10.48047/jocaaa.2023.31.04.58

INVESTIGATION OF WIRELESS NETWORK INTELLIGENT SENSING AND SLICE RESOURCE MANAGEMENT IN THE CONTEXT OF 5G

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ABSTRACT

5G, in part to the lightning-fast development of wireless communication, is a game-changer that can provide smart sensing and effective slice resource management. The advancements in 5G technology provide the groundwork for the integration of intelligence into wireless networks, which is crucial for new applications that need extremely reliable low-latency communication (URLLC), large amounts of connected devices, and faster data rates. Networks can now detect, evaluate, and adjust to changing circumstances in real time, all thanks to intelligent sensing. This improves decision-making and leads to optimal performance. Network resources may be logically partitioned into customisable slices using slice resource management. These slices can then be assigned unique service needs, such as those for mission-critical applications, the Internet of Things (IoT), or enhanced mobile broadband (eMBB). Using 5G as a backdrop, this study demonstrates how intelligent sensing and slice resource management work together to provide effective QoS delivery, scalability, and flexibility. In addition, it delves into the difficulties of dynamic allocation, interoperability, and security, all the while highlighting how AI and ML may facilitate adaptive solutions. The report highlights the importance of 5G in these interconnected areas since it paves the way for 6G and future intelligent networks, which was lead to the emergence of digital ecosystems that are smarter, safer, and more robust. In the end, this study explains in detail how intelligent sensing based on 5G and slice resource management help next-gen communication infrastructures evolve sustainably.

10.48047/jocaaa.2023.31.04.58

KEYWORDS: *5g Networks, Wireless Network Intelligence, Slice Resource Management, Intelligent Sensing.*

1. INTRODUCTION

A major step forward in improving worldwide connectivity and allowing a wide range of next-generation applications has been the advent of five-generation (5G) wireless communication. 5G is a radical departure from its forerunners, bringing with it new features such as mMTC, improved mobile broadband (eMBB), and ultra-reliable low-latency communication (URLLC). These capabilities have set the stage for intelligent sensing while also slice resource management to be integrated, which are crucial for network adaptation and efficiency. Networks can now detect, understand, and react to traffic and environmental conditions in real-time thanks to intelligent sensing. This allows for better resource utilisation and optimised decision-making. Also, using slice resource management, operators may partition a physical network into several virtualised segments that can be adjusted to meet the needs of individual services. These ideas work hand in hand to provide QoS, scalability, and flexibility in very unpredictable and diverse settings. In order to tackle issues like interoperability, security, and effective allocation, it is crucial to investigate the 5G history in connection to smart sensing and slice resource management (Efunogbon et al., 2025). In addition, it reveals important details about how 5G might pave the way for 6G and subsequent intelligent networks, which in turn can make digital ecosystems smarter, safer, and more adaptable. In order to deal with challenges like interoperability, security, and effective allocation, it is crucial to investigate the 5G history in connection to smart sensing and slice resource management. In addition, advanced sensing and slicing capabilities afforded by 5G are becoming crucial due to the rising need for smart cities, driverless cars, the Internet of Things (IoT), and industrial automation. In addition to increasing dependability and optimising spectrum utilisation, they also make

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systems more flexible and suitable for a wide range of uses. The importance of AI and ML in improving smart resource allocation and predictive network management is further highlighted by this analysis. This shift is made possible by the technological foundation provided by the 5G era's intelligent sensing and slice resource management (Moreira et al., 2025).

2. BACKGROUND OF THE STUDY

The fifth-generation (5G) network is a critical facilitator of sophisticated applications and services, and it has been instrumental in the fast advancement of wireless communication technologies, which in turn have changed the digital ecosystem. The revolutionary features introduced by 5G, in contrast to earlier generations, are eMBB, URLLC, and mMTC, or massive machine-type communication. In addition to facilitating quicker data transfer, these qualities pave the way for an infrastructure that is very intelligent, adaptable, and service-oriented. When considering this, two key elements—slice resource management and intelligent sensing—stand out as vital supports for 5G networks' effective operation and flexibility. The term "intelligent sensing" is used to describe systems that can detect, understand, and react to changing traffic and environmental circumstances in wireless networks. The ability to make well-informed judgements about data routing, resource allocation, and QoS maintenance is given to networks via this. In contrast, with slice resource management, it is possible to create several virtualised network slices on top of a single physical infrastructure (Sugumar, 2025). The Internet of Things (IoT), smart cities, driverless cars, and industrial automation are just a few examples of the many possible uses for this modular approach. The combination of these technologies guarantees efficiency, scalability, and flexibility while keeping service-level agreements (SLAs) intact for a wide range of use cases. The combination of artificial intelligence (AI) while using machine learning (ML) for predictive intelligent adaptive network operations is notably highlighted in the research of 5G

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in connection to intelligent sensing and slice resource management. It also deals with issues like security, resource optimisation, and interoperability in increasingly diverse settings. With the worldwide expansion of digital services, this research highlights the importance of 5G as the backbone of future networks (Alwakeel & Alnaim, 2024).

3. PURPOSE OF THE STUDY

The purpose of this research is to better understand how 5G was improved intelligent sensing effective slice resource management in wireless networks. Smart cities, driverless cars, the IoT, and industrial automation are just a few of the many applications that may benefit from 5G's revolutionary capabilities in meeting the growing need for dependable, high-speed, and flexible communication networks. The overarching goal of this research is to learn how intelligent sensing improves network performance and decision-making by increasing its capacity to detect, understand, and react to environmental and traffic data in real-time. Simultaneously, it delves into how operators may dynamically distribute virtualised resources across several network slices to fulfil diverse quality of service (QoS) demands using slice resource management. The research aims to emphasise the two methods' contributions to network scalability, flexibility, and effective resource utilisation by studying their integration against the 5G backdrop. Concerning interoperability, security, integrated energy efficiency, it also seeks to determine the advantages and disadvantages of using intelligent sensing and resource slicing. The significance of AI and ML in facilitating adaptive and predictive tactics for allocating resources is another key objective. In the conclusion, this research aims to shed light on how 5G might pave the way for 6G and future intelligent networks, allowing for digital ecosystems that are smarter, safer, and more robust to handle society's and industry's increasing needs (Afan & Arslan, 2025).

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4. LITERATURE REVIEW

5G is a game-changer in the world of wireless communication; it can handle all kinds of applications with lightning-fast speeds, minimal latency, and enormous amounts of connected devices. 5G brings sophisticated frameworks for adaptive and productive network management, in addition to capacity enhancements, according to recent research. Intelligent sensing and slice resource management are at the heart of these developments and are being studied more and more as potential facilitators of strong 5G performance. The importance of intelligent sensing in areas like as traffic prediction, environment-aware adaptation, and real-time network monitoring cannot be overstated. Additionally, research establishes a connection between intelligent sensing, AI, and ML, demonstrating how predictive algorithms may improve resource utilisation and decrease latency in intricate situations. However, a lot of research on slice resource management has focused on network slicing, where different applications make use of different virtualised slices. Using dynamic distribution of bandwidth, processing power, and storage across distinct slices, the results show that slice resource management guarantees flexibility (Lorincz et al., 2024). The three main types of improved mobile broadband, ultra-reliable low-latency communications, and enormous machine-type communications may all be catered to using this method. The significance of its scalability and flexibility in meeting changing customer expectations has been highlighted in several studies. In addition, academics have taken an interest in intelligent sensing as a potential efficiency optimisation technique when combined with slice resource management. Adaptability, security, and interoperability are all improved when real-time sensing and dynamic slicing are used together in heterogeneous 5G contexts. Artificial intelligence (AI) models have the ability to enhance traffic balance and predictive slice distribution, according to studies. Interoperability within slices, energy efficiency, along with guaranteeing security in

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very dynamic networks are still obstacles. In sum, the research proves that 5G is essential for intelligent sensing efficient slice resource management (Asif et al., 2024).

5. RESEARCH QUESTION

- How does the 5G network architecture support the integration of intelligent sensing for enhancing wireless communication efficiency?

6. METHODOLOGY

6.1 Study Design

Data analysis was performed quantitatively utilising SPSS version 25. Researchers assessed the strength and course of the statistical relationship by employing an odds ratio along with a 95% confidence interval. The researchers established a statistically significant criterion at $p < 0.05$. A comprehensive analysis unveiled the fundamental characteristics of the data. Quantitative methods are frequently employed to assess data gathered through polls, questionnaires, and surveys, along with data analysed using computational 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

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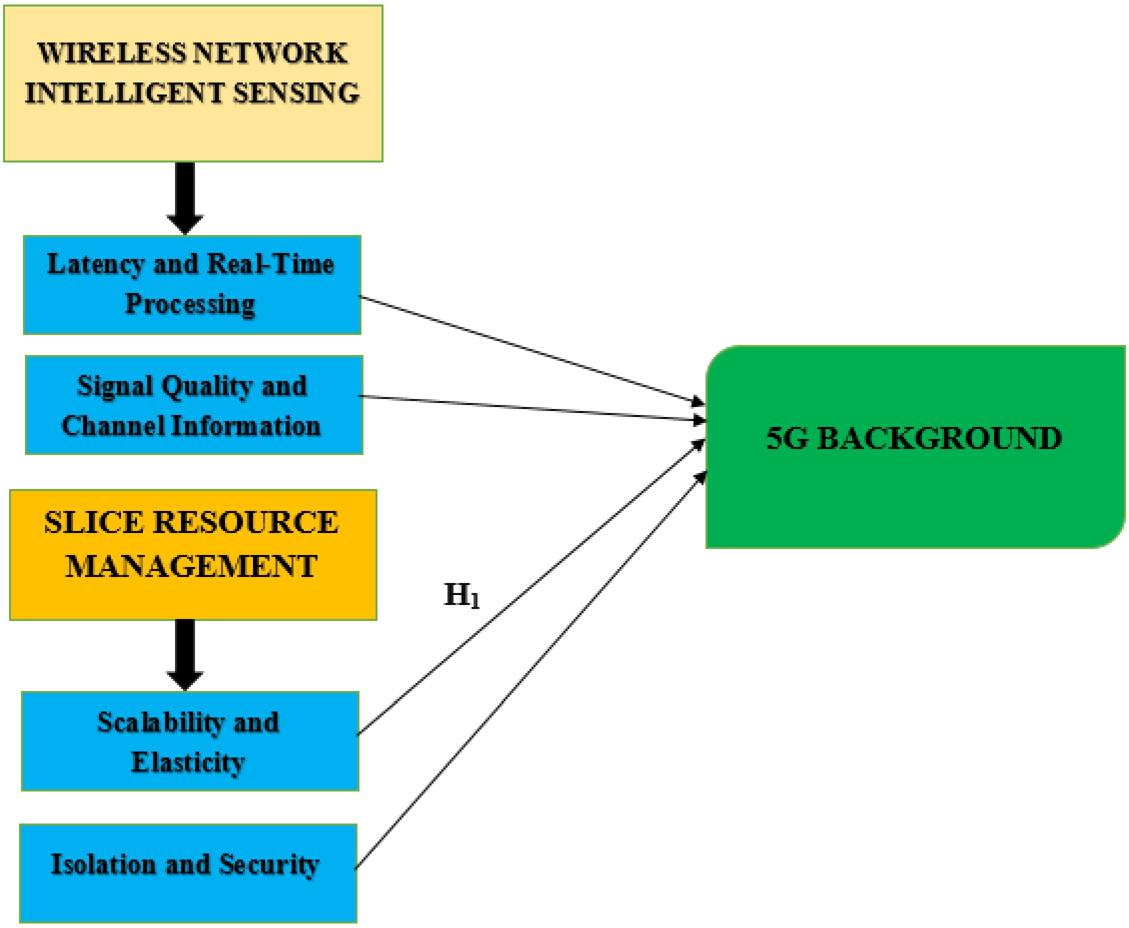
6.4 Statistical Software

SPSS 25 and MS Excel were used to do the statistical analysis.

6.5 Statistical Tools

Descriptive analysis helped us understand the main features of the data. The researcher must analyse the data using ANOVA.

7. CONCEPTUAL FRAMEWORK



8. RESULT

Factor Analysis

Factor Analysis (FA) is frequently employed to uncover latent variables within observable data. Using coefficients of regression to generate ratings is a standard approach when there are no clear visual or diagnostic indicators present. Success in FA is highly dependent on models. The

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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 size is defined as a KMO value between 0.8 and 1. According to Kaiser, these are the acceptable limits: Below are the entrance requirements as out by Kaiser:

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

A range of 0.70 to 0.79 is considered average for middle grades.

Ranging from a 0.80 and 0.89 on the quality point scale.

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 The Bartlett Test of Sphericity. The sample is adequate if the Kaiser-Meyer-Olkin statistic is 0.953. Bartlett's sphericity test shows that the p-value is 0.00. When Bartlett's sphericity test gives a positive result, researchers might conclude that a correlation matrix is not an identity matrix.

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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

Also, Bartlett's Test of Sphericity showed that correlation matrices are widely used. The Kaiser-Meyer-Olkin test shows that the sample is good enough at 0.953. The researchers got a p-value of 0.00 using Bartlett's sphericity test. A significant outcome of Bartlett's sphericity test indicated that the correlation matrix was ineffective.

❖ INDEPENDENT VARIABLE

- **SLICE RESOURCE MANAGEMENT**

Efficiently managing, regulating, and optimising network resources across several virtualised slices in a 5G context is called Slice Resource Management. Network slicing allows for the partitioning of one physical network into several logical networks, with each network configured to meet a unique set of needs, such as eMBB, URLLC, or mMTC. Making ensuring that every slice has enough storage, processing power, and bandwidth to fulfil its QoS and SLA expectations is the goal of effective slice resource management. Allocating resources dynamically, prioritising traffic, balancing loads, and continuously monitoring the network are all part of it. The use of smart algorithms, AI, and real-time analytics in slice resource management improves efficiency, flexibility, along with scalability. In the end, it's vital for a variety of 5G apps to operate, since it guarantees fairness, optimises performance, and keeps the network stable regardless of the users or apps using it.

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❖ FACTOR

- **SCALABILITY AND ELASTICITY**

Modern computer, networking, and even cloud-based systems rely on scalability and elasticity, particularly in the context of the 5G paradigm. A scalable system may scale up its resources, either horizontally (by adding more nodes) or vertically (by adding more power to existing computers), to manage additional workloads or users. Maintaining efficiency and reliability in the face of increasing demand is the hallmark of a scalable system. Elasticity, in contrast, allows resources to be automatically increased or decreased in response to changes in demand, highlighting flexibility. One example is the allocation of extra bandwidth or processing capacity during high consumption and the release of resources during low demand to reduce expenses. Optimal resource utilisation, cost efficiency, and flexibility are achieved when scalability and elasticity work together. These characteristics are critical for future 5G networks to serve a wide range of applications, including the Internet of Things (IoT), intelligent network services, and ultra-reliable, low-latency communications.

❖ DEPENDENT VARIABLE

- **5G BACKGROUND**

The upcoming 5G mobile communication standard is a significant upgrade over its predecessors, 4G and 3G. 5G is a significant improvement over its predecessors in terms of connection reliability, latency, and capacity, as well as speed and quality of data transfer and voice calls. Smart cities, driverless vehicles, industrial automation, and the Internet of Things (IoT) are just a few examples of how its architecture is designed to support the exponential growth of connected devices. 5G operates by using state-of-the-art innovations like as millimeter-wave spectrum, massive MIMO, network slicing, and edge computing. These

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developments allow it to provide data rates of up to 10 Gbps, connect millions of devices per square kilometre, and give latency as low as 1 millisecond.

- **Relationship of between Scalability and Elasticity & 5G Background**

The relationship between 5G Background, Scalability, and Elasticity is in the way that these two concepts facilitate the effective operation of networks of the future. With scalability, 5G networks can add resources to handle more traffic, more users, and more services without sacrificing performance. Conversely, elasticity enables these resources to be real-time modified, which improves efficiency and cost-effectiveness by scaling up throughout peak loads and scaling down during low demand. 5G is very versatile, because to its scalability and flexibility, and it can guarantee QoS in a wide range of situations. For the seamless migration to 6G and subsequent intelligent networks, this connection is crucial for allowing smart sensing, network slicing, along with resource management.

On the basis of the above discussion, the researcher formulated the following hypothesis, which was analyse the relationship between Scalability and Elasticity & 5G Background.

“H_{01}: There is no significant relationship between Scalability and Elasticity & 5G Background.”

“H_1: There is a significant relationship between Scalability and Elasticity & 5G Background.”

Table 2: H_1 ANOVA Test

ANOVA					
Sum					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41582.670	258	5657.517	851.434	.000
Within Groups	634.310	519	5.336		
Total	42216.98	777			

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The result of this investigation is significant. The F value is 851.434, and the p-value is .000, which is less than the .05 alpha level, therefore it is significant. This indicates that the null hypothesis is rejected and the "H1: There is a significant relationship between Scalability and Elasticity & 5G Background" is accepted.

9. DISCUSSION

The study of 5G backdrop for smart sensing in wireless networks along with slice resource management demonstrates 5G's revolutionary significance in allowing communication infrastructures that are smarter and more adaptive. 5G brings new capabilities such enhanced mobile broadband (eMBB), massive machine-type communication (mMTC), and ultra-reliable low-latency communication (URLLC). These provide the groundwork for intelligent sensing as also dynamic network slicing, which were not possible in previous generations. Better resource utilisation and consistent service quality under fluctuating demands are made possible by networks that are equipped with intelligent sensing, which allows them to monitor, understand, and react to real-time situations. These sensing capabilities, when combined with slice resource management, enable the development of specialised network slices that meet the needs of applications like autonomous systems, smart cities, and the Internet of Things. Maximising this integration is possible with the use of AI and ML, which allows for more secure systems, adaptive traffic management, and predictive resource allocation. Problems with interoperability among slices, excessive power consumption, and providing strong security in diverse settings are still major roadblocks. If 5G-enabled intelligent sensing and slicing resource management are to reach their full potential, these obstacles must be overcome. In addition, the talk emphasises how this integration improves 5G apps now and lays the framework for 6G, with more autonomous, sustainable, more intelligent networks predicted in that generation.

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10. CONCLUSION

In conclusion, 5G's history in the context of smart sensing in wireless networks and slice resource management highlights 5G's critical function beyond that of a high-speed communication technology. It solidifies 5G's position as a game-changing technology that can handle a wide range of data-intensive, mission-critical applications by combining cognitive sensing with dynamic slice resource management. With the help of intelligent sensing, networks can better understand and react to their environments in real-time, leading to more efficient and dependable decision-making. Furthermore, with the help of slice resource management, real infrastructure may be partitioned into several virtualised slices that can be customised to meet unique needs, such eMBB, URLLC, or mMTC. These processes work in tandem to provide QoS, scalability, and flexibility in diverse settings. Predictive and adaptive solutions for intelligent sensing and resource allocation are driven by artificial intelligence (AI) and machine learning (ML), according to the research. To be sure, 5G networks have a lot of promise, but there are still certain problems with interoperability, energy efficiency, and security that need fixing. 5G's intelligent detection and slicing resource management features improve existing apps and set the stage for smarter networks in the future.

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