRODUCTION
  This chapter explains the introduction that will support the work of the next chapter. This chapter contains background, problem identification, objective, scope of work, research methodology, hypothesis, and structure of thesis.
- CHAPTER 2: BASIC CONCEPT
  This chapter explains the basic concepts that will support the work of the next chapter. This chapter contains 5G NR, 5G private network, smart port, 5G technical planning, 5G economic planning, and 5G private regulation.
- CHAPTER 3: SYSTEM MODEL AND RESEARCH DESIGN
  This chapter explains the system model of this thesis, information about the research area, 5G technical planning calculation, and 5G economic planning calculation.
- CHAPTER 4: RESULT AND ANALYSIS
  This chapter describes the results obtained based on technical and economic analysis calculations. This chapter also analyzes 5G private network regulations to produce recommendations for telecom operators.
- CHAPTER 5: CONCLUSIONS AND RECOMMENDATION
  This chapter describes the conclusions of the results of the research that has been done and suggestions for developing this thesis research in the future. In Indonesia.