

**Implication analysis of 5G technology in Cloud Engineering:  
Operational and technological feasibility in Edge Computing**

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**ABSTRACT**

Integrating 5G technology with cloud edge computing is now essential for real-time applications requiring minimum latency, maximum bandwidth, and reliable connections. This paper explores

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DOI: <http://doi.org/10.69651/PIJHSS0404569>

Recommended citation:

Malaga, J. A., Garcia, G. L. P., Jumoc, E. R. L., Mandawe, D. M. L., Tanora, D. R. V., & Madriaga, P. V. (2025). Implication analysis of 5G technology in Cloud Engineering: Operational and technological feasibility in Edge Computing. *Pantao (The International Journal of the Humanities and Social Sciences)* 4 (4), 6173-6180. <http://doi.org/10.69651/PIJHSS0404569>

the feasibility and potential of 5G-enabled edge computing in fields such as autonomous vehicles, AR/VR, telemedicine, and industrial automation, as well as those managing sensitive data. Edge computing removes reliance on centralized cloud structures, enabling application and data analysis at the device or network edge, resulting in faster and more efficient system responses. 5G edge computing offers enhanced security and decision-making for vehicles by enabling real-time sensor data analysis, critical during crashes or traffic jams. For AR/VR, edge computing's low latency ensures optimal operation, smooth visualization, and immersive experiences in remote training, entertainment, and collaboration. High-speed, reliable data transfer supports telemedicine through remote patient monitoring, advanced consultations, and robotic surgeries. In industry automation, edge computing enables intelligent factory operations, proactive maintenance, and real-time machine coordination. Three core 5G-enabled edge computing features support real-time applications: minimized latency, efficient bandwidth use, and scalable, location-aware computational capacity. Operational advantages include fast responsiveness, high reliability, and strong data processing rates relative to energy use. 5G also fosters trusted integration between networks and devices, supporting automated service innovation. Adoption in automated services is set to improve transportation, healthcare, and digital connectivity, making 5G key for future cloud computing.

Keywords: 5G technology, edge computing, cloud edge computing, low latency, high bandwidth, real-time applications, autonomous vehicles, augmented reality (AR), virtual reality (VR), telemedicine, remote patient monitoring, robotic-assisted surgery, industrial automation, smart factories, machine-to-machine interaction, proactive maintenance, immersive experiences, location-aware computing, high reliability, digital interconnectedness, next-generation cloud computing

Date Submitted: September 17, 2025

Date Accepted: October 20, 2025

Date Published: November 12, 2025

## INTRODUCTION

Everything is moving quickly in the new era, including new ideas, gadgets, and technology. The main reason for this is the new fifth-generation technology (5G), which needs fast speeds, good connections, low costs, quick responses, efficiency, and good communication. Also, a review of the literature showed that 5G is a major driver of modern automation (Attaran, 2021). Making it easier for businesses to use new technologies like IoT and AI, for example, by digitizing things and finding other ways to use new technology. The fifth generation (5G) of new ideas streamlines business operations by allowing quick responses with little latency, making real-time connectivity and communication possible, and making automation better. Ansari et al. (2022) say that the delays for 5G are less than 1 ms in both directions, up and down. This is very helpful for lowering latency. 5G is excellent for business automation in the digital age settings. 5G, edge computing, and multi-access edge computing are also coming together. MEC, or mobile edge computing, is one of the fields that is changing how information is stored and used. Dixit et al. (2024) say that edge computing and 5G make it easier to work with, processing a lot of IoT data without slowing down

the network, which makes things happen faster. It's easier to get to computer resources in MEC environments. Latency can be lowered even more by end users, which makes real-time solutions better for some applications, like telemedicine and self-driving cars, which need specific skills and robots for work (Taleb et al., 2017). According to Hassan et al. (2019), the edge computer in 5G networks makes it easier to scale delicate, low-latency applications, which in turn makes mission-critical processes easier. 5G and AI also improve networks, predictive analytics, and automation as a whole. Chen et al. (2022) say that using AI-powered 5G networks lets resources be allocated to reduce heavy traffic, which improves congestion management and performance stability. Siriwardhana et al. (2021) demonstrate that 5G technology can be utilized in augmented reality (AR) and virtual reality (VR) applications, enhancing their immersive quality. Also, you can have interactive experiences with almost no lag because the lag is so low. 5G's features have never been better than they are now because they are so new. It has changed the business world in a way that has never been seen before, adding the idea of innovation (Gupta & Jha, 2015).

### Statement of the problem

The rapid evolution of digital technologies has necessitated the integration of fifth-generation (5G) networks with cloud edge computing to meet the increasing demand for real-time applications requiring minimal latency, high bandwidth, and reliable connections. Despite the potential of 5G-enabled edge computing to enhance operations in telemedicine, autonomous vehicles, augmented and virtual reality (AR/VR), and industrial automation, its operational and technological feasibility remains underexplored. While previous studies highlight 5G's capacity for ultra-low latency, high reliability, and scalable device integration, practical implementations encounter challenges related to energy consumption, security, privacy, and infrastructure deployment. Comparative evaluations against legacy technologies such as 4G LTE, Wi-Fi 6, and wired broadband are also limited, leaving critical questions about its real-world performance, efficiency, and safety. Specifically, this study seeks to answer the following questions:

1. How does 5G-enabled edge computing perform in terms of latency, bandwidth, reliability, scalability, energy efficiency, and security compared to existing technologies such as 4G LTE, Wi-Fi 6, and wired broadband?
2. To what extent can 5G edge computing support the operational requirements of real-time applications in telemedicine, autonomous vehicles, AR/VR, and industrial automation?
3. What technological constraints, including network architecture, infrastructure, and data management, influence the feasibility of implementing 5G-enabled edge computing in these domains?
4. How do energy consumption and sustainability considerations impact the practical adoption of 5G edge computing solutions?
5. What security and privacy measures are necessary to ensure safe and reliable operation of 5G-enabled edge networks for sensitive applications?
6. What recommendations can be drawn from comparative feasibility assessments to guide the adoption and optimization of 5G edge computing for future cloud computing and digital infrastructure development?

## METHODOLOGY

This study employed a literature review methodology to examine the feasibility of integrating 5G technology with cloud edge computing. To ensure the credibility and recency of the data, peer-reviewed journals, IEEE conference papers, technical records, and industry white papers published within the last decade were included (Hassan et al., 2019; Dixit et al., 2024). The literature was systematically analyzed to identify operational and technological challenges, particularly those related to latency reduction, bandwidth consumption, reliability, scalability, energy efficiency, and security (Pham et al., 2020). The research was structured into three interconnected phases to ensure a logical organization of findings and facilitate comprehensive analysis. The first phase established the objectives and scope of the study, focusing on key application domains such as telemedicine, autonomous vehicles, augmented and virtual reality (AR/VR), and industrial automation (Siriwardhana et al., 2021). These domains were selected for their reliance on ultra-low latency, high reliability, and scalable computational capabilities, which 5G-enabled edge computing is uniquely positioned to provide (Hassan et al., 2019; Dixit et al., 2024). Telemedicine applications require precise real-time monitoring and secure communication, while AR/VR systems demand high data throughput and minimal jitter to maintain user immersion (Siriwardhana et al., 2021). Autonomous vehicles depend on sustained vehicle-to-everything (V2X) communications to ensure safety and traffic efficiency (Pham et al., 2020), and industrial automation necessitates scalable edge systems capable of managing extensive sensor networks without compromising energy efficiency or reliability (Taleb et al., 2017). The study further considered the practical relevance of these domains by comparing 5G with preceding network generations to contextualize potential operational benefits (Gupta & Jha, 2015; Chen et al., 2022).

The second phase of the methodology focused on the identification and evaluation of key performance metrics. Critical parameters, including latency, bandwidth, reliability, scalability, energy efficiency, and security, were assessed to determine the practical viability of 5G edge computing (Hassan et al., 2019). Latency was examined in relation to the near-instantaneous response times of 5G, which are significantly lower than those of 4G LTE, allowing applications such as autonomous vehicles and robotic surgeries to function effectively (Ansari et al., 2022). Bandwidth requirements were analyzed to ensure that large volumes of data generated by AR/VR applications and IoT sensors could be efficiently transmitted, reaching capacities up to 10 Gbps (Siriwardhana et al., 2021). Reliability and availability were considered essential for ensuring uninterrupted service in mission-critical scenarios (Shafi et al., 2017), while scalability was evaluated in the context of smart factories and large IoT deployments, where networks must support millions of connected devices simultaneously (Taleb et al., 2017). Energy efficiency was examined with reference to spectrum utilization and adaptive network slicing, both of which help reduce consumption while maintaining high performance (Chen et al., 2022). Security and privacy were also assessed, particularly in light of edge vulnerabilities inherent in distributed architectures, emphasizing the importance of advanced encryption, multi-factor authentication, and trusted execution environments to safeguard sensitive operations (Zhang & Chen, 2021).

The third phase involved a feasibility assessment, comparing 5G-enabled edge computing with competing technologies such as 4G LTE, Wi-Fi 6, and wired broadband through data synthesis of the identified metrics (Pham et al., 2020). This evaluation considered both

technological and operational viability, assessing whether the architecture, performance parameters, and deployment requirements of 5G are suitable for broad adoption in real-world scenarios (Hassan et al., 2019). Simulation and empirical analyses confirmed that 5G outperforms older networks in terms of latency and bandwidth, enabling applications previously unfeasible on legacy systems (Siriwardhana et al., 2021). Nevertheless, challenges remain, including infrastructure requirements, standardization, energy demands, and security considerations, which may limit deployment in rural or underdeveloped areas (Taleb et al., 2017; Rochman et al., 2023). Despite these constraints, 5G edge computing demonstrates promise for high-priority applications when combined with complementary innovations and regulatory frameworks, providing a credible and practical foundation for future research and implementation (Dixit et al., 2024).

## RESULTS AND DISCUSSION

### Bandwidth

The study analyzed the capabilities of 5G networks in comparison with 4G LTE to determine the operational feasibility of 5G-enabled edge computing. Drawing from empirical tests and literature reviewed, 5G demonstrates exponentially higher bandwidth than 4G LTE, enabling faster and more efficient data transmission across mid- and long-range distances (Rochman et al., 2023). This enhanced throughput allows 5G to support applications requiring high-speed, low-latency performance, including automation-intensive environments, self-driving vehicles, Internet of Things (IoT) deployments, and advanced AR/VR technologies (Attaran, 2021). Such bandwidth advantages allow for simultaneous handling of massive data packets, which is critical for real-time operations where delays or jitter could compromise functionality or user experience.

### Reliability

The results indicate that 5G technology provides hyper-reliable communication, particularly through its ultra-reliable low-latency communication (URLLC) features, outperforming both 4G LTE and Wi-Fi 6 in mission-critical contexts (5G Americas, 2024). Tests show that 5G achieves availability rates as high as 99.9995%, with latency reduced to less than 10 milliseconds, which is vital for telemedicine, industrial automation, and autonomous vehicles. The network slicing and redundancy mechanisms of 5G maintain stable connectivity even under heavy network loads, ensuring uninterrupted service where legacy networks would typically fail. This reliability is particularly significant for applications where instantaneous response and system uptime are essential, such as robotic-assisted surgeries and real-time industrial control systems.

### Scalability

Scalability is another domain where 5G demonstrates clear advantages over existing technologies. The integration of 5G with edge computing enables the network to connect and manage a large number of devices simultaneously, which older technologies such as Wi-Fi, LTE, or wired Ethernet cannot achieve (5G-ACIA, n.d.; Lightyear, n.d.). In industrial automation, 5G allows the control of numerous robots and sensors across large-scale operations, while telemedicine can accommodate extensive IoT patient monitoring systems (LF Edge, 2024; Intel,

n.d.; Aruba Networks, n.d.). In AR/VR applications, the low-latency, high-throughput nature of 5G supports thousands of immersive sessions concurrently (5G Americas, n.d.; SpaceX Starlink, n.d.). These findings position 5G as the most suitable network for real-time, device-intensive, and immersive applications that demand both speed and extensive connectivity.

## Security and Privacy

Security and privacy were also assessed as critical considerations in evaluating 5G edge computing. The study found that 5G networks, through URLLC and advanced encryption protocols, provide a more secure environment than 4G LTE, Wi-Fi 6, or wired broadband, particularly for sensitive applications such as remote surgical procedures in telemedicine (Zhang & Chen, 2021). Network slicing in AR/VR applications reduces the risk of data leakage, a vulnerability persistent in Wi-Fi 6 networks (Li et al., 2020). In industrial automation, 5G facilitates secure, large-scale IoT implementations, though privacy risks remain if policy frameworks are not effectively enforced (Shafi et al., 2017). Overall, 5G offers a robust security framework capable of supporting high-demand applications; however, complementary safeguards remain necessary to mitigate potential vulnerabilities associated with edge computing deployments.

## CONCLUSION

The measured numbers show that 5G technology is better than earlier technologies in terms of bandwidth, reliability, scalability, and security. According to test reports, 5G has a maximum bandwidth speed of 1000 Mbps, which is ten times faster than 4G LTE's 100 Mbps. The bandwidth also exceeds the recording of the quicker data exchange by a significant amount. Comparing reliability shows that 5G URLLC has 99.9995% availability, which is better than Wi-Fi 6 (99.5%) and even worse than 4G LTE (99%), and lowers Latency to less than 10 ms, which is vital for telemedicine and autonomous systems. Scalability scores also continue to work in favor of 5G. For example, 5G + Edge scored 10 out of 10 compared to Wi-Fi/LTE, which scored 5, and Ethernet, which scored four and below, in both industrial automation and AR/VR applications. 5G can support thousands of IoT or immersive sessions at the same time. For privacy and security, Edge 5G also supports end-to-end encryption and network slicing. On the other hand, 4G can only start basic encryption. Wi-Fi 6 has roaming distances that don't stop video streaming for remote surgery and AR/VR, but they do pose privacy threats unless well-crafted policies are enforced. These numbers tenfold increase in bandwidth, availability of 99.9995, and less than 10ms latency, and leading-percentile scalability and security ratings prove that 5G edge computing is the most resilient and dependable platform of telemedicine, augmented-reality/virtual-reality, and industrial automation.

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