Title: Unlocking 5G Network Slicing: A Comprehensive Survey on Blockchain Marketplace Utilizing NFTs, AI, and Advanced Resource Management.

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Contents

Introduction

Role of Blockchain:
- Blockchain enables decentralization and security in 5G, ensuring transparent and secure resource allocation.
- NFTs enhance traceability and secure ownership.

Role of AI:
- AI optimizes network operations through data-driven decision-making, improving automation and efficiency.

Objective:
- Survey's goal is to explore blockchain-based solutions and challenges in 5G networks.

Background

5G Concepts:

- Network slicing, SDN, and NFV.
- Radio Access Network (RAN) and Open RAN's role.

Blockchain Overview:

- Marketplace concept using blockchain and NFTs.
- Smart contracts for managing network slices.

Blockchain Applications:

- Enhanced resource allocation.
- Integration with AI and edge computing for automation.

Comparative Analysis

Clustering and Categorization of Solutions

- **With the Use of NFTs**: This category focuses on solutions that leverage Non-Fungible Tokens (NFTs) to represent network slices. NFTs are used to uniquely represent and track network slices as digital assets, facilitating transparent, decentralized trading and resource management. These solutions aim to bring innovation to 5G network slicing, offering new business models, resource flexibility, and secure ownership.

- **Without the Use of NFTs**: This category covers solutions that implement blockchain in network slicing but do not rely on NFTs. Instead, these solutions often focus on permissioned or permissionless blockchains for secure, automated resource allocation, without incorporating the unique properties of NFTs. These systems aim for efficient resource management, enhanced security, and automation in 5G network operations.

Comparative Analysis

The categorization also considers factors like **blockchain technology**, **AI model, slicing support.** Each category highlights unique strengths, and weaknesses of the implementations.

Authors	Technology	Blockchain	AI Model	NFT support	Slicing	Advantages	Disadvantages
Faisal [30]	JITRA	H. Fabric	-	-	●	Scalability	Possible false positives
Afraz [36]	5G Slice Brokering	Ethereum	-	-	●	Transparency, automation	Privacy concerns, scalability issues
Mensah [31]	Blockchain-Enabled FL	Tendermint	FL	-	●	Efficiency	High computational overhead
Bandara [24]	Kaputa	Moose	-	✓	○	Transparency, dynamic slice trading	Complex management, data overhead
Foytik [26]	SliceGPT	Ethereum	GPT-3.5	✓	●	Efficiency	High computational needs, scalability limits
Huy Do [32]	Blockchain SDN	H. Fabric	-	-	⊜	Security	Complexity, latency issues, high oper. costs
Aryal [34]	Open RAN	Quorum	-	-	●	Confidentiality, access control	Scalability issues, storage/latency issues
Shetty [27]	Blockchain NFT FL UAV	Cosmos	FL	✓	⊜	UAV, provenance tracking	High comp. overhead, possible false positives
Michoulis [29]	FraMark	H. Fabric	-	✓	●	Dynamic resource alloc. with fractional NFTs	High computational needs

TABLE I: Comparative analysis of blockchain-enabled network slicing solutions.

✓= NFT support, ● = Slicing supported on-chain, ○ = Slicing supported off-chain, ⊜ = Slicing support on-chain and off-chain

Main Findings

Blockchain-Enabled Network Slicing:

- Blockchain improves resource management and allocation via decentralized ledgers and smart contracts.
- NFTs enable unique representation and traceability of network slices, allowing secure trading and leasing.

Network Flexibility and Efficiency:

- AI and edge computing optimize real-time resource allocation for dynamic 5G applications.
- Blockchain enables on-demand provisioning and scalability, improving cost-effectiveness.

Security and Privacy Enhancement:

- Blockchain ensures secure transactions and data integrity.
- Federated Learning maintains data privacy by sharing only model updates.

Main Findings

AI and Federated Learning for Optimization:

- AI models predict demand and automatically allocate resources for efficient operations.
- Federated Learning enables distributed optimization without compromising data privacy.

Interdisciplinary Collaboration:

- Collaboration across telecommunications, AI, and cryptography fields is crucial for developing scalable solutions.

Challenges

Integration Complexity

- Interoperability among blockchain, AI, and edge computing.
- Real-time adaptation to dynamic network slice requirements.

Cybersecurity

- Encryption and decentralized protocols.
- Addressing vulnerabilities like unauthorized access.

Future Directions

Innovative Technologies:
- Exploring larger datasets with AI and ML.
- Federated learning for improved data privacy and security.

Research Needs:
- Optimizing blockchain for speed and scalability.
- Enhancing cybersecurity frameworks in 5G integrations.

Conclusion

Blockchain Impact:
- Improves efficiency, security, and scalability in 5G network slicing.
- Integrates NFTs, AI, and Federated Learning for decentralized, automated operations.

Business Innovation:
- NFTs enable trade and flexibility of network slices.
- Smart contracts reduce costs and complexity.

Challenges:
- Integration, privacy, and scalability issues need further research.

Future Directions:
- Combine AI and Federated Learning with optimized blockchain for speed and scalability for 5G networks.

Thank you.