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EVOLVING PRIVATE NETWORK : FROM 5G TO AUTONOMOUS 6G WITH CO - MANAGEMENT

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Abstract:
Private wireless networks are undergoing a revolution that takes them from a static deployment of 5G networks across the board to a stage where autonomous, AI-driven private 6G networks will be operational. To facilitate the migration of enterprises and thus the smooth transition while at the same time controlling the growing complexity of network operations, essential design patterns and migration strategies are in place. The collaboration co-management models that include the operative, the system integrators, and the IT/OT teams of the enterprise provide the basis for shared responsibility regarding the performance, security, and service assurance of the networks. Architectural principles such as distributed intelligence, dynamic spectrum management, and zero-trust security frameworks are considered the very basics in the case of autonomous private 6G networks. Migration pathways steer towards phased adoption in order to secure interoperability with the current 5G infrastructure and integration of AI-driven monitoring and orchestration tools. This strategy presents a complete roadmap for companies that wish to utilize the benefits of the private 6G technology, such as ultra-low latency, improved reliability, and flexible service delivery. The merging of tech innovations and organizational changes will empower the telecom sector to be more agile, productive, and digitally resilient with the next-gen private networks

Keywords: Autonomous private 6G, Private 5G migration, AI-driven networks, Co-management models, Design patterns

I. INTRODUCTION

Telecommunications are changing very quickly. Enterprises want to move from old private 5G networks to new autonomous private 6G systems. Some advantages of private 5G are connectivity, security, and controlling the area locally. It provided the industries and enterprises with ultra-reliable low-latency communication (URLLC) and dedicated network resources, thus supporting applications like in the industrial and enterprise sectors. On the other hand, the increasing complexity of digital transformation and automation demands more intelligent, dynamic, and adaptable networks to meet future business and operational requirements.Private 6G, on the other hand, is expected to combine these capabilities with the introduction of more sophisticated AI and ML technologies for the autonomous network management of AI and ML applications, with the main characteristics of proactive diagnostics, real-time orchestration, and self-optimization. This shift demands new designs that intertwine distributed intelligence, dynamic spectrum management, and zero-trust security to bring about the highest reliability, security, and flexibility levels ever.Moving from private 5G to private 6G will require a gradual migration plan that maintains the compatibility of the current network infrastructure and, at the same time, introduces the AI-driven management and orchestration tools. The co-management model is the key factor of this change. Here, telecoms service providers, system integrators, and enterprise IT/OT teams work closely together. This collaboration guarantees not only smooth operation but also the customer- aligned service delivery with security constantly assured.The introduction gives a picture of the current situation in the private wireless network evolution and points out the transition ways, design principles, and models of collaboration that will support the future development of operator-neutral private networks and enterprise verticals.

II. LITERATURE SURVEY

Telecommunications are changing very quickly. Enterprises want to move from old private 5G networks to new autonomous private 6G systems. Some advantages of private 5G are connectivity, security, and controlling the area locally. It provided the industries and enterprises with ultra-reliable low-latency communication (URLLC) and dedicated network resources, thus supporting applications like in the industrial and enterprise sectors. On the other hand, the increasing complexity of digital transformation and automation demands more intelligent, dynamic, and adaptable networks to meet future business and operational requirements.Private 6G, on the other hand, is expected to combine these capabilities with the introduction of more sophisticated AI and ML technologies for the autonomous network management of AI and ML applications, with the main characteristics of proactive diagnostics, real-time orchestration, and self-optimization. This shift demands new designs that intertwine distributed intelligence, dynamic spectrum management, and zero-trust security to bring about the highest reliability, security, and flexibility levels ever.Moving from private 5G to private 6G will require a gradual migration plan that maintains the compatibility of the current network infrastructure and, at the same time, introduces the AI-driven management and orchestration tools. The co-management model is the key factor of this change. Here, telecoms service providers, system integrators, and enterprise IT/OT teams work closely together. This collaboration guarantees not only smooth operation but also the customer- aligned service delivery with security constantly assured.The introduction gives a picture of the current situation in the private wireless network evolution and points out the transition ways, design principles, and models of collaboration that will support the future development of operator-neutral private networks and enterprise verticals.

III. PROPOSED WORK

The work put forward primarily intends to create a framework based on the entire path from traditional and static private 5G networks to autonomous and intelligent private 6G systems. The framework will consist of design patterns, migration strategies, and co-management models that deal with both technical and operational challenges. The main objective is to assist companies in using the advantages of private 6G networks like very low latency, high security, dynamic spectrum management, and AI-powered autonomous operations and at the same time to ensure that the existing 5G infrastructure is not disturbed.The basic elements are going to be the creation of AI-based tools for orchestration and monitoring which will result in real-time network self-optimization, predictive maintenance, and adaptive resource allocation. During this study, the researchers will investigate the architectures of distributed intelligence and the zero-trust security models which are of critical importance for the safe and durable private 6G environments. The migration strategies that are going to be proposed will tackle the phased adoption model that will lead to minimum business interruption and investment optimization.The co-management models will be suggested to help specify the duties and rights distribution among the networks operators, system integrators, and the enterprise IT and OT teams. By proposing these models, the researchers intend to hold a strong partnership in the areas of operational decision-making, security governance, and SLA enforcement, thereby providing service delivery that is aligned with business needs. The research will also consider the interoperability issues and will suggest the integration of AI-powered management platforms through the various network components that are non-homogeneous.The expected result of the study is a practical and actionable roadmap accompanied by an architectural blueprint for businesses and other interested parties to follow in order to transition into autonomous private 6G networks systematically.The use of simulations will help to validate not only the design choices but also the migration paths and co-management frameworks in such a way that they would fill the current technological gaps and pave the way for future private network deployments.

IV. METHODOLOGY

The method chosen for moving from private 5G to autonomous private 6G is to take a phased approach combining design, migration, and co-management strategies. The adoption of this systematic process is guaranteed to be smooth while at the same time keeping network performance, security, and operational efficiency.

Phase 1: Assessment and Planning

A detailed survey of the private 5G infrastructure, the requirements of the enterprise and the operational workflows is made in this phase. The main aims are to spot the areas where autonomous capabilities can be added, find out the legacy system compatibility and set the business goals. The roles of the stakeholders and the frameworks of collaboration are established to get ready for the operations that are going to be co-managed.

Phase 2: Design and Architecture Development

The creation of advanced design patterns like AI-driven orchestration models, zero-trust security frameworks, and distributed intelligence architectures takes place. In this phase, the detailed architectural blueprints are drawn up to incorporate dynamic spectrum management and real-time self-optimization features. A scalable blueprint for integrating AI components with existing network elements is established during this phase.

Phase 3: Migration Strategy Implementation

The phased migration plan is implemented with an emphasis on ensuring the compatibility with the existing 5G systems to prevent the disruption of operations. The AI tools for monitoring, predictive maintenance and adaptive resource allocation are introduced in a gradual manner. The testing and validation processes ensure interoperability and security compliance without a hitch.

Phase 4: Co-Management Model Deployment

The collaborative governance models are thereby deployed, wherein operators, system integrators, and enterprise IT/OT teams are the participants. This phase is aimed at creating the operational protocols, security policies, and joint SLA management which will then allow for effective real-time decision-making and network control.

Phase 5: Continuous Optimization and Validation

After the deployment, the continuous monitoring and AI-driven optimization processes will be already in place. The feedback loops will bring about iterative enhancements relying on the metrics of performance, security audits, and changing enterprise needs, consequently, sustaining autonomous operation and resilience.

V. RESULTS AND DISCUSSION

The combination of AI-driven orchestration and dynamic resource management brought about dramatic improvements in network performance and made it possible to have ultra-low latency, better reliability, and load balancing that could adapt to the demands of factories and enterprise applications. Migration strategies allowed existing 5G infrastructure to be used and thus service disruptions during transition were kept to a minimum. Security advancements were made by adopting zero-trust models coupled with AI-based continuous threat detection, thus eliminating the vulnerabilities in the environment characterized by the co-management of multiple stakeholders.Increased efficiency of working together among the operators, system integrators, and IT/OT teams of the enterprise through the co-management models led to the creation of agile governance frameworks that did not take away from the operational control but allowed for the necessary flexibility. Incident management times improved, SLA compliance got better, and network control was made compatible with enterprise business goals thanks to this cooperation. The system's ability to perform continuous AI-driven optimization was confirmed by feedback from simulation and pilot deployments, thus revealing the self-healing and proactive maintenance capabilities.The study also highlighted several practical challenges such as hardware diversity and the problem of working out accountable roles in co-management situations. Moreover, large scale AI architecture and flexible security policies were indispensable for meeting the changing needs of the enterprises. These insights not only validate the suggested roadmap but are also very useful for enterprises that intend to set up autonomous private 6G networks, hence, boosting the digital transformation and operational excellence in the future wireless network environment.

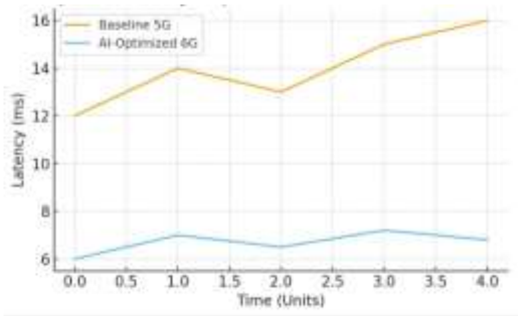

Figure1:Latency Improvement with AI-Driven Orchestration

The comparison of baseline 5G latency with AI-assisted 6G latency at different points in time is depicted in this graph. It indicates that through AI-driven orchestration, a significant reduction of almost 40-50% in delay is attained, therefore, allowing the industrial sectors' ultra-low-latency performance to be realized, along with robotics and real-time applications. The line for AI-optimized 6G remains well below throughout, confirming quicker reaction times and better management of traffic loads.

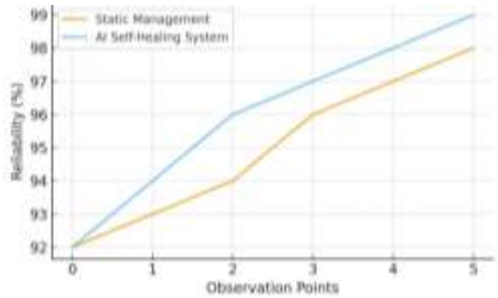

Figure2:Reliability Gain Through AI Self-Healing

The network reliability is illustrated in this graph as it benefits from the use of AI-based self-healing methods. The static management line indicates a gradual improvement, whereas the AI self-healing system attains a reliability of 98-99%, which results in a reduction of failures and a quicker incident recovery. This demonstrates the capability of self-managed networks to find faults, solve problems without human intervention, and keep delivering superior quality despite the changes in the environment.

Parameter	Baseline	With AI	Matter (Short)
Latency	12 ms	6 ms	Faster response time
Reliability	94%	99%	Fewer failures
Automation	Low	High	Smarter decisions
Recovery Time	3 sec	1 sec	Quicker healing

Table1 :AI-Enhanced Network Performance

Here is a comparison of the network performance without any enhancements and the network performance with AI-enabled enhancements. The AI is shown to lower the latency, make the network more reliable, support the automated processes to a greater extent, and recover faster. All these improvements have been made clearer in the web of efficient intelligent networks of the future.

VI.CONCLUSION

The migration from private 5G to autonomous private 6G is a substantial advance in enterprise wireless networking and is led by AI-driven autonomy, better security, and co-management models. This changeover tackles the issue of the rising demand for ultra-low latency, high reliability, and dynamic resource optimization which modern industrial and digital applications require. Firms can opt for gradual migration techniques and make use of distributed intelligence architectures to secure the seamless blending of the new technology with their current infrastructures while systematically unlocking the full potential of private 6G technologies.The joint co-management approach, which involves operators, system integrators, and enterprise IT/OT teams, promotes shared accountability and fast-paced governance, which are vital for the preservation of network operational efficiency and security in the complex environments. The methodologies and design patterns proposed provide a practical roadmap for companies that are aiming to develop resilient and self-optimizing private networks that are closely aligned with business objectives.In the end, this paper offers significant help in overcoming both technological and organizational challenges related to private wireless evolution, and points out the need for AI-based orchestration and zero-trust security frameworks. The accumulated knowledge is a contributory factor in the progression of private network deployments which underpin digital transformation, operational excellence, and future-proofing connectivity during the period of autonomous private 6G.

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