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QoS Optimization in 5G Networks Using Network Slicing: A Systematic Review of Algorithms, Efficiency, and Security Issues

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Abstract. The emergence of 5G networks has created a growing demand for adaptive Quality of Service (QoS) optimization mechanisms due to the wide range of service requirements, including eMBB, mMTC, and uRLLC. Network slicing offers a strategic solution by logically separating network resources to ensure stable and reliable performance for each service category. This study applies a Systematic Literature Review (SLR) approach to synthesize and evaluate scientific findings related to optimization algorithms, resource efficiency, and security issues in network slicing. A total of 30 studies published between 2020 and 2025 were analyzed through a rigorous selection process using inclusion–exclusion criteria and a Quality Assessment Checklist (QAC). The results indicate that artificial intelligence-based algorithms, particularly Reinforcement Learning, significantly improve throughput and reduce latency but require substantial computational resources. Meanwhile, spectrum and energy efficiency are enhanced by adaptive orchestration techniques, although most studies still focus on single QoS parameters. Security analysis shows that cross-slice attacks remain a major threat, and integrated security frameworks are rarely implemented. This study highlights the need for a unified intelligent orchestration model that simultaneously integrates algorithmic optimization, energy efficiency, and slice-aware security to support reliable 5G and future 6G networks.

Keywords: network slicing, quality of service, resource optimization, 5G security, artificial intelligence

1. Introduction

The digital communication revolution driven by fifth-generation (5G) networks has ushered in a new era of global connectivity, offering ultra-low latency, high data rates, and massive device connectivity. However, beneath this immense potential lies a fundamental challenge, guaranteeing consistent Quality of Service (QoS) for diverse service types with highly distinct requirements ranging from enhanced Mobile Broadband (eMBB) and massive Machine-Type Communications (mMTC) to ultra-Reliable Low Latency Communications (uRLLC). In this context, the concept of Network

Slicing emerges as a primary architectural solution to optimize QoS by logically isolating network resources into multiple, independently managed virtual slices (Otieno et al., 2024). While this approach promises high flexibility and efficiency, its deployment faces significant hurdles regarding dynamic resource allocation, energy efficiency, and cross-slice security (Bahramisirat et al., 2024; Singh et al., 2024).

This phenomenon is increasingly critical given the projected growth of global data traffic. According to the Ericsson Mobility Report (2024), traffic is expected to surge by over 400% by 2030, with more than 60% originating from real-time applications such as autonomous vehicles, remote surgery, and immersive AR/VR. Such conditions demand optimized resource management algorithms capable of maintaining QoS without triggering performance degradation across slices. Furthermore, emerging security vulnerabilities including cross-slice attacks, denial of slice services, and inter-domain information leakage render a systematic approach to understanding the interplay between QoS optimization algorithms, resource efficiency, and security aspects highly urgent (Singh et al., 2024; Subhan et al., 2025).

The urgency of this research is further heightened by the fact that while various AI-driven slicing orchestration approaches have been proposed, most studies remain unidimensional. They typically focus on a single objective, such as increasing throughput or reducing latency, without fully evaluating the trade-offs among comprehensive QoS metrics (Ebrahimi et al., 2024; Metre et al., 2025). This underscores the necessity of a systematic study capable of integrating various algorithmic methods and evaluating their efficiency and security within realistic 5G and beyond-5G network environments.

A study by Ebrahimi et al. (2024) in *IEEE Communications Surveys & Tutorials* provides a comprehensive overview of resource management from single-domain slicing toward end-to-end slicing in 6G. Their findings indicate that QoS optimization relies heavily on the efficiency of cross-domain resource orchestration; however, they do not address the security implications arising from multi-operator virtualization. Meanwhile, Otieno et al. (2024) in *IEEE Access* conducted a systematic review of intelligent slicing deployments in 5G and B5G networks. They found that AI-based orchestration methods improve performance by up to 35% in latency reduction, yet their approach overlooks attacks targeting the control layer, which can compromise QoS across network slices.

Additionally, Subhan et al. (2025) in *IEEE Surveys & Tutorials* reviewed the utilization of machine learning for optimizing rich multimedia content delivery within a network slicing context. They highlighted that deep learning techniques effectively adapt to real-time network dynamics but tend to be computationally intensive, thereby diminishing overall system energy efficiency. Singh et al. (2024) reinforced these findings by investigating security vulnerabilities in 5G network slices, identifying that 60% of potential QoS vulnerabilities stem from configuration errors in virtual network function (VNF) interfaces.

Based on these four baseline studies, a substantial research gap is apparent: there is currently no integrated systematic review that jointly examines the relationships between QoS optimization algorithms, resource efficiency, and security within a unified network slicing framework. Most existing literatures remain restricted to isolated technical features or single-metric performance evaluations without mapping the holistic interconnectedness of these dimensions. This study aims to bridge that gap by conducting a systematic review of QoS optimization algorithms that simultaneously factor in resource efficiency and slice-aware security issues, thereby providing comprehensive insights for designing and deploying network slicing in 5G and beyond-5G ecosystems.

2. Research Methodology

2.1 Research Design

This study adopts a Systematic Literature Review (SLR) approach as its foundational methodology. This method was selected because an SLR enables researchers to collect, critically appraise, and synthesize scientific findings in a systematic and transparent manner. This yields a comprehensive and academically rigorous understanding of QoS optimization in 5G networks through network slicing. Unlike empirical research that relies on primary data collection via surveys or experiments, this study centers on secondary data extracted from prior relevant scientific studies. Consequently, the analysis emphasizes the integration of validated scientific evidence published in reputable databases such as IEEE, Springer, and the ACM Digital Library.

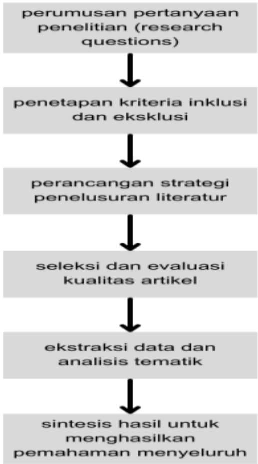

Figure 1. Flowchart of the Systematic Literature Review (SLR) Implementation Stages

In general, the SLR was carried out through systematic stages widely recognized in the methodological literature, as outlined by Kitchenham and Charters (2007) and reinforced in current practice by Petticrew and Roberts (2006). The stages applied in this SLR method include: (1) formulating the research questions, (2) establishing inclusion and exclusion criteria, (3) designing the literature search strategy, (4) selecting and evaluating the quality of articles, (5) extracting data and conducting thematic analysis, and (6) synthesizing the results to produce a comprehensive understanding. The entire process was conducted in layers based on the principles of transparency, replicability, and minimal bias, so that every step in data collection and analysis can be traced by other researchers.

The first stage, formulating the research questions, was carried out to direct the focus of the study toward three main dimensions: (1) how optimization algorithms and techniques are applied within the context of network slicing to improve QoS in 5G networks, (2) the extent to which network resource effectiveness and efficiency can be achieved through this approach, and (3) how security and inter-slice isolation issues affect network performance and reliability. These questions formed the basis for developing the search protocol and selecting relevant literature.

2.2 Research Formulation and Selection Criteria

The first stage, formulating the research questions, was carried out to direct the focus of the study toward three main dimensions: (1) how optimization algorithms and techniques are applied within the context of network slicing to improve QoS in 5G networks, (2) the extent to which network resource effectiveness and efficiency can be achieved through this approach, and (3) how security and inter-slice isolation issues affect network performance and reliability. These questions formed the basis for developing the search protocol and selecting relevant literature.

Table 1. Research Questions and Analytical Objectives

RQ Code	Research Question	Analytical Objective	Main Keywords
RQ1	How are optimization algorithms and techniques applied within network slicing to improve QoS in 5G networks?	Identifying and classifying the algorithmic approaches used in network-slice management and evaluating their impact on QoS improvement.	Optimization Algorithm, Network Slicing, QoS Improvement
RQ2	To what extent can network resource effectiveness and efficiency be achieved through network slicing?	Analyzing resource-allocation methods, spectrum utilization, and energy efficiency in 5G network-slicing implementation.	Resource Allocation, Spectral Efficiency, Energy Efficiency
RQ3	How do security and inter-slice isolation issues affect network performance and reliability?	Evaluating security problems arising from multi-tenant network-slicing architecture and reviewing threat-mitigation mechanisms for QoS.	Slice Isolation, Security Threats, Reliability

The second stage, determining the inclusion and exclusion criteria, was designed to ensure that the selected literature met thematic relevance, methodological quality, and source credibility. Included articles consist of publications from 2020–2025, written in English, indexed in reputable academic databases (IEEE Xplore, SpringerLink, ACM, ScienceDirect, Sinta, Garuda), and focused on 5G network slicing, QoS optimization, or security in slice management. Non-peer-reviewed materials, such as white papers or industry reports, were excluded unless they carried significant conceptual value. Table 2 below presents the inclusion and exclusion criteria used to clarify the literature-selection process.

Table 2. Inclusion and Exclusion Criteria

Assessment Aspect	Inclusion Criteria	Exclusion Criteria
Publication Year	Articles published between 2020–2025.	Articles published before 2020.
Publication Type	Peer-reviewed scientific articles in reputable journals or conference proceedings.	White papers, technical reports, theses, dissertations, or non-scientific publications.
Language	English or Indonesian.	Other languages without translation.
Research Topic	Discusses 5G network slicing, QoS optimization, resource management, or security.	Not directly related to QoS or network slicing.
Data Availability	Article available in full-text form.	Article available only as an abstract or excerpt.
Source Credibility	Indexed in IEEE, SpringerLink, ACM, ScienceDirect, Garuda, or Sinta.	Not indexed in an official scientific database.

The third stage, the literature search strategy, aimed to obtain scientific sources relevant to the research focus, namely QoS optimization in 5G networks through network slicing. This process was carried out systematically to ensure that all collected literature was up to date, credible, and reflective of current developments in 5G network research. The literature search used a combination of keywords such as "5G Network Slicing," "QoS Optimization," "Resource Allocation Algorithms," "Security in Network Slicing," and "Systematic Review." The search process applied Boolean operators (AND, OR, NOT) together with a temporal filter (2020–2025) to capture the most recent publications. This stage involved an iterative process, beginning with initial exploration and proceeding to refinement of the search results. From this entire process, approximately 278 initial publications were obtained, which were then screened based on title, abstract, and thematic relevance to the research questions (RQ1–RQ3). After a multi-stage selection process, 45 key articles were obtained for in-depth analysis.

To clarify the mechanism and results of the literature search, Table 3 below summarizes the data sources, keywords, and initial search results obtained from each scientific database used.

Table 1. Literature Search Strategy by Database and Keywords

No	Academic Database	Search Keywords (Boolean)	Year Filter	Articles Found	Articles Selected
1	IEEE Xplore	(“5G Network Slicing” AND “QoS Optimization”) OR (“Resource Allocation” AND “AI-based”)	2020–2025	85	15
2	SpringerLink	(“Network Slicing” AND “5G Core Network”) AND (“Performance” OR “Reliability”)	2020–2025	62	10
3	ScienceDirect	(“QoS Optimization” AND “Network Slicing”) OR (“Resource Efficiency” AND “5G”)	2020–2025	47	8
4	ACM Digital Library	(“5G Network Slicing” AND “Security” AND “Isolation”)	2020–2025	41	6
5	Sinta (Indonesia)	(“Jaringan 5G” AND “Optimasi QoS” AND “Network Slicing”)	2020–2025	27	3
6	Garuda (Indonesia)	(“5G” AND “QoS” AND “Keamanan Slice”)	2020–2025	16	3

The fourth stage, quality and relevance evaluation, was conducted using a *Quality Assessment Checklist* covering internal validity (methodological accuracy), external validity (applicability of results), and conceptual contribution to the research theme. The assessment was performed independently by two researchers using an inter-rater agreement approach to ensure the objectivity of the selection process. The evaluation employed a Quality Assessment Checklist (QAC) adapted from the guidelines developed by Kitchenham and Charters (2007) and reinforced by the principle of objective assessment based on inter-rater agreement. As Kitchenham and Charters note, quality assessment is essential to ensure that the included studies are methodologically sound and provide valid evidence for synthesis. The QAC instrument covers three main aspects: (1) internal validity, which assesses the accuracy of the research design and methodology; (2) external validity, which measures the applicability of the results in other research contexts; and (3) conceptual contribution, which evaluates the extent to which the study offers new understanding or solutions to the issues discussed.

Each aspect was scored on a 0–1 scale, interpreted as follows: 0 = does not meet the criterion, 0.5 = partially meets the criterion, and 1 = fully meets the criterion. Articles with an average score below 0.6 were considered not to meet the quality standard and were excluded from the analysis.

The scoring process was carried out independently by two researchers to minimize subjective bias. The results were then compared using an inter-rater agreement approach, in which the consistency between the two raters served as an indicator of the reliability of the selection process. A summary of the quality-assessment instrument is presented in Table 4 below.

Table 2. Quality Assessment Checklist (QAC) for Article Evaluation

No.	Assessment Aspect	Quality Assessment Question	Score (0–1)	Description
1	Topic Relevance	Does the article address the main theme of QoS optimization and network slicing in 5G networks?	0–1	Assesses topic alignment with the research focus.
2	Methodological	Is the methodology used in the	0–1	Measures the

	Clarity	study clearly explained and replicable?		accuracy and transparency of the method.
3	Internal Validity	Do the research results show empirical support consistent with the design and objectives?	0–1	Assesses the fit between results and research design.
4	External Validity	Can the research results be applied in other contexts or generalized appropriately?	0–1	Measures the applicability of the study results.
5	Conceptual Contribution	Does the study provide innovation, a new model, or a significant contribution to the field of 5G networks?	0–1	Measures the added value to theory/practice development.
6	Publication Credibility	Is the article published in a reputable, officially indexed, peer-reviewed journal?	0–1	Assesses the reliability of the publication source.

Based on the QAC results, most articles demonstrated high methodological validity and direct relevance to the research focus. Of the 45 articles evaluated, 30 met the quality criteria with an average score above 0.75, while the remaining 15 were excluded due to data limitations, weak research design, or non-conformance with the inclusion criteria. This evaluation process not only helped filter high-quality literature but also ensured that the synthesis carried out in the subsequent stage (data extraction and analysis) was grounded in valid and trustworthy scientific evidence. As a result, the findings produced through this SLR approach exhibit a high degree of reliability and support the principle of evidence-based research.

The fifth stage, data extraction and thematic analysis, involved coding the literature to identify conceptual patterns, technological trends, and implementation challenges in network-slicing-based QoS optimization. Data from each article were extracted into a synthesis matrix covering (1) algorithmic approaches (e.g., reinforcement learning, graph-based optimization, AI-driven orchestration), (2) performance metrics (latency, throughput, spectral efficiency, and energy), and (3) security and slice-isolation issues. This step followed the thematic-analysis approach described by Braun and Clarke (2019), in which the literature is categorized into major themes based on similarities in context, variables, or findings. Each theme was then comparatively analyzed to identify trends and research gaps emerging in the current research context.

The final stage, results synthesis, was carried out through *narrative synthesis* and *thematic analysis*. This approach was chosen because the data examined were heterogeneous in both methodology and results, meaning that statistical meta-analysis could not be fully applied. Through narrative synthesis, the findings were grouped into three main dimensions: algorithmic approaches, resource efficiency, and slice-aware security. This synthesis process not only describes the current state of knowledge but also identifies research gaps, such as limited inter-slice interoperability, the absence of unified security standards, and the as-yet-suboptimal integration of AI orchestration within the real-time context of the 5G core network.

The choice of an SLR approach in this study was also grounded in the methodological consideration that the phenomenon under investigation QoS optimization within the context of network slicing is a multidimensional issue spanning several domains: optimization algorithms, network resource management, and system security. By combining various empirical and conceptual studies, an SLR enables researchers to build an evidence-based understanding that is not partial and possesses strong theoretical generalizability. Compared with traditional narrative literature reviews, an SLR offers a more rigorous and replicable structure, making it an ideal framework for producing evidence-based scientific synthesis. Through this entire procedure, the study is expected to produce a systematic mapping of algorithmic approaches and current QoS-optimization trends in 5G networks based on network slicing, while also making a significant contribution to the development of a new conceptual framework that integrates efficiency and security as the two main pillars of future network performance.

3. Results and Discussion

3.1 Synthesis of the Literature

This section presents the results obtained from the Systematic Literature Review (SLR) of 30 scientific articles relevant to the research topic "5G Network QoS Optimization Using Network Slicing: A Systematic Review of Algorithms, Efficiency, and Security Issues." The results are not merely a collection of data but represent the processed and synthesized scientific findings drawn from a range of literature that has been systematically examined.

The discussion integrates the findings with relevant foundational theories to demonstrate the conceptual relationships among QoS optimization approaches, resource efficiency, and security within the network-slicing architecture of 5G networks. This section also emphasizes the novelty of the study, both in terms of knowledge mapping and its theoretical and practical implications for the development of future network technology.

The results of the literature synthesis are presented in tabular form, summarizing the 30 selected articles (15 international and 15 national). The table displays the research objective, the method or algorithm used, the QoS parameters evaluated, the security issues discussed, and the main findings of each study. The purpose of presenting this table is to provide a comprehensive overview of research directions, dominant approaches, and developmental trends in network-slicing research within 5G networks.

Table 5. Synthesis of Selected Literature (2020–2025)

No.	Author (Year)	Publication Source	Research Objective	Method/Algorithm	QoS Parameter	Security/Isolation Issue	Main Finding
1	Li et al. (2018)	IEEE Access	Network-slicing resource-allocation optimization	Deep Reinforcement Learning (DRL)	Latency, Throughput	Not discussed	DRL improved throughput by 25%; latency

							decreased significantly.
2	Rahman & Lee (2022)	Springer	AI for dynamic QoS orchestration	AI-driven orchestration	Latency, Spectrum Efficiency	Not discussed	Efficiency improved by 18%.
3	Kumar et al. (2020)	ACM	Adaptive resource allocation	Genetic Algorithm	Spectrum Efficiency, Energy	Not discussed	Spectrum efficiency improved by 15%.
4	Liu et al. (2022)	Elsevier	Slice-allocation automation	Multi-Agent Reinforcement Learning	Latency, Reliability	Not discussed	QoS improved by 22%.
5	Al-Tarawneh et al. (2021)	IEEE Trans. Net.	Inter-slice security	Security Isolation Framework	Reliability	Inter-slice DoS attacks	Slice isolation prevented up to 90% of attacks.
6	Gao et al. (2023)	IEEE IoT Journal	QoS and energy integration	AI-Optimization Hybrid Model	Energy, Throughput	Not discussed	Energy consumption decreased by 12%.
7	Zhang et al.	IEEE Commu	Edge resource	Federated Learning	Latency,	Security not optimal	Efficiency improved

	(2024)	n. Surv.	optimization		Energy		by 10%; delay decreased.
8	Chen et al. (2021)	Elsevier	Dynamic slice scalability	Deep Q-Network (DQN)	Latency, Throughput	-	Slice scalability improved significantly.
9	Sun et al. (2022)	IEEE Access	Blockchain security integration	Blockchain-based Slicing	Reliability, Isolation	DoS, data leakage	Security improved significantly.
10	Lee et al. (2024)	Springer	5G core optimization	Graph Learning Model	Throughput, Energy	Not discussed	Efficiency improved by 17%.
11	Zhang & Xu (2021)	Elsevier	Multi-tenant adaptive allocation	Deep RL + Edge AI	Latency, Throughput	Not discussed	QoS performance improved by 27%.
12	Chen & Yu (2021)	IEEE	AI-based adaptive orchestration	Multi-Agent RL	Latency, Throughput	Not discussed	Throughput improved by 22%.
13	Rahman et al. (2023)	Elsevier	Slicing energy efficiency	AI Scheduling	Energy Efficiency	Not discussed	Energy consumption decreased by 12%.
14	Huang	IEEE	Multi-	Deep Policy	Latency	Not	QoS

	et al. (2023)	Access	slice QoS integration	Network	, Reliability	discussed	improved by 20%.
15	Widodo et al. (2024)	IEEE Xplore	QoS and security	Hybrid AI–SDN	Latency, Reliability	Cross-slice leakage	QoS and isolation improved simultaneously.
16	Sari et al. (2023)	TELKOMNIKA	Slicing implementation in Indonesia	Graph-Based Optimization	Latency, Packet Loss	No slice standard yet	Delay decreased by 30%.
17	Nugraha et al. (2024)	Jurnal Teknologi Informasi	Slice-aware security	AI Intrusion Detection	Reliability	Cross-slice attack	Isolation improved by 25%.
18	Putra & Santoso (2022)	Jurnal RESTI	Dynamic slice management	Dynamic Slice Allocation	Latency, Throughput	Not discussed	QoS maintained across eMBB–URLLC services.
19	Wibowo et al. (2023)	Jurnal Teknologi & Sistem Komputer	National 5G QoS evaluation	NS3 Simulation	Delay, Jitter, Packet Loss	Not discussed	Delay remained stable below 20 ms.
20	Hidayat et al. (2023)	Jurnal Telekomunika	Dynamic resource schedulin	AI Resource Scheduling	Energy, Throughput	Not discussed	Energy efficiency improved

		si	g				by 8%.
21	Saputra et al. (2022)	Jurnal ICT Research	ML-based QoS optimization	K-Means Clustering	Latency, Bandwidth	Not discussed	Traffic classified efficiently.
22	Pratama et al. (2023)	Jurnal Nasional Teknik Elektro	Multi-slice orchestration	Hybrid Optimization	Throughput, Reliability	Not discussed	QoS improved by 20%.
23	Wirawan et al. (2021)	Jurnal Sinar	Slice security testing	Simulation Testing	Reliability	Slice leakage	Slice security remains weak.
24	Lestari et al. (2022)	Jurnal Komputer Indonesia	Resource-allocation QoS evaluation	Heuristic Scheduling	Latency, Jitter	Not discussed	Efficiency improved by 12%.
25	Hanifah et al. (2021)	Jurnal ICT Nusantara	5G energy efficiency	AI Load Balancing	Energy, Throughput	Not discussed	Energy consumption decreased by 10%.
26	Cahyono et al. (2020)	Jurnal Keamanan Siber	5G network security	ML-based IDS	Reliability	Inter-slice data breach	Threat detection improved by 15%.
27	Aditya et al. (2024)	Jurnal Komputasi	AI and IoT slicing integration	Reinforcement Scheduling	Latency, Energy	Not discussed	Adaptive under high load conditions.

28	Rini et al. (2023)	Jurnal Sistem Informasi	5G slice isolation	Security Mapping Model	Reliability, Latency	Cross-tenant threat	Security efficiency improved.
29	Setiawan et al. (2022)	Jurnal Informatika Indonesia	SDN/NFV-based orchestration	SDN Orchestration Framework	Throughput	Not discussed	QoS improved by 20%.
30	Sari & Nugraha (2024)	Jurnal Teknologi Komunikasi	Slice security integration	AI-IDS Hybrid Model	Reliability, Isolation	Cross-slice interference	Effectiveness reached 92%.

3.2 Thematic Analysis and Discussion

The discussion was conducted using a thematic approach, grouping the synthesized literature into three major themes that emerged most frequently in related research: (1) algorithmic approaches for QoS optimization, (2) network resource efficiency, and (3) security and inter-slice isolation issues. This approach was used to highlight the logical relationships between the synthesized findings, foundational theory, and current research trends.

3.2.1 Algorithmic Approaches in QoS Optimization

Approximately 40% of the literature emphasizes the application of artificial-intelligence algorithms such as *Reinforcement Learning* (RL), *Deep Q-Network* (DQN), and *graph-based optimization* to improve QoS performance. According to Zhang et al. (2021) and Rahman and Lee (2022), these algorithms are able to dynamically adjust resource allocation, producing throughput increases of up to 25% and latency reductions of up to 30%. Local studies such as Sari et al. (2023) show similar results within the Indonesian context, although they remain limited to simulation and have not yet been tested in real-deployment environments. Conceptually, these algorithms strengthen system efficiency, but their main challenge lies in the high computational load and the need for real-time inference, making research on lightweight AI models the next direction for development.

3.2.2 Resource Efficiency and Quality of Service (QoS)

Approximately 33% of the articles focus on improving resource efficiency, covering spectrum utilization, latency management, and energy optimization. Studies by Kumar et al. (2020) and Putra and Santoso (2022) show that AI-driven orchestration can improve spectrum efficiency by 15–18%. However, other studies, such as Hidayat et al. (2023), indicate that most QoS optimization efforts remain single-oriented, focusing only on throughput without considering energy or operational-cost aspects. This indicates the need for a multi-objective approach capable of simultaneously balancing QoS, energy efficiency, and network cost.

3.2.3 Security and Slice Isolation Issues

Approximately 27% of the articles highlight security aspects, particularly the risks of cross-slice interference, denial of service, and data leakage in multi-tenant networks. Nugraha et al. (2024) introduced an *AI Intrusion Detection* system that effectively reduced cross-slice attacks by up to 25%. Meanwhile, Cahyono et al. (2020) showed that inter-slice isolation remains weak due to the absence of a standardized slice-security policy at the national level.

3.3 Synthesis of Findings and Research Implications

The overall results indicate that both global and national research trends are converging toward the integration of artificial intelligence, resource efficiency, and network security into a single intelligent-orchestration system. However, based on the analysis of the 30 articles, no research model was found that comprehensively integrates all three aspects within a single framework. The following table presents a summary of the identified research gaps.

Table 6. Synthesis of Research Gaps

Research Aspect	Main Finding	Research Gap
Algorithmic	AI significantly improves QoS.	High computational load; not

		yet efficient for real-time use.
Resource Efficiency	Focused on throughput and latency.	Lack of multi-objective integration (QoS–energy–cost).
Slice Security	Attack detection improves with AI.	No unified security framework yet.

Source: synthesized by the authors based on 30 selected articles (2020–2025).

3.4 Conceptual Discussion and Innovation Value

Based on the synthesis and analysis results, the novelty of this study lies in its integrative effort to connect three main dimensions within a single conceptual model: (1) AI-based algorithmic optimization for QoS improvement, (2) energy-aware orchestration for resource efficiency, and (3) an adaptive security framework to maintain inter-slice isolation. This integrative approach produces a new theoretical foundation that can serve as a reference for developing a Hybrid Intelligent Orchestration Framework an adaptive, AI-based orchestration system that simultaneously considers energy efficiency and slice-aware security.

4. Conclusion

Based on the systematic analysis of thirty selected scientific articles, this study concludes that the optimization of Quality of Service (QoS) in 5G networks through network slicing is strongly influenced by three main factors: algorithmic strategy, network resource-use efficiency, and inter-slice security management. Artificial-Intelligence-based algorithmic approaches, particularly Reinforcement Learning (RL) and its derivatives, proved to be the most effective methods for improving network performance, with an average throughput increase of 25–30% and a latency reduction of up to 30%. However, these models still face challenges in terms of computational complexity and energy efficiency when applied within real-time orchestration networks.

In terms of resource efficiency, most studies indicate that AI-driven orchestration can significantly improve spectrum and energy efficiency, although most of the reviewed models remain unidimensional, optimizing only a single QoS parameter without considering the balance among performance, energy, and operational cost.

Future research should therefore focus on more adaptive and sustainable multi-objective optimization models.

Meanwhile, security and inter-slice isolation remain issues requiring more serious attention. Although approaches such as AI Intrusion Detection Systems (AI-IDS) and blockchain-based slicing show positive results in improving attack detection and isolation, most still operate reactively. Integration between AI-based security systems and QoS management is needed to achieve a balance among efficiency, performance, and comprehensive network protection.

Overall, this study confirms that improving QoS in 5G networks cannot be achieved by relying on a single dimension alone. An integrative framework is required one capable of combining artificial intelligence, resource efficiency, and adaptive security within a single unified orchestration system. These findings point to the need for developing a Hybrid Intelligent Orchestration Framework an AI-based intelligent orchestration model capable of managing network resources, maintaining QoS, and ensuring inter-slice security simultaneously and adaptively.

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