CHAPTER 1
INTRODUCTION

1.1 Background

The global communication technology boom has led to a steadily rising user base, with predictions of a significant decrease in unconnected populations within the next five years [1], [2]. This underscores the critical role of high-speed internet and digital technologies in national advancement across various sectors [2]. However, Indonesia faces a persistent digital divide between urban and rural areas. While urban centers benefit from advanced 4G and emerging 5G infrastructure, many remote and hard-to-reach areas remain underserved, limiting access to critical online services [3]. Traditional internet service providers (ISPs) have played a significant role in increasing connection throughout the nation, but large geographic distances and inadequate infrastructure continue to be significant barriers, particularly in rural and isolated areas [4]. Furthermore, rural and distant areas telecommunications and internet infrastructures are falling behind their urban counterparts due to low population and economic conditions. This necessitates urgent research into rural wireless access, coverage, cost, and dependability [2].

To address these disparities, both Fourth Generation (4G) and Fifth Generation (5G) cellular networks provide wireless networks for both mobile and fixed service applications and services. Additionally, geostationary earth orbit (GEO) and low earth orbit (LEO) satellites are especially useful for Internet connectivity in rural and isolated places, and there are clear-sky outdoor nodes nearby [2]. Recognizing this potential, the Indonesian Business Competition Supervisory Commission (KPPU) recommends focusing Low-Earth Orbit (LEO) satellite internet services, like Starlink, in underdeveloped and remote 3T regions to bridge digital inequality. Starlink's advanced technology is seen as ideal for areas beyond the reach of conventional providers [5]. Wayan Toni Supriyanto, Acting Director General of Digital Ecosystem at the Ministry of Communication and Digital Economy, emphasized the need for diverse infrastructure solutions, including satellites, cables, and radio, with technology prioritization guided by detailed competitive analysis considering technical, and societal impacts [5].

In response to these connectivity challenges, the Indonesian government officially facilitated the entry of Starlink into the retail internet market in 2024 [6].

PT Starlink Services Indonesia, the local legal entity of Starlink, was established and completed the necessary licensing processes for ISP and VSAT services. According to the Ministry of Communication and Informatics (Kominfo), Starlink's user equipment passed national standardization, and its operational feasibility testing was conducted in Ibu Kota Nusantara after Eid 2024. This policy development followed the removal of satellite-based internet services from the Negative Investment List (DNI), which allows full foreign ownership in the sector and reflects the state's commitment to expanding internet access through non-terrestrial infrastructure. Initially introduced through a business-to-business collaboration with Telkomsat, Starlink has since expanded its services to individual users in Indonesia, with a particular focus on rural and industrial areas where terrestrial networks remain limited. Kominfo has emphasized the importance of maintaining fair competition and protecting consumer interests, requiring Starlink to comply with national regulations concerning business practices and service quality.

Starlink, a network established by SpaceX, offers internet services through satellite technology. The concept of an internet solution was initially introduced by SpaceX in 2015. By 2019, the first batch of 60 Starlink satellites was launched into orbit [7]. LEO satellite networks, like Starlink, differ from conventional cellular networks in that they use unique connectivity and communication technology. In contrast to cellular networks, which depend on base stations on land, Starlink uses a constellation of satellites to function. A satellite links to a user-side dish and then interacts with a ground station. The Internet receives and sends data through these ground stations. Starlink requires a line-of-sight between satellites and user equipment. Satellite communications may be obstructed with by obstructions like trees or towering structures. As a result, Starlink performs better in open and rural locations. On the other hand, heavily populated locations are ideal for cellular networks since a dense base station deployment guarantees dependable connectivity. Furthermore, the two types of networks can have very different performance and coverage characteristics because of their different deployment methodologies and, consequently, service availability [8].

Prior research on Starlink's impact on ISP competition in Indonesia highlights its potential for improving remote internet access while addressing challenges for conventional ISPs [7]. A related study published in the CoNEXT Companion '23 also highlights these complementary strengths and weaknesses. The research compared the performance and coverage of Starlink's low-earth-orbit (LEO) satellite networks with cellular networks across five U.S. states [8]. The findings revealed that Starlink outperforms cellular networks in rural areas, providing better throughput and coverage, while cellular networks excel in urban areas due to higher capacity and more stable infrastructure. The synergistic integration of Starlink and cellular networks is proposed as an effective strategy to enhance connectivity across diverse geographic conditions [8]. This concept is relevant to Indonesia, where both satellite and terrestrial networks could complement each other to ensure reliable internet access nationwide.

This paper aims to comprehensively analyze and compare the performance of Starlink satellite service and traditional terrestrial cellular networks (4G/5G) across diverse geographical settings in West Java, Indonesia: specifically, in densely populated urban areas and sparsely populated rural regions. We hypothesize that although Starlink, as a satellite technology, may exhibit higher latency compared to cellular networks, Starlink has great potential to effectively address the persistent digital divide in Indonesia, especially in rural and remote areas where conventional cellular infrastructure is often unavailable or inadequate. Through an in-depth exploration of the trade-offs in performance between these two technologies, including throughput, latency, jitter, packet loss, and network availability, this study aims to determine whether Starlink can serve as a viable alternative or a synergistic complementary solution to traditional cellular networks in bridging the connectivity gap in remote locations across the Indonesian archipelago. The findings of this study are expected to provide crucial empirical insights for policymakers, telecommunications service providers, and other stakeholders in formulating more effective and efficient network deployment strategies to achieve national broadband access equity.

1.2 Problem Identification

Indonesia has adopted various technologies, including 4G, 5G, and Low Earth Orbit (LEO) satellites, to improve connectivity and support digital growth. However, a significant digital divide persists between urban and rural areas. While cities benefit from advanced 4G and emerging 5G networks, many remote and underserved regions still lack reliable internet access, limiting their ability to engage in essential online services like education, healthcare, and e-commerce. To mitigate this challenge, it is essential to conduct a study of the technical, economic, and regulatory aspects on how 5G can be utilized in urban areas and Starlink can help improve connectivity in rural regions, ultimately enabling more equitable access to digital resources across Indonesia.

1.3 Objectives

Based on the background and problem identification that form the foundation of this thesis, the objective of this research is to deliver a study on how Starlink and 5G can complement each other in specific areas, leveraging their distinct characteristics. The objectives can be described as follows.

1. Technical Analysis to evaluate key performance metrics such as throughput, latency, jitter, packet loss, network availability, link budget, and capacity analysis for Starlink and cellular networks in different environments.

2. Economic Analysis to assess the affordability of each service relative to regional minimum wages, and to examine the business model by identifying key stakeholders involved, including users, regulators, and national operators.

3. Regulatory Analysis to review the legal and regulatory frameworks affecting the coexistence of both technologies, and to provide actionable policy recommendations that support secure and equitable integration.

1.4 Scope of Work

To maintain focus and clarity in this thesis research, several limitations and assumptions have been established. The scope of the study is outlined as follows:

1. This research adopts a case study approach based on four distinct geographical categories: Dense Urban (Bandung City), Urban (Bandung Regency), Suburban (Karawang Regency), and Rural (Garut Regency).

2. Cellular focusing on 5G network. In rural areas where 5G infrastructure is not yet available, 4G data is used as a reference to assess connectivity.

3. The analysis considers key Quality of Service (QoS) indicators, including throughput, latency, jitter, packet loss, and network availability.

4. Capacity analysis is conducted using the Shannon capacity formula, applied to Starlink's Ku Band downlink frequency (10.7–12.7 GHz). The bandwidth used in this analysis is assumed as follows: Starlink 240 MHz, 5G 100 MHz, and 4G 20

5. The regulatory analysis focuses on Indonesia's national telecommunications policies and concludes with a policy brief that outlines recommendations to support the coexistence of Starlink and 5G in Indonesia.

1.5 Hypothesis

This research hypothesizes that the coexistence of Starlink and 5G networks in Indonesia will be most effective when each technology is deployed in areas that align with its inherent strengths and characteristics. Specifically, 5G is expected to perform optimally in densely populated urban environments that demand high bandwidth and low latency, while Starlink is anticipated to provide more reliable internet connectivity in rural or remote regions where terrestrial 5G infrastructure is limited or unavailable.

1.6 Research Methodology

1. **Literature Study** This phase involves reviewing relevant theories and concepts related to Starlink and 5G networks. Theoretical references are obtained from scholarly books, peer-reviewed journals, conference proceedings, and official publications to build a solid conceptual framework for the study.

2. **Data Collection** Data collection includes both primary and secondary data to support the analysis. Secondary data sources include population data from Badan Pusat Statistik (BPS) for West Java and official documents from Starlink and Telkomsel. Primary data are collected through field measurements and observations conducted in four different area types: dense urban, urban, suburban, and rural. The key network performance metrics gathered include throughput, latency, jitter, packet loss, and network availability.

3. **Technical Analysis** This step analyzes the performance of Starlink and 5G networks using the Quality of Service (QoS) indicators obtained from field testing. The evaluation includes throughput, latency, jitter, packet loss, and availability. Furthermore, link budget to determine the SNR and capacity analysis is conducted using the Shannon capacity formula to estimate the theoretical capacity of each technology based on bandwidth and signal quality in various geographic scenarios.

4. **Economic Analysis** Economic Analysis to assess the affordability of each service relative to regional minimum wages and to analyze the business models from the perspectives of user, regulator, and national.

5. **Regulatory Analysis** This step involves examining the national regulatory framework and policies relevant to the coexistence of Starlink and 5G in In-

donesia. The objective is to identify regulatory challenges, potential opportunities, and broader policy implications associated with the deployment of both technologies. The analysis concludes with the development of a policy brief that offers actionable recommendations for policymakers to support effective and secure technological coexistence.

1.7 Methodology

1. CHAPTER I – INTRODUCTION

   This chapter, will includes the introduction, research background, problem identification, objectives, scope of work, hypothesis, research methodology, and writing systematics.

2. CHAPTER II – LITERATURE REVIEW

   This chapter, presents theoretical studies that will support and underpin this research. The theory that will be conducted is about satellite communications and 5G.

3. CHAPTER III – RESEARCH METHODOLOGY

   This chapter will discuss the research scheme that will be carried out the process of data collection and analysis.

4. CHAPTER IV – RESULT AND DISCUSSION

   This chapter will give the result of the technical, economic, regulatory analysis, and policy brief is presented.

5. CHAPTER V – CONCLUSION, RECOMMENDATION AND FUTURE WORKS

   This chapter describes the conclusion of technical and regulatory analysis. It will then draw conclusions, recommendations and future research.