CHAPTER I
INTRODUCTION

1.1 Background

The use of information and communication technology (ICT) in Indonesia shows rapid development along with the increasing population, directly proportional to the increase in internet penetration. In 2024, the total population of Indonesia is 281,603,800 people, and as many as 221,563,479 people are already connected to the Internet. Figure 1 show that the internet penetration rate in Indonesia in 2024 is 79.50 percent, while in 2023, it is 78.19 percent. ICT development indicators based on the number of people connected to the Internet in 2023-2024 increased by 1.31 percent[1][2].

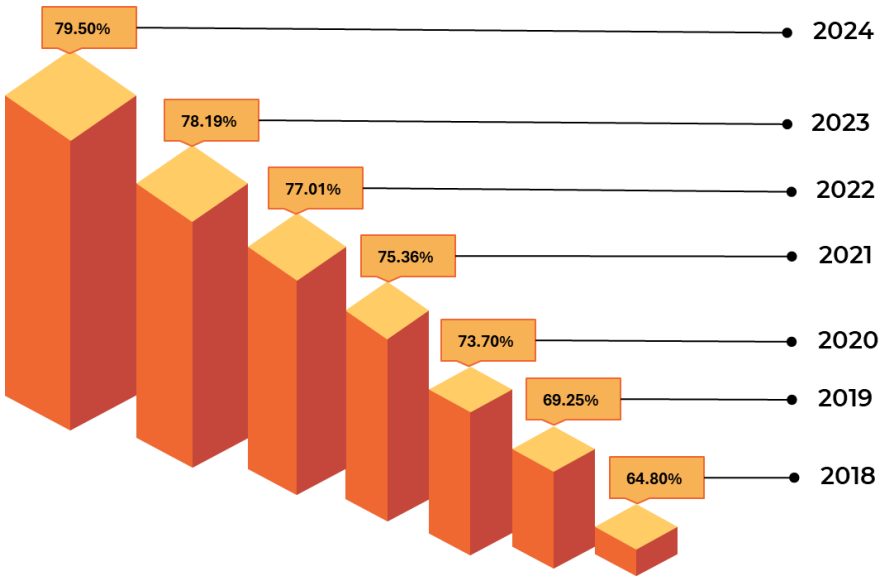

Figure 1.1 Growth of Penetration Level of Indonesia[1]

The development of internet penetration is also supported by the growth in the use of cellular telecommunications equipment. Apart from being a medium of communication, the use of cellular phones has grown rapidly since the internet. In 2022, 67.88 percent of Indonesia's population owned a cellular phone[3]. Since 2021, Indonesia has entered a new phase where 5G cellular networks have started commercial operations since service trials were conducted in Indonesian cities such as Bandung, West Java[4][5]. This 5G network service also marks the simultaneous

operation stage of its presence in the country by not necessarily replacing the existing network[6]. 5G development requires high Capital Expenditure (CAPEX) and Operation Expenditure (OPEX)[7]. As internet users grow, the potential need for greater network capacity can be provided on 5G networks. Operators are expected to maintain customer service quality, such as high internet speed, low latency, and connectivity. Based on the review of capacity requirements, operators can decide to allocate their resources and avoid over-investment optimally. Operators can also plan OPEX and CAPEX investments more efficiently based on segmenting customer needs, behavior, and preferences[8][9].

Previous research has conducted several planning reviews regarding coverage of the capacity requirements available for implementing 5G NR networks into important findings as a basis for preparing materials and case studies in the initial simulation using Mentum Planet 7.2.1 in the industrial area. There are eight design scenarios applied, including variations in uplink and downlink conditions, the location of base stations built outdoor-to-outdoor (O2O) and outdoor-to-indoor (O2I), and differences in conditions between senders and receivers without line of sight (LOS) obstructions and non-line of sight (NLOS) obstructions. This approach allows a deeper understanding of each condition to be comprehensively evaluated in a calculated manner in 5G network planning[10][11]. Evaluating the difference in SS-RSRP, SS-SINR, and data rate parameters, scenario 1 (downlink O2O LOS) using mid-band frequencies has a better network than scenario 2 (downlink O2O NLOS) using high-band frequencies. This is because scenario 2 experiences problems between gNodeB and terminal users, has a larger number of sites, and is prone to increasing interference[12]. Until before the government officially auctioned frequencies for 5G, many researchers and practitioners in the field of telecommunications conducted network coverage planning simulations [13][14]. The transition of television broadcasts to digital systems opens significant opportunities for developing 5G networks, mainly through spectrum availability at 700 MHz. This frequency, previously used for analog television broadcasts, is strategic for 5G networks because it has good propagation characteristics, can cover longer distances, and is more effective in penetrating buildings than higher frequencies. With the 700 MHz frequency, 5G development in areas with low

population density, such as rural areas and large industrial areas, become more practical and economical. In addition, this spectrum can help fill coverage gaps by providing stable signal quality, enabling better signal penetration, and supporting various usage scenarios, including IoT in industry and other technology applications. Research related to the 5G NR network design simulation by utilizing the 700 MHz frequency was conducted in Bandung City[15]. This simulation aims to understand the infrastructure needs of economic factors related to the cost of Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) components needed to implement the 5G NR network[16]. Once the government officially conducts the frequency auction in May 2021, national telecom operators can already utilize the spectrum they have acquired to commercially expand 5G networks[17]. 5G services that are currently operating commercially use 2 existing cellular frequency bands, namely the 1800 MHz and 2.3 GHz frequency bands [18]. The Ministry of Communication and Information conducts farming and refarming of the radio frequency spectrum to optimize the utilization of radio frequency bands. According to him, the 5G network in Indonesia is prepared for Low Band in the 700 MHz frequency band, Middle Band in the 3.5 GHz and 2.6 GHz frequency bands, and High Band in the 26 GHz and 28 GHz frequency bands[19].

The deployment of 5G networks in Indonesia, particularly in Bandung City, is still uneven, as was determined by prior study based on the network planning stage, which includes coverage area and network capacity. This study starts with a network design simulation to determine the new gNodeB sites required in Bandung City utilizing the current frequency of 2.3 GHz and bandwidth of 50 MHz. Then, using a multi-parameter data approach, strategic techniques will be developed to support Bandung City's 5G network planning. The parameters that are utilized to examine the demands of users are derived from network parameter data, specifically Downlink (DL) Throughput, Uplink (UL) Throughput, Payload (Data Volume), and Active User (User Density). There are multiple steps involved in preparing this thesis proposal. Section I contains the introduction. Section II explains the research literature review. Section III describes the methods, calculations, and data used in the research. Section IV contains simulation and

analysis results. Section V is the conclusion and recommendations obtained from the research.

1.2 Problem Identification

The problem identification from this research is as follows:

1. The number of internet users in Bandung City continues to increase. It is projected that approximately 205,530 users by 2030 will require additional network infrastructure to maintain service quality.
2. The 5G network infrastructure in Bandung City is not yet fully deployed. There is only 12 Of the 30 sub-districts, currently have 5G coverage.
3. The 49 sites from existing 5G in Bandung City representing only 30% of the total estimated requirement, are insufficient to cover the entire Bandung City region.
4. The high capital expenditure (CAPEX), approximately $12,154.33, equivalent to 196 million IDR, and operational expenditure (OPEX), about $50,039.32, equivalent to 810 million IDR, involved in deploying 5G NR networks remains a significant concern for service providers.

1.3 Objectives

The objectives from this research is as follows:

1. To develop a scalable network planning strategy that addresses coverage gaps in each sub-district of Bandung City and ensures optimal signal delivery.
2. To determine the total number of users through capacity planning methods to provide the best possible service.
3. To identify the potential sub-districts in Bandung City that do not yet have access to 5G NR networks.
4. To enhance network infrastructure efficiency by leveraging existing 4G LTE sites for accelerating 5G NR deployment.
5. To provide data-driven recommendations for strategic 5G coverage development based on areas with high user demand in Bandung City.

1.4 Scope of Work

The scope of work from this research is as follows:

1. The geographical area for the research area was conducted in Bandung City with urban characteristics.
2. Link budget calculation scheme Non-Standalone, Urban Macro (UMa), Outdoor-to-Outdoor propagation model using 2300 MHz frequency and 50 MHz bandwidth.
3. Key Performance Indicator (KPI) using Synchronization Signal Reference Signal Received Power (SS-RSRP), Synchronization Signal-Signal to Noise Ratio (SS-SINR) and Throughput.
4. Data collection and analysis are based on the distribution of one existing operator X in Bandung City. Sites from other operators are not taken into account in this study.
5. Data for user demand analysis in this study is primary parameters, namely Active User, Payload, Downlink Throughput and Uplink Throughput.
6. This research does not include the scenario of building a new site from scratch (greenfield).
7. Feasibility study for 5G network deployment based on technical, economic, regulation analysis.

1.5 Hypothesis

The Hypothesis from this research is as follows:

1. The current 5G infrastructure in Bandung City is insufficient to meet the projected user demand by 2030, potentially leading to a decline in service quality if no additional infrastructure is developed.
2. Technical parameters such as payload, active users, downlink, and uplink throughput at the subdistrict level can serve as a reliable basis for accurate and data-driven 5G network planning.
3. The business feasibility of implementing 5G NR in Bandung City is viable, especially by utilizing existing 4G LTE sites to reduce costs and deployment time while maintaining network performance.

1.6 Research Methodology

The research methodology with maps using Work Packages (WP) consisting of several parts is shown in Figure 1.2 below.

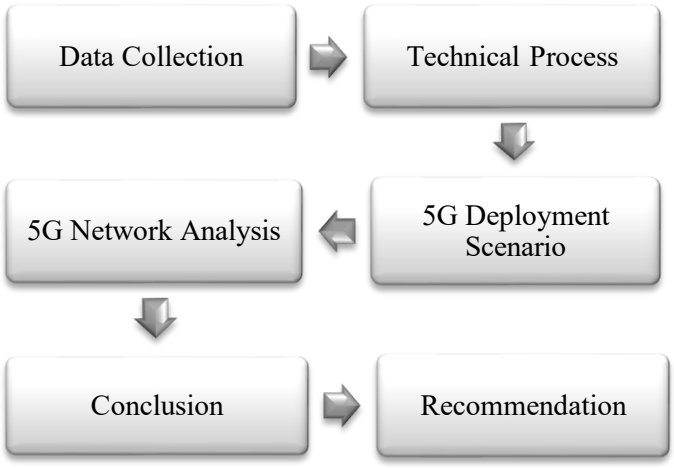

Figure 1.2 The Mindmap Research

WP 1: Collection of materials and data required for the study.

WP 2: Technical process in the form of coverage and capacity planning.

WP 3: 5G NR network development based on potential parameters distribution.

WP 4: Analysis based on KPI, business feasibility and regulatory.

WP 5: Conclusion containing the results according to the research objectives.

WP 6: Recommendations as input for further research.