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1G to 5G Mobile Network in Indonesia

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ABSTRACT

The rapid development of mobile communication technology, from the first generation (1G) to the fifth generation (5G), reflects not only global technological advancements but also adaptations to local needs and unique infrastructural challenges in Indonesia. This paper provides a review of the evolution of mobile network technologies from 1G to 5G, focusing particularly on their implementation and impact in Indonesia. The advent of 5G marks a significant milestone worldwide, including in Indonesia, bringing profound changes in how people access and utilize communication technologies. Understanding this technological journey is increasingly relevant, considering its potential to drive innovation across various sectors such as healthcare, education, and industry. Hence, grasping the progression from 1G to 5G is essential not only for technology professionals but also for the general public who will directly experience these advancements.

Keywords: *mobile network, communication technology, 1G to 5G*

1. INTRODUCTION

Cellular communication technology has experienced rapid development since the introduction of the first generation (1G) to the fifth generation (5G). In the Indonesian context, this evolution reflects not only global technological advances but also adaptation to local needs and unique infrastructure challenges. This review paper will include an in-depth explanation of technological developments from 1G to 5G, with a special focus on implementation and impact in Indonesia. The development of 5G technology has now reached a significant point in various parts of the world, including Indonesia. The implementation of 5G brings major changes in the way society accesses and utilizes communications technology. Knowledge about this technology is becoming increasingly relevant considering its potential to drive innovation in various sectors such as health, education and industry. Therefore, understanding the journey from 1G to 5G is not only important for technology professionals but also for the general public who will feel the direct impact of developments in Indonesia.

Even though there is a lot of literature discussing cellular technology, we realize that there is still a lack of journals that comprehensively discuss the journey and development of technology from 1G to 5G, especially in Indonesia. Information regarding this evolution is highly relevant and necessary to provide a thorough understanding of how technology has developed and what the implications are for users at a basic level. The lack of resources that touch on this aspect indicates a gap that needs to be filled to provide a holistic perspective.

The main aim of this paper is to increase the general public's awareness and understanding of the evolution of cellular technology from 1G to 5G. We want to ensure that ordinary people can follow these developments and understand their implications in everyday life. By providing clear and easy to understand explanations, we hope to help people stay relevant to technological developments, especially mobile technology, which increasingly influences various aspects of life. Through this review, we also want to encourage a wider discussion about the importance of adapting and accepting new technology in order to support national development and improve people's quality of life. With an organized structure and comprehensive explanation, we hope that this review paper can become a useful reference source for anyone who wants to understand the journey of cellular technology from 1G to 5G, especially in the Indonesian context.

2. METHOD

The method we use to write this journal is qualitative by reviewing journals about the development of internet networks from 1G to 5G in Indonesia along with in-depth insights about e-commerce, evolution of network technology, implementation in Indonesia, challenges faced, and impact on society. The data used for this review was obtained through online searches from national and international journals and we also examined industry reports, government publications and other relevant sources.

We classified the papers selected for review according to their generations, namely 1G, 2G, 3G, 4G, and 5G. The qualitative method we use is to evaluate the arguments, results and implications of each paper. The results of our analysis are organized into a structured review, where each paper is analyzed separately. We also present a brief summary of each paper, emphasizing the methodology used, results and contributions. In addition, we present a synthesis of our overall results, describing general patterns and advantages and disadvantages in the development of internet networks in Indonesia from various points of view.

3. DISCUSSION

Mobile network technology has developed starting from 1G, 2G/2.5G technology, 3G, 4G, up to 5G. In 2023, the technologies used in Indonesia include

1. 2G/2.5 G GSM (Global System for Mobile Communication)
2. 3G technology
    - UMTS (Universal Mobile Telecommunications System)
    - HSPA (High-Speed Packet Access)
3. 4G LTE (Long-Term Evolution)
4. 5G NR (New Radio)

3.1 1G Technology

In the first generation or 1G network, the network came from ARPANET and MILNET. In the 1980s, the first-generation communication system was introduced, namely using an analog system whose capabilities were only voice communication and low data speeds. The 1G channel capacity is 30 Khz and the frequency band is 800-900 Mhz (Triana 2021). This generation used a communication technique called Frequency Division Multiple Access (FDMA). This technique made it possible to divide up the frequency allocation in a cell for use by each customer in that cell, so that each customer when making a conversation had their own frequency. The example was AMPS (Advanced Mobile Phone System) with analog transmission, which meant the sound signal was converted into an analog electrical signal

In Indonesia, 1G technology was first introduced in 1984. Key features 1G can be seen at Table 1. At that time, PT Telkom together with PT Rajasa Hazanah Perkasa provided cellular communication services using NMT (Nordic Mobile Telephone) technology using a frequency of 450 MHz. Technically, 1G operates using an analog system generally known as AMPS (Advanced Mobile Phone Service), which only has a maximum speed of 2.4 Kbps. 1G can only be used to make telephone calls, even with poor quality, wastes battery and is not encrypted. So, conversations can be tapped using a radio scanner.

Table 1. Key Features 1G

KEY FEATURES	1G
Time	1984
First Location	Jakarta(PT Rajasa Hazanah Perkasa)
Technology	AMPS Advanced Mobile Phone System
Frequency Spectrum – Bands	824 MHz-849 MHz 869 MHz-894 MHz
Access Protocol	FDMA Frequency Division Multiple Access
Advantage	Pioneer of internet networks in his time
Deficiencies	Because it is still the first generation, there are still many that needs to be developed
Popular Technology	Analog mobile phones (Motorola DynaTAC, Nokia Mobira Senator, Ericsson Hotline)

3.2 2G Technology

In the 1990s, the 2G network system emerged which aimed to improve services on the 1G network. In this second generation, digitization has begun to improve sound quality, security, and also technology that allows Short Message Service (SMS), Multi Media Service (MMS).

The technology used was GSM (Global System for Mobile Communications) where each call was assigned a specific time slot on a frequency, then there was CDMA (Code Division Multiple Access) spectrum spread technique to allow several users to share one frequency channel. By increasing the frequency range to 850Mhz-900Mhz for uplink and downlink 900-970Mhz, the sound quality was clearer and the channel capacity was larger, namely 200Khz. Then, after that there was 2.5G using GPRS technology, namely data communications technology introduced as an upgrade of GSM to provide packet data services, then EDGE (Enhanced Data rates for GSM Evolution) uses more advanced modulation techniques to increase data speeds up to three times compared to GPRS (General Packet Radio Service) where the increase in maximum data speed for 2G and 2.5G technology is 10 Kbps to 473 Kbps making it possible to also send emails and browse.

2/2.5G technology is still maintained in Indonesia because it is basic network for telecommunications. Especially in inland areas, this technology is considered the most stable. Key features 2G are illustrated in Table 2.

Table 2. Key Features 2G

KEY FEATURES	2G
Release	1993
First Location	Jakarta (Telkomsel GSM)
MOBILE SYSTEM	GSM, Global System for Mobile communications cdmaOne (IS-95) Code Division Multiple Access
Frequency Spectrum (MHz)	Uplink:890-915 Downlink: 935-960
Access Protocol	Code Division Multiple Access
Advantage	There has been digitalization compared to the first generation to improve voice quality and security, making SMS possible
Deficiencies	Even though the voice quality is clearer, the call quality is still limited because data capacity and services are still limited
Popular Technology	SMS and MMS

3.3 3G Technology

In the early 2000s, the third generation or 3G was introduced, which can serve broadband data services such as internet, video on demand, music on demand, games on demand, and other on demand, which allows us to choose music, video or game programs as easily as choosing a channel. on TV. Such high speeds are also capable of serving video conferencing and other video streaming. This 3G data speed reaches 2 Mbps for slow-moving access and 384 kbps for wide area access. The technology used is CDMA2000, UMTS, W-CDMA which is a development of CDMA and GSM which increases speed and capacity.

Then, there is 3.5G where they use advanced technology from UMTS, namely HSDPA (High Speed Downlink Packet Access) and HSUPA ((High Speed Uplink Packet Access), namely moffer higher download speeds, typically between 1.8 Mbps to 14.4 Mbps and offer higher upload speeds, typically between 1.4 Mbps to 5.76 Mbps. Key features 3G are given by Table 3.

Table 3. Key Features 3G

KEY FEATURES	3G	
Release Year	Early 2000s (2005)	
First Location (in Indonesia)	Jakarta, Surabaya and Batam by Telkomsel	
MOBILE SYSTEM	UMTS WCDMA Universal Mobile Telecommunications Service	CDMA 2000 1xEV-DV Code Division Multiple Access
Frequency Spectrum	1920-1980 MHz.(Downlink)	2110-2170 MHz.(Uplink)
Access Protocol	CDMA	
Advantage	The data speed is higher than 2G so that internet access is better and wider, you can start using the vidcall service.	
Deficiencies	Latency is still higher than the next generation so it is still not optimal for streaming or real time applications	
Popular Technology	More sophisticated mobile internet (email, browsing, online applications) and also video calls	

3.4 4G Technology

In the late 2000s to 2010s the fourth generation appeared which offered incredible speeds including faster mobile web access, IP telephony, gaming services, video conferencing, and 3D television. This fourth generation provides speeds of up to 100 Mbps for high mobility and 1 Gbps for low mobility.

This 4G technology is LTE (Long Term Evolution) or also called 3.9G, namely this technology uses OFDMA which was developed previously FDMA which allows download speeds of up to 150 Mbps. 4G systems are integrated IP-based systems, enabling services such as IP telephony, ultra-broadband internet access, gaming services, and HDTV streaming that also include the convergence of wired and wireless networks, including GSM, wireless LAN, and Bluetooth.

Later, the frequencies previously used for the 3G network will be transferred to be used on the 4G network while also helping to allocate the 5G network. 4G technology is currently the main cellular telecommunications network and also the internet. Table 4 shows key features 4G.

Table 4. Key Features 4G

KEY FEATURES	4G LTE
Release Year	2013
First Location (Indonesia)	Bali by Telkomsel
MOBILE SYSTEM	Frequency Domain Multiplexed Modulation MIMO Antennas (FDMA)
Frequency Spectrum (GHz)	2.4 - 5.8
Access Protocol	OFDMA
Switching Technology	Internet Protocol (IP) Packet Switching (Voice and Data)
Advantage	Much higher data speeds than 3G, enabling HD video streaming, online gaming, and fast downloads of real-time applications. And its capacity is large and massive.
Deficiencies	It still requires many cell towers close together to ensure good coverage, especially in dense urban areas where many users are prone to signal interference.
Popular Technology	Mobile Broadband (HD video streaming and online gaming), LTE/VoLTE (long term evolution and voice over is a faster technology than the previous generation)

3.5 5G Technology

Lastly, which is currently being developed in the 2020s is the fifth generation or 5G. 5G is designed to connect all devices with seamless connectivity and ultra-low latency. 5G networks were first launched commercially in South Korea in March 2019 by KT, LG Uplus, and SK Telecom. This technology offers speeds of up to 10 Gbps, which is more than 600 times faster than current 4G speeds, enabling 4K movie downloads in 25 seconds.

Average latency is around 10 milliseconds, and can go down to 1 millisecond, so 5G is capable of connecting more devices simultaneously than 4G, which is important for the Internet of Things (IoT) where devices such as sensors, smart homes, and industrial devices can connect and communicate efficiently.

Technology 5G combines various advanced technologies such as Massive MIMO (Multiple Input Multiple Output) which allows the use of multiple antennas to increase network capacity and coverage. Beamforming is a technique that increases signal efficiency and expands

coverage by directing signals directly to user devices and network slicing which allows the creation of virtual networks that can be tailored to the needs of specific applications or services. Meanwhile, 5G, which is a new technology, is now starting to be used in Indonesia. Table 5 describes key features 5G.

Table 5. Key Features 5G

KEY FEATURES	5G
Release Year	2018
First Location (Indonesia)	"*Telkomsel 5G Experience Center*" coincides with the momentum of the 2018 Asian Games
MOBILE SYSTEM	Base Band Multiplexed Modulation MASSIVE MIMO Antennas NFV, Network Function Visualization NS, Network Slicing
Access Protocol	OFDMA
Switching Technology	Internet Protocol (IP) Packet Switching: Voice and Data
Specified Peak Data Rates	Downlink: 20 Gb/s - Uplink: 10 Gb/s
Core Network	CLOUD DISTRIBUTED CORE NETWORK + EDGE NETWORKS
2030 GOALS	Latency: 1ms - < 10 ms / Mobility: Up to 500 Km/h Broadband Dense Areas Connectivity: 2000 Users/Km2 Broadband Indoor Areas Connectivity: 75,000 Users/Km2 Broadband Crowd Access Connectivity: 150,000 Users/ Km2
Advantage	Enables ultra-smooth user experiences for applications such as VR/AR, 8K streaming and more. Ultra-low latency, down to under 1 millisecond, is ideal for applications that require real-time response, such as autonomous vehicles and telemedicine. flexible and broad for IoT.
Deficiencies	5G coverage is still limited and focuses more on dense urban areas and the development and implementation of 5G infrastructure requires very large investments.
Popular Technology	IoT (Smart Home), VR/AR, Streaming 4K/8K, Smart Vehicles

The number of cellular telephone subscribers in Indonesia has continued to increase since 2018, from 319.43 million subscribers to 365.87 million subscribers in 2021. However, in 2022, there was a decline to 342.61 million subscribers, showing a decrease of 6.36 percent. This decline occurred in line with the improvement in the Covid-19 pandemic situation in 2022, where people are starting to return to normal activities and reducing dependence on online activities, which is likely to affect the number of cell phone subscribers.

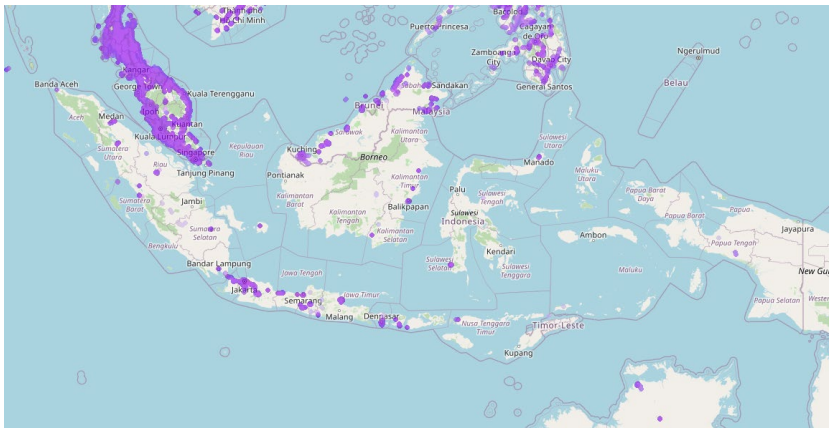

Figure 1. 5G coverage map (Telkomsel, XL Axiata, IM3, and Smartfren) in Indonesia and surrounding areas [5]

Table 6. Cellular Network 2G Coverage to Villages [6].

No	Region	Number of Villages	2G					
			Village					
			Served	Not Served	Very well	Good	Enough	Not enough
1	Sumatra	25417	25375	42	25338	10520	4334	209
2	Java	25281	25280	1	25277	5649	2014	483
3	Kalimantan	7235	7041	194	6838	4527	3407	877
4	Sulawesi	10611	10522	89	10351	6054	685	230
5	Bali Nusa	5208	5207	1	5202	3387	1722	620
6	Maluku	2426	1960	466	1826	1527	1188	595
7	Papua	7374	4273	3101	3283	3081	2990	2521
Total		83552	79658	3894	78115	34745	16340	5535

Figure 1 shows 5G coverage map in Indonesia while Table 6 presents cellular network 2G coverage.

Table 7. Cellular network 3G coverage to villages [6].

No	Region	Number of Villages	3G					
			Village					
			Served	Not Served	Very well	Good	Enough	Not enough
1	Sumatra	25417	24993	424	23321	8138	13845	6777
2	Java	25281	25271	10	25159	25042	7793	411
3	Kalimantan	7235	6391	844	4987	1732	4445	5804
4	Sulawesi	10611	9861	750	8909	5247	4730	6347
5	Bali Nusa	5208	5032	176	4628	4881	3653	1894
6	Maluku	2426	1200	1226	978	529	504	1028
7	Papua	7374	1790	5584	1235	841	882	1349
Total		83552	74538	9014	69217	46410	35852	23610

Table 8. Cellular network 4G coverage to villages [6].

No	Region	Number of Villages	4G					
			Village					
			Served	Not Served	Very well	Good	Enough	Not enough
1	Sumatra	25417	25230	187	23900	13770	19701	6704
2	Java	25281	25265	16	25117	22669	8192	1366
3	Kalimantan	7235	6457	778	5040	5274	6246	5685
4	Sulawesi	10611	10109	502	9272	5423	9621	8368
5	Bali Nusa	5208	5111	97	4680	4980	4588	2708
6	Maluku	2426	1613	813	1303	717	1296	1146
7	Papua	7374	2536	4838	1577	975	1934	1784
Total		83552	76321	70889	78115	53808	51578	27761

Table 7 describes cellular network 3G coverage while Table 8 shares cellular network 4G coverage.

Based on Table 6 to Table 8:

- 2G Coverage: Almost all villages in Java and Sumatra are well served. Papua still has many villages that are not served.
- 3G Coverage: Java has the best coverage with very few villages unserved. Sumatra also has quite good coverage.
- 4G Coverage: Java and Sumatra continue to show the best coverage, with significant improvements compared to 2G and 3G networks. Papua is still the region with the biggest challenges in 4G network coverage.

Overall, mobile network coverage in Indonesia increased from 2G to 4G, with Java and Sumatra showing excellent coverage across all network types. However, regions such as Papua and Maluku still require special attention to increase their network coverage.

4. CONCLUSION

This paper examines the cellular technology from the first generation (1G) to the fifth generation (5G) in Indonesia. Each generation of mobile technology has different features and advantages. 1G, which began to be used in 1984 in Jakarta, offers a basic analog communication system. Significant improvements occurred in 2G in the 1990s with digitalization enabling SMS and MMS services as well as improvements in voice quality and security. The third generation (3G), which began to appear in the early 2000s in Indonesia, brought an increase in data speeds and began to support internet and video call services. This technology uses UMTS and CDMA2000, providing better data speeds compared to 2G. However, higher latency is still an obstacle for real-time applications such as streaming.

In the late 2000s, 4G began to be rolled out with much higher data speeds, reaching up to 100 Mbps for high mobility and 1 Gbps for low mobility. This technology enables applications such as HD video streaming, online gaming, and video conferencing. 4G was first introduced in Indonesia in 2013 in Bali by Telkomsel, and uses LTE technology which relies on OFDMA to increase spectrum efficiency and data speeds. The latest generation 5G began operating in Indonesia in 2021 after a series of trials. 5G offers speeds of up to 10 Gbps and ultra-low latency, enabling better connectivity and supporting more devices simultaneously. This technology is important for the development of the Internet of Things (IoT) and various industrial and smart home applications in the future.

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