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EXPLORATION OF WIRELESS NETWORK INTELLIGENT SENSING AND SLICE RESOURCE MANAGEMENT UNDER 5G BACKGROUND

FU YIMING 1, OYYAPPAN DURAIPANDI 2

ABSTRACT

Wireless communication has been revolutionised by the fast development of 5G technology, which incorporates ultra-low latency, enormous device compatibility, and high-speed connection. One of the most important new functions of wireless networks is intelligent sensing, which goes beyond simple transmission and allows networks to understand their environments by analysing signal properties like amplitude fluctuations and channel status information. Concurrently, slice resource management is critical for many application situations because it ensures scalability, security, and effective allocation of network resources while also guaranteeing quality of service (QoS). The 5G framework's cognitive sensing and network slicing capabilities make it possible to provide uninterrupted support for mission-critical services. These services include smart healthcare, autonomous vehicles, industrial automation, and immersive apps. In order to optimise the performance and reliability of networks, this study delves into the connection between wireless intelligent sensing and slice resource management, demonstrating how these two concepts function together. In order to integrate these technologies and prepare for 6G along with future intelligent networks, the research stresses that 5G is the essential platform. Quick development of 5G technology has revolutionised wireless communication with its integration of ultra-low latency, enormous device compatibility, and high-speed connection. A new and important function in wireless networks, intelligent sensing goes beyond standard communication and allows networks to understand and interpret their environments by analysing signal characteristics including amplitude changes, channel status information, and Doppler shifts. Simultaneously, slice resource management is critical for many application situations because it ensures scalability, security, isolation, and quality of service while using network resources effectively.

KEYWORDS: *Wireless Network Intelligent Sensing, Slice Resource Management, 5G Communication, Quality of Service (QoS)*

1. INTRODUCTION

A new age in wireless communication has begun with the advent of 5G networks, which can serve an unprecedented number of devices with lightning-fast data rates, almost no latency, and very dependable connection. 5G isn't only about faster connections; it's also about enabling smart applications and sophisticated services in many other fields, including healthcare, transportation, industry, especially smart cities. Wireless network intelligent sensing and slice resource management are two crucial parts of this architecture that have received a lot of attention. The amplitude, phase, along with channel state information (CSI) that are intrinsic to wireless signals are used in wireless network intelligent sensing to derive useful information about the surroundings. Because of this, networks may now take part in sensing activities such as object identification, motion detection, and environmental monitoring, expanding their significance beyond that of typical communication networks. Opportunities for context-aware apps, security systems, and autonomous systems reliant on real-time awareness are expanded with these capabilities. Slicing the network into smaller, more manageable pieces and optimising their allocation and use for individual services is the focus of slice resource management. Slice management allows networks to accommodate heterogeneous applications such as mMTC, enhanced mobile broadband, and quality of service (QoS), which in turn allows for scalability and security. Networks can handle URLLC, eMBB, and other similar uses. Investigating how intelligent sensing as well as slice resource management may work together in the context of 5G reveals how these two technologies can boost performance, flexibility, and dependability. Sixth generation (6G) networks are expected to be more intelligent as well as productive if these technologies are included (Ejaz et al., 2024).

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2. BACKGROUND OF THE STUDY

Improving data rates, connection, and the user experience have been the primary goals of mobile communication technology advancement from 1G to 4G. The arrival of 5G networks, on the other hand, signifies a sea change since they allow for sophisticated applications that combine sensing, cognitive decision-making, and communication at higher speeds with reduced latency. Some see 5G as the foundation of next-gen intelligent systems, which was necessary to meet the increasing need for smart healthcare, driverless cars, industrial automation, and more immersive virtual experiences. Among the new developments in this revolution is wireless network intelligent sensing, which makes use of the physical characteristics of wireless signals—including amplitude, phase, and channel state information (CSI)—to derive environmental context. Reduced deployment costs and real-time environmental awareness are achieved by the use of the existing communication infrastructure in wireless intelligent sensing, as opposed to traditional sensors. Systems that rely on pinpoint accuracy, such smart transportation, security monitoring, and motion detection, cannot function without this proficiency. Slice resource management, like sensing, is now essential to 5G. Through the process of network slicing, it is possible to build several virtual networks that are tailored to fulfil distinct performance needs, all residing on the same physical infrastructure. In situations where several applications compete for a limited amount of resources, its efficacy depends on efficient resource allocation, scalability, and QoS guarantee. It is critical to study the 5G framework's slice resource management and wireless intelligent sensing interactions. It lays the groundwork for future 6G advancements by showcasing how these technologies improve network flexibility, dependability, and efficiency (Yu et al., 2024).

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3. PURPOSE OF THE STUDY

The aim of this research aims to investigate how 5G networks may include intelligent sensing for wireless networks and slice resource management, with an emphasis on how these two components work together to improve next-generation communication systems. The continued worldwide rollout of 5G technology opens up possibilities for cognitive features beyond traditional communication in addition to improving connection and capacity. Slice resource management guarantees the optimal allocation of limited network resources to serve varied applications, while wireless intelligent sensing allows networks to monitor, analyse, and react to changes in the environment in real time. The goal of this research is to find out how these two factors work together to make complicated situations like smart cities, autonomous driving, healthcare monitoring, and industrial automation more efficient, reliable, and adaptable. The study aims to demonstrate how 5G lays a strong groundwork for sensing and resource management integration, which improves QoS and user experience by analysing their connection. Furthermore, the study aims to provide light on the difficulties, potential benefits, and long-term consequences of merging these technologies, thereby paving the road for further investigation and advancement (Zhang et al., 2025).

4. LITERATURE REVIEW

Advanced capacities beyond high-speed communication have been offered by 5G networks. These capabilities are most noticeable in wireless intelligent sensing and network slice resource management. In order to guarantee the adaptability, effectiveness, and dependability of a network, these two areas are progressively seen as complimentary features. Opportunities in healthcare, automobile autonomy, and smart security systems are made possible by wireless intelligent sensing, which takes advantage of the characteristics of wireless signals—like phase,

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amplitude, and channel state information (CSI)—to understand the environment and user actions. 5G is scalable and cost-effective since it reuses transmission signals for sensing activities, which means less need for separate sensor equipment. At the same time, managing slices of resources is key to 5G's full potential. Enhanced mobile broadband (eMBB), ultra-reliable low-latency communication (URLLC), and massive machine-type communication (mMTC) are just a few examples of the types of services that may reside on a single physical infrastructure thanks to network slicing. To provide quality of service (QoS) and isolation among varied applications, Liu and Wang (2025) stress that appropriate resource allocation within slices is vital. In order to adapt to changing traffic needs, AI-driven methods are being used more and more to dynamically assign computation, storage, and spectrum. A growing body of literature is exploring the potential benefits of combining intelligent sensing alongside slice resource management. Predicting user movement, traffic loads, and other environmental interference, sensing data may enable proactive optimisation and enhance slice efficiency. This cooperation is especially important in mission-critical applications that need both real-time awareness and stringent quality of service, such as autonomous cars and remote healthcare. For 5G to be a success, intelligent sensing appropriate slice resource management are crucial, according to the research. 6G networks, which were supposed to further enhance intelligence, flexibility, and efficiency, were built upon these (Chen et al., 2024).

5. RESEARCH QUESTION

- How can intelligent sensing techniques improve the accuracy and efficiency of wireless network resource allocation in 5G network slicing?

6. METHODOLOGY

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6.1 Research Design

The SPSS version 25 was used for the quantitative data analysis. A 95% confidence interval and odds ratio were used by the researchers to assess the direction and strength of the statistical association. A statistically significant criteria was established by the researchers at $p < 0.05$. The data's basic features were revealed via a thorough investigation. Quantitative methods are often used to evaluate data collected via polls, questionnaires, and surveys, as well as data analysed using computing tools for statistical evaluation.

6.2 Sampling

Research participants completed questionnaires to furnish data for the study. Utilising the Rao-soft tool, researchers ascertained that the study comprised 657 individuals. Researchers disseminated 896 questionnaires to the public. The researchers obtained 823 replies, eliminating 45 due to incompleteness, yielding a final sample size of 778.

6.3 Data and Measurement

The study mostly utilised data acquired from a questionnaire survey. The participant's essential demographic information was requested first. Participants were subsequently given a 5-point Likert scale to evaluate the online and offline channels. The researchers rigorously analysed several resources, especially internet databases, for this secondary data acquisition.

6.4 Statistical Software

The statistical analysis was conducted using SPSS 25 and MS Excel.

6.5 Statistical Tools

The primary characteristics of the data were understood via the use of descriptive analysis. Using ANOVA, the researcher must examine the data.

7. CONCEPTUAL FRAMEWORK

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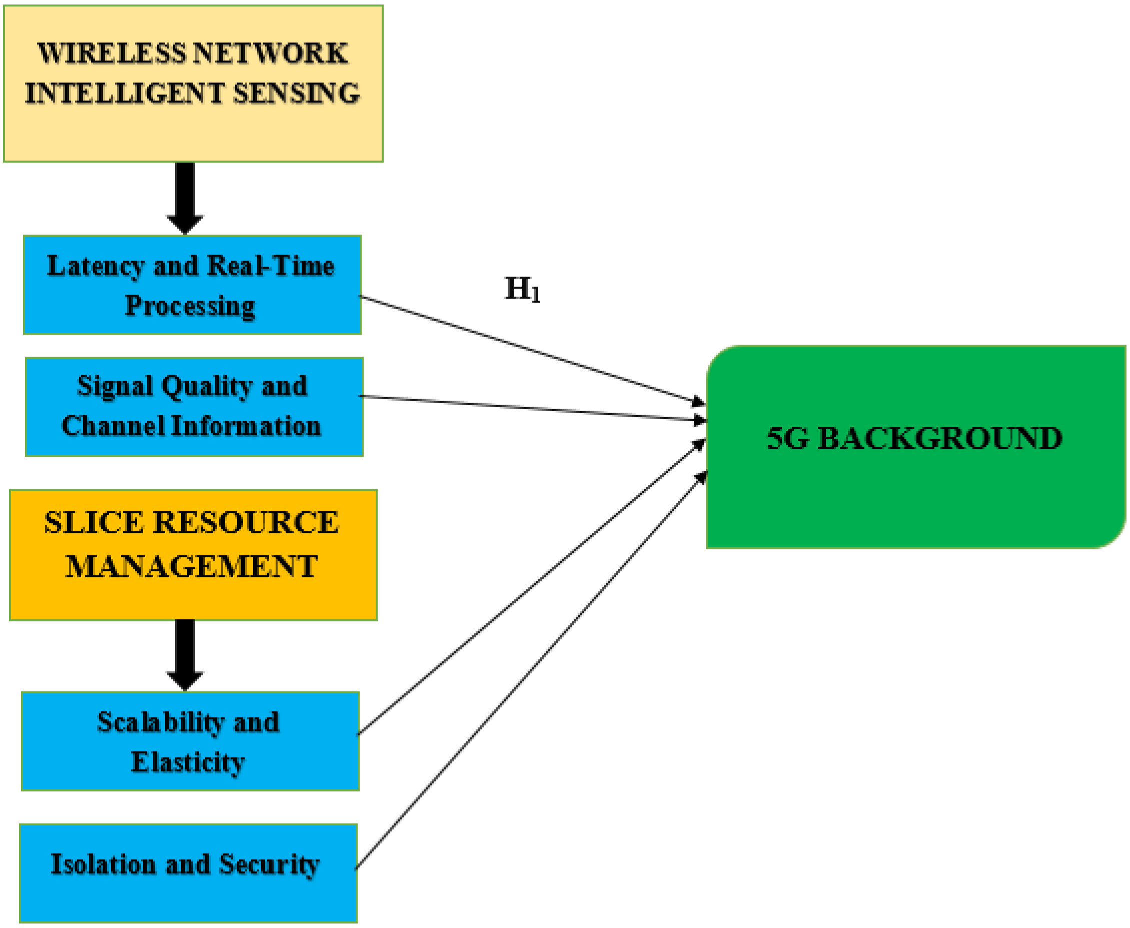

8. RESULT

Factor Analysis

Factor Analysis (FA) is often used to find hidden variables in observable data. It is common practice to use regression coefficients to generate ratings when there are no easily visible visual or diagnostic signs. Success in FA is highly dependent on models. The goals of modelling are to identify errors, intrusions, and apparent linkages. The Kaiser-Meyer-Olkin (KMO) Test is one tool for evaluating datasets that have been generated by numerous regression analyses. The representativeness of the model and the variables in the sample are checked by them. There seems to be data duplication based on the numbers. Data is more easily comprehensible when proportions are smaller. The output of KMO is an integer from 0 to 1. A sufficient sample

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size is defined as a KMO value between 0.8 and 1. According to Kaiser, these are the acceptable limits: The standards that Kaiser has established for admission are as follows:

A dismal 0.050 to 0.059, worse than the typical 0.60 to 0.69

The typical range for middle grades is between 0.70 and 0.79.

Having a quality point score between 0.80 and 0.89.

Between 0.90 and 1.00, they find wonder.

Testing for Bartlett's Sampling Adequacy and KMO (Table1) The Kaiser-Meyer-Olkin.953 scale

According to Bartlett's sphericity test, these are the results: chi-square, sig.=.000, about 190 degrees of freedom This proves that the statements made for sampling were legitimate. In order to determine whether the correlation matrices were relevant, the researchers used Bartlett's Test of Sphericity. An adequate sample is defined as one with a value of 0.953 according to the Kaiser-Meyer-Olkin measure. The results of Bartlett's sphericity test provide a p-value of 0.00. You can tell the correlation matrix isn't an identity matrix if Bartlett's sphericity test returns a positive result.

Table 1: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.953
Bartlett's Test of Sphericity	**Approx. Chi-Square**	3252.983
	df	190
	Sig.	.000

In addition, the widespread use of correlation matrices was confirmed by Bartlett's Test of Sphericity. The sample adequacy measure, as measured by Kaiser-Meyer-Olkin, is 0.953. Using Bartlett's sphericity test, the researchers obtained a p-value of 0.00. A substantial result of Bartlett's sphericity test demonstrated that the correlation matrix was unsuccessful.

❖ INDEPENDENT VARIABLE

• WIRELESS NETWORK INTELLIGENT SENSING

Internet Connection Modern wireless communication systems may detect and comprehend their environments in addition to transmitting data; this feature is called intelligent sensing. Intelligent sensing relies on signal characteristics like amplitude, phase, and channel state information (CSI) to identify changes, objects, or motion, as opposed to conventional networks that only prioritise connection. Thanks to this integration, wireless systems may now back up a wide range of applications, including security surveillance, autonomous driving, smart homes, and healthcare monitoring. Four main components are necessary for intelligent sensing to work: accurate channel and signal information, environmental consciousness, effective management of resources, and state-of-the-art data processing powered by artificial intelligence. Wireless networks are able to increase situational awareness, spectrum utilisation, and context-aware service provision by merging sensing and communication capabilities. As 5G and 6G enabled next-generation networks, intelligent sensing became an essential component, enhancing digital ecosystems' intelligence, security, and adaptability.

❖ FACTOR

• LATENCY AND REAL-TIME PROCESSING

Contemporary computer and networking systems rely heavily on low latency and real-time processing. The term "latency" describes the amount of time that elapses between sending a request and receiving a response. It is the amount of time it takes for data to get from one location to another in a network. Applications like online gaming, video conferencing, driverless cars, and industrial automation rely on low latency for quick reaction. Quality of life, ease of use, and system dependability may all take a hit from even little delays. However, in order to provide quick results, real-time processing necessitates processing and analysing data either immediately or within a very little time period. Systems that cannot afford delays, such healthcare monitoring, financial trading, robotics, and emergency response systems, rely heavily on this capabilities. 5G, the Internet of Things (IoT), and networks powered by artificial intelligence (AI) rely on real-time processing and minimal latency to execute flawlessly, accurately, and with lightning speed.

❖ DEPENDENT VARIABLE

• 5G BACKGROUND

5G, the next generation of mobile communication, is a huge improvement over earlier generations like 4G and 3G. In contrast to previous networks, 5G enables ultra-reliable, low-latency, and high-capacity connection in addition to quicker data transmission and enhanced voice communication. Its architecture is built to accommodate not only smartphones, but also the exponential expansion of linked devices in areas like as smart cities, autonomous cars, industrial automation, and the Internet of Things (IoT). 5G leverages cutting-edge innovation including millimeter-wave spectrum, massive MIMO, network slicing, and edge computing to function. Thanks to these advancements, it can link millions of devices per square kilometre, provide latency as low as 1 millisecond, and enable data speeds of up to 10 Gbps. Built on 5G's enhanced wireless broadband, ultra-reliable communication, as well as machine-type connectivity are future intelligent programs and digital ecosystems.

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- ### Relationship of between Latency and Real-Time Processing & 5G Background

A key component of next-gen communication system progress is the link between 5G, real-time processing, and latency. Applications requiring immediate or near-instantaneous treatment of data, such autonomous driving, telemedicine, especially industrial automation, are severely hindered by latency, or the time it takes for data to travel from sender to receiver. The very low latency needed for these important jobs was sometimes beyond the capabilities of traditional 4G networks. With 5G on the horizon, latency can drop to 1 millisecond, allowing for very dependable and quick real-time processing. Devices and systems may now communicate and make choices almost quickly thanks to this breakthrough. Autonomous cars, for instance, can respond instantly to changing road conditions thanks to 5G, and remote surgeries can now take place in real time thanks to the technology. Smarter, quicker, as well as more secure digital applications are made possible by 5G, which acts as a technical backbone that reduces latency and enables real-time processing.

On the basis of the above discussion, the researcher formulated the following hypothesis, which was analyse the relationship between Latency and Real-Time Processing & 5G Background.

"H_{01}: There is no significant relationship between Latency and Real-Time Processing & 5G Background."

"H_1: There is a significant relationship between Latency and Real-Time Processing & 5G Background."

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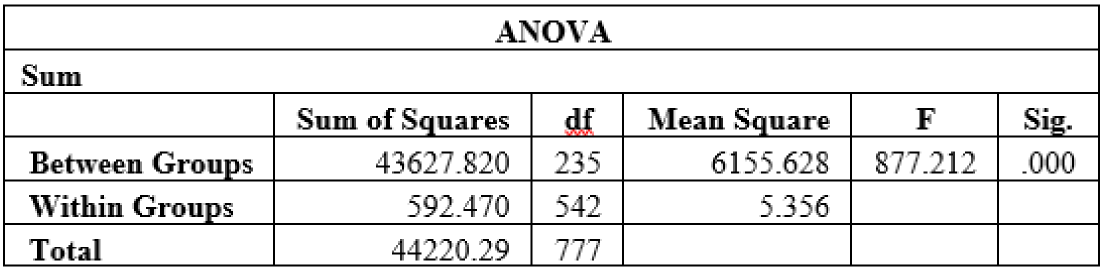
Table 2: H_1 ANOVA Test



ANOVA

Sum

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43627.820	235	6155.628	877.212	.000
Within Groups	592.470	542	5.356		
Total	44220.29	777			

The finding is significant in this research. F=877.212, with a p-value of.000 (below the.05 alpha level), approaches statistical significance. This means the ***"H_1: There is a significant relationship between Latency and Real-Time Processing & 5G Background."*** is accepted, and rejected the null hypothesis.

9. DISCUSSION

A major milestone on the road to intelligent, adaptive, flexible, and resource-efficient communication systems has been reached with the 5G framework's incorporation of wireless network intelligent sensing as well as slice resource management. Intelligent sensing captures and analyses ambient information using wireless signals, allowing networks to operate beyond data transmission. Applications like autonomous vehicles, smart security, and healthcare monitoring need real-time situational awareness, which 5G networks are able to provide. Networks can reduce latency and improve dependability with the capacity to recognise human mobility, environmental interference, and object movement. This gives them the capability to make predictive and adaptive decisions. Slice resource management also makes sure that different kinds of services may work together well on the same hardware. Whether it's very low latency, tremendous bandwidth, or huge connection, 5G ensures it by separating resources into customised virtual slices. For applications with a high degree of criticality, where poor resource allocation might compromise the system or cause performance degradation, this

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functionality is absolutely necessary. The mutual reinforcement is when intelligent sensing and slicing work together in harmony. Slice allocation may be guided dynamically by sensing data, and enough resources can be guaranteed for sensing activities via efficient slice management. By working together, they create an autonomous system that can adapt to new and different kinds of applications. However, there are still major obstacles, including issues with energy efficiency, data privacy, and spectrum scarcity.

10. CONCLUSION

Investigating intelligent sensing in wireless networks including slice resource management against the backdrop of 5G emphasises their critical significance in defining communication systems in the future. By allowing them to detect and understand changes in their surroundings via sophisticated signal processing, intelligent sensing expands the capabilities of wireless networks beyond simple data transmission. Applications requiring situational awareness and very low latency, such healthcare monitoring, autonomous cars, and industrial automation, have shown to be mission-critical in nature and need this capacity in real-time. Slice resource management, in contrast, makes sure that 5G networks can optimise and distribute resources across several virtual slices, each tailored to a different set of service needs. In order to maximise efficiency and dependability, slicing ensures quality of service (QoS), scalability, and isolation, allowing diverse applications to operate inside a single infrastructure. There is clear synergy between these two technologies when they are combined. Efficient resource management guarantees that intelligent sensing has access to sufficient resources, while sensing supplies context data that may direct proactive slice allocation. They operate in tandem to make today's wireless networks more efficient, secure, and flexible. Issues including energy limitations, data privacy concerns, and spectrum shortages persist notwithstanding these

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advancements. In order to fully use 5G, it is crucial to resolve these challenges. Future research should focus on improving sensing, orchestrating resources, and using AI to build communication ecosystems that are genuinely autonomous and intelligent.

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