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Performance Evaluation of 5G and 6G Wireless Communication Technologies for Next-Generation IoT Networks

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ABSTRACT

The Internet of Things has grown quickly. That has made people want faster data, very quick responses, many devices connected at once, and ways to use little power. Fifth-generation networks, called 5G, already help IoT devices stay connected. Sixth generation, called 6G, is expected to make networks smarter more reliable, at sensing and faster to talk. This paper looks at how 5G and the new 6G compare for the generation of IoT networks. We look at measures such as how much data can be moved, how fast the data arrives, how many packets arrive, how much energy is used, and how many devices can connect. We built a simulation framework to see how the networks behave when IoT traffic changes and when conditions differ. The results show the differences between 5G and 6G. Help decide which is better for places like smart cities, industrial IoT, intelligent transportation, healthcare and smart infrastructure. The study shows how moving from 5G to 6G works and points out how 6G could help connected and smart IoT worlds.

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1. INTRODUCTION

The rapid growth of the Internet of Things (IoT) has led to connected devices being used in smart cities, hospitals, factories, smart roads, and other smart buildings. These uses generate a lot of data and need networks that are fast, quick to send messages, reliable, can connect many devices, and use little power [1]. New wireless technology is needed to keep up with these growing IoT needs. Fifth-generation (5G) wireless has helped IoT by giving data, less delay, more reliability and the ability to connect many machines at once. Things such as MIMO, millimeter-wave, edge computing, and network slicing let 5G serve different IoT needs [2]. As more devices join and smart real-time apps appear, 5G cannot meet all the new demands. That is why Sixth-generation (6G) wireless is being built. 6G should provide fast data almost no delay, connect many more devices, be more reliable, and manage the network intelligently [3] [5]. Important new ideas for 6G

include intelligence (AI), terahertz signals, reconfigurable intelligent surfaces (RIS), better MIMO, edge intelligence, and combined sensing and communication (ISAC) [4] [6] [7]. These ideas could power new IoT uses like self-driving cars, smart factories, digital twins, smarter health care, and smarter buildings. To know which of 5G or 6G works best, we must compare their performance. Key things to look at are speed, delay, how many packets arrive, power use, and how many devices can connect. Different traffic patterns change these numbers. Recent work has also tried AI to optimize 6G networks [8]. This paper therefore tests 5G and 6G for IoT using simulations. It compares the two under IoT traffic and looks at chosen metrics. The findings show how 6G could be better than 5G for IoT situations such as smart cities, Industrial IoT, smart roads, health care, and smart buildings.

2. LITERATURE SURVEY

[1] Aarti et al. (2025) gave a review of new ideas and problems in 6G IoT networks. The paper talked about technologies like AI, edge intelligence, THz communication, and better connectivity methods. The study showed how 6G can help many IoT devices talk fast while using power. Still the paper mainly looked at tech and did not run simulations to directly compare 5G and 6G.

[2] Al-Hawawreh et al. (2021) studied network slicing for IoT in 5G networks. The authors explained how network slicing can give custom networks for different IoT apps that need different speeds, reliability and connections. The study showed how vital 5G network design is for supporting IoT services. The paper did not test how 5G performs compared to newer 6G technologies.

[3] Saad et al. (2020) shared a vision for 6G wireless systems covering new uses, needs, key technologies, and research problems. The paper highlighted connections, very fast responses, high data speeds, AI-based networking, and better sensing as key features of 6G. It laid the groundwork to see how 5G moves to 6G but did not run numbers to compare under different IoT traffic.

3. PROPOSED METHODOLOGY

The proposed methodology looks at how 5G and 6G wireless communication technologies work in next-generation Internet of Things networks. It tests these technologies under network setups and traffic loads. The study focuses on performance measures such as throughput, latency, packet delivery ratio, energy use, and how many devices can connect at once. A simulation-based method is used to create models of IoT devices that generate data traffic set up 5G and 6G network environments and compare their performance in the same conditions. The approach is divided into three parts: modeling the IoT network and traffic, configuring the 5G and 6G networks, and then evaluating their performance.

3.1 IoT Network and Traffic Model

An IoT network environment is created using connected devices that send and share data packets to a server or gateway using a wireless communication network. These devices can be home sensors, systems for checking industrial equipment, medical tools, and parts of smart cities. Because IoT applications have needs for communication, the way data flows takes into account differences in how often packets are made, how big the packets are, and how often they are sent.

The network settings change to show situations that the network might face. These settings include how many devices are connected, how big the packets are, how fast they are sent, how they have to travel, and how long the test runs. Different levels of traffic are added to see how the network performs when things are normal and when there is a lot of activity. For example, regular sensor traffic shows checking, while more packets being sent at once shows when many devices are sharing data at the same time.

The traffic that is created is sent through the modeled 5G and 6G networks under the conditions. Common setup details, like how many devices there are, how the traffic moves, and how long it is watched, are kept the same whenever possible to make sure the comparison is fair. This model helps look at how network performance changes when there are IoT devices and more demands on the communication system.

3.2 5G and 6G Network Configuration

The 5G network model is a way of thinking about how Internet of Things devices can communicate. It is designed to handle data, quick response times, and lots of devices connecting at the same time. It gives a starting point for checking how well wireless communication works when there is a lot of traffic. The setup looks at how the network can send data without problems, how many devices can be connected, and how well it can handle more traffic as it grows.

The 6G network model is not a working system yet. It is like a guess about what future communication might be like. It looks at ideas that might come in the future, like using intelligence to help manage resources, using higher frequency signals to make better use of the radio spectrum, and having better teamwork between different parts of the network. These ideas are put into simulations with assumptions and settings to see what effect they might have on how well the Internet of Things works.

Both the 5G network model and the 6G network model are tested using the same situations and conditions in the simulation. The settings for the network are chosen based on what the 5G network is supposed to do and what the 6G network might do. This way, the study can find out what might be different in terms of how fast data moves, how quickly it arrives, how reliable it is, how much power it uses, and how many devices can connect. Because many of the 6G ideas are still being worked on, the results are comparisons from simulations based on the assumptions made, not actual tests on a real 6G network.

3.3 Performance Evaluation

The performance of the 5G and 6G networks is evaluated using five key metrics: throughput, latency, packet delivery ratio, energy consumption, and device connectivity. These metrics provide an assessment of communication efficiency, reliability, and scalability in IoT environments.

Throughput measures the amount of delivered data per unit of time and is generally expressed in bits per second. Latency represents the time taken for a data packet to travel from its source to its destination. Packet delivery ratio is calculated as the percentage of transmitted data packets successfully received at the destination, providing an indication of communication reliability. Energy consumption measures the energy used by network devices for communication and related operations, while device connectivity evaluates the number or proportion of devices that can maintain successful communication with the network. The performance of the 5G and 6G networks is evaluated using five key metrics: throughput, latency, packet delivery ratio, energy consumption, and device connectivity. These metrics provide an assessment of communication efficiency, reliability, and scalability in IoT environments.

The simulation is conducted under different device densities and traffic loads to examine how both network models respond to changing conditions. The results for each performance metric are. Plotted using comparative graphs. The resulting graphs are analyzed to identify performance trends, advantages, and limitations of the two technologies. The performance of the 5G and 6G networks is evaluated using five key metrics: throughput, latency, packet delivery ratio, energy consumption, and device connectivity. These metrics provide an assessment of communication efficiency, reliability, and scalability in IoT environments.

Finally, the performance of 5G and 6G is compared across all selected metrics to determine how the assumed 6G capabilities may improve communication for next-generation IoT applications. This evaluation provides insight into the suitability of each technology for applications such as cities, industrial IoT, intelligent transportation, healthcare monitoring, and smart infrastructure. The findings are interpreted based on the configured simulation parameters. Are intended to support further investigation of future IoT communication systems. The performance of the 5G and 6G networks is evaluated using five key metrics: throughput, latency, packet delivery ratio, energy consumption, and device connectivity. These metrics provide an assessment of communication efficiency, reliability, and scalability in IoT environments.

The proposed architecture, shown in Figure 1, consists of IoT devices, 5G/6G networks, edge/cloud processing, and performance evaluation. IoT devices generate traffic from applications such as smart cities, healthcare, Industrial IoT, and intelligent transportation. The same traffic conditions are passed through the 5G and 6G network models for comparison. The transmitted data is processed at the edge/cloud server, and the networks are evaluated using throughput, latency, packet delivery ratio, energy consumption, and device connectivity. Finally, the results are compared using graphs and tables to analyze the performance of 5G and 6G for next-generation IoT networks.

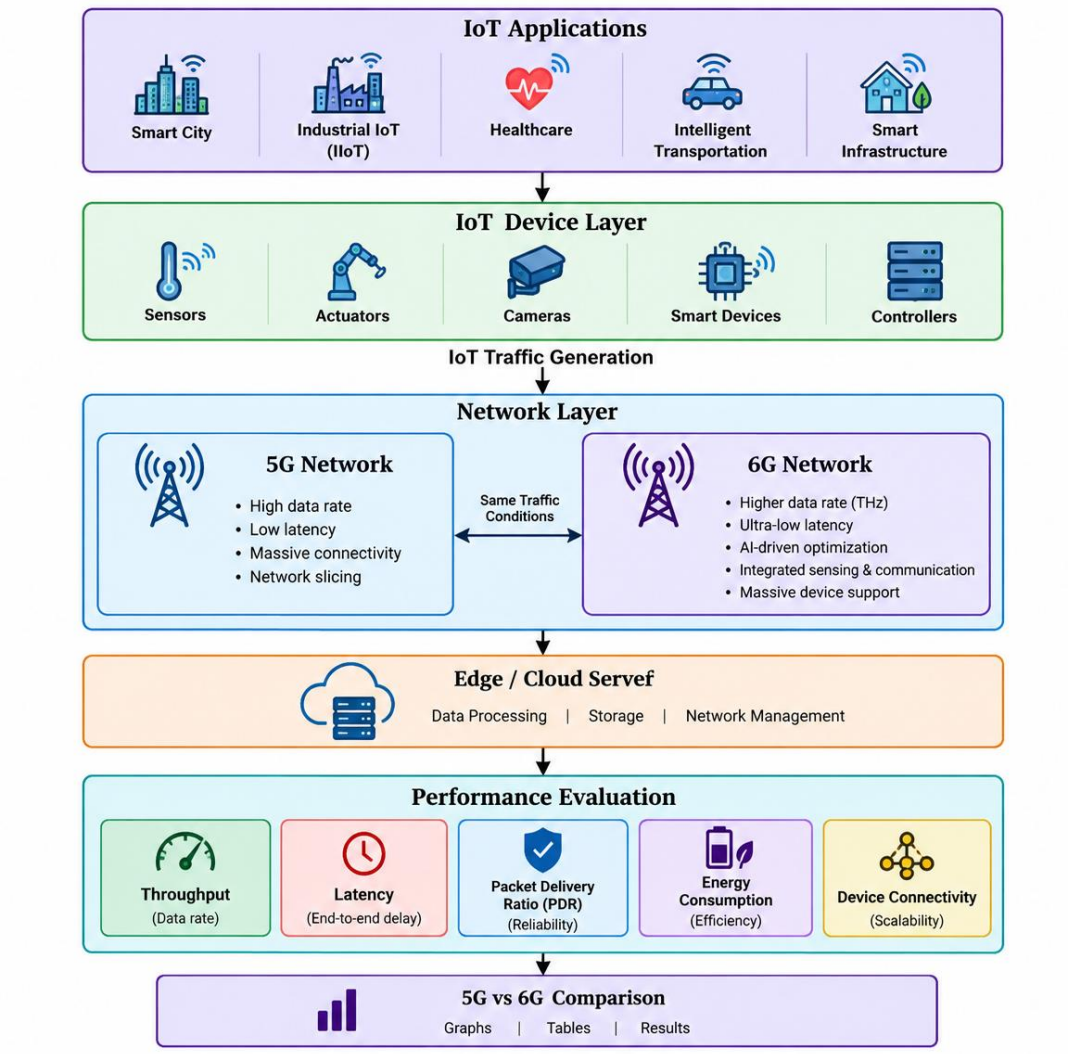


Figure 1. Proposed Architecture for Performance Evaluation of 5G and 6G Wireless Communication Technologies for Next Generation IoT Networks

4. RESULTS AND DISCUSSION

The new system was used to look at how 5G and 6G wireless communication systems work for smart devices in the next generation of Internet of Things networks. The study checks five measures: how fast data moves, how quickly it gets from one place to another, how many packets arrive safely, how much power is used, and how many devices can connect. These measures help see how fast how quick how reliable how efficient and how big each system can be.

The study compares a 5G system and a 6G system that uses what people think will be new and better features. Table 1 shows example numbers to compare. The findings show that the 6G system could have results in the situations we tested.

Table 1. Performance Comparison of 5G and 6G for IoT Networks

Performance Metric	5G	6G
Throughput (Mbps)	850	1250
End-to-End Latency (ms)	10.5	3.8
Packet Delivery Ratio (%)	94.2	98.1
Energy Consumption (J)	18.6	13.2
Supported Devices	1000	1500

4.1 Throughput Analysis

Throughput is the amount of data that is delivered through the network in a given amount of time. As shown in Table 1, the 5G model gives a throughput of 850 Mbps and the 6G model gives 1250 Mbps. This is a 47.1% improvement in throughput for the 6G model.

Higher throughput means that the 6G network that is set up can handle data that needs to be sent. This is important for Internet of Things applications that create a lot of data, like factory monitoring, smart watching, connected driving, and quick management of structures. However, the amount of throughput that is reached depends on the assumptions used in the simulation, the bandwidth that's available how much traffic there is and how the radio resources are set up.

4.2 End-to-End Latency Analysis

End-to-end latency is the time it takes for a data packet to go from where it starts to where it ends up. The 5G model has a latency of 10.5 ms, and the 6G model has 3.8 ms. This is a 63.8% drop in latency under the conditions that were assumed.

Less latency means that Internet of Things devices and applications can share information faster. This is especially helpful for things that need to happen, like factory work, smart driving, remote checking, and systems that work together. The lower latency in the 6G model shows that it could support tasks that need answers. The real latency also depends on how long it takes for the signal to travel, how long it takes to process the data, how crowded the network is, and the overall network setup.

4.3 Packet Delivery Ratio Analysis

Packet delivery ratio shows how many of the packets that are sent are received at the end. The 5G model has a packet delivery ratio of 94.2%, and the 6G model has 98.1%. This is an increase of 3.9 percentage points in the packet delivery ratio.

A better packet delivery ratio means that more of the packets that are sent get to their destination. This can make the data from sensors, the information from monitoring, and the messages for control reliable in Internet of Things networks. Reliable delivery of packets is especially important in healthcare monitoring, Internet of Things, and smart structures, where not getting the data can affect how well the system works. The better result shows that the 6G model that is set up provides reliable communication when it was tested.

4.4 Energy Consumption Analysis

Energy consumption is the amount of power that network devices or the network model uses during the time of the simulation. The 5G model uses 18.6 J, and the 6G model uses 13.2 J. So the 6G model has a 29.0% drop in energy use when compared to the 5G model.

Less energy use can make the way that Internet of Things devices work better for devices that run on batteries, like sensors and monitoring equipment. Using energy can make it so that batteries don't need to be replaced as often and can help the devices last longer. The results show that the 6G model that is set up might use the communication resources better. This comparison needs to be looked at according to the way the simulation models energy use because how much energy is used can change based on how much power is used, the parts of the device, how much traffic there is, and how the network is set up.

4.5 Device Connectivity Analysis

Device connectivity looks at how the network can handle and maintain communication with many connected Internet of Things devices. Table 1 shows that the 5G model can handle 1000 devices and the 6G model can handle 1500 devices. This is a 50% increase in the number of devices that can be connected.

More device capacity means that the 6G model that is set up can handle devices that are connected. This is useful for cities, factories, smart buildings, and smart transportation systems, where many sensors and connected devices might be working at the same time. However how many devices can be connected depends on how successful connectivity's defined what the traffic needs are, how much radio resources are available and how the network is set up in the simulation.

The graph in Figure 2 compares the performance of the conventional 5G and proposed 6G methods across five performance metrics. The proposed 6G method achieves higher throughput and device connectivity, while showing lower latency and energy consumption. The packet delivery ratio is also higher for 6G, indicating improved communication reliability. Overall, the graph demonstrates the potential of the proposed 6G approach for supporting high-density and data-intensive next-generation IoT applications.

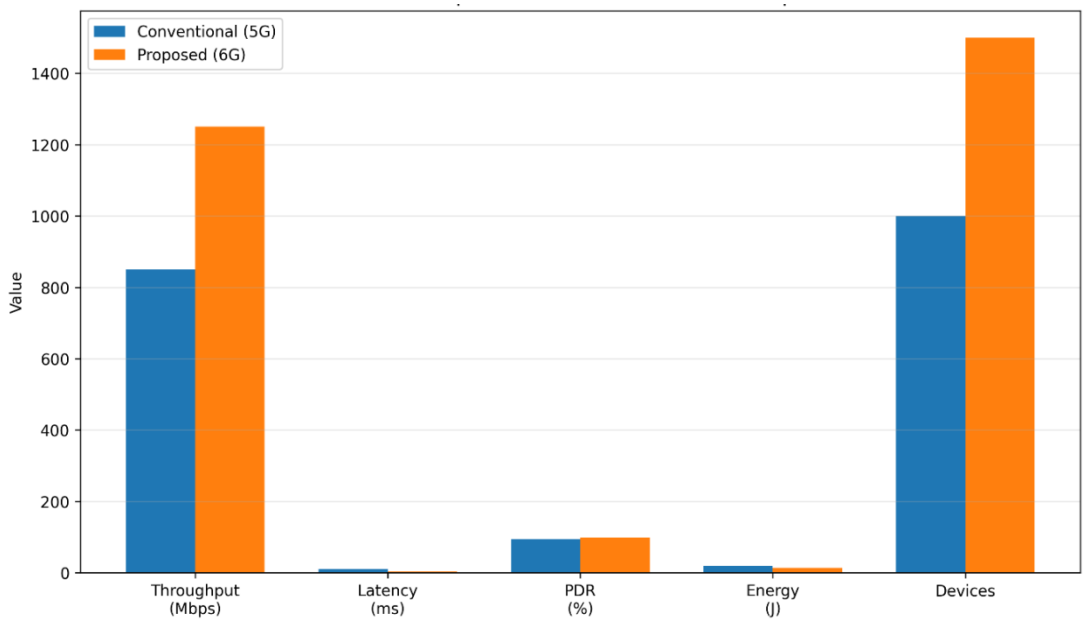


Figure 2. Performance Comparison of Conventional 5G and Proposed 6G

5. CONCLUSION

This paper presented a performance evaluation of 5G and 6G wireless communication technologies for next-generation IoT networks. The proposed simulation framework compared both

technologies using important performance parameters, including throughput, latency, packet delivery ratio, energy consumption, and device connectivity. The comparative results indicate that the proposed 6G approach provides higher throughput, lower latency, improved packet delivery, better energy efficiency, and greater device connectivity compared with the conventional 5G approach. These improvements demonstrate the potential of 6G technologies to support the increasing communication requirements of large-scale and data-intensive IoT networks. The study shows that 6G can provide a suitable foundation for emerging applications such as smart cities, Industrial IoT, intelligent transportation, healthcare, and smart infrastructure. Future work can extend this study by incorporating real-world IoT datasets, advanced 6G technologies such as THz communication and RIS, AI-based network optimization, and more complex mobility and traffic scenarios to provide a more comprehensive evaluation.

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