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RESEARCH ARTICLE

Spectrum Management in 6G HetNet Based on Smart Contracts and Harmonized Software-Defined Networking-Enabled Approach

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Abstract – 6G networks are predicted to provide new prospects for Smart Cities and Internet of Things (IoT) applications because of their global seamless coverage. Therefore, to fulfil the growing need for huge data rates for 6G and greater applications, network capacity must be enhanced. As a result, there is an increase in spectrum demand. Only by successfully sharing existing spectrum and avoiding spectrum underutilization will the increased demand for cellular services be addressed. As a result, for 6G to achieve considerably enhanced network capacity, efficient spectrum management systems must be developed. As a result, maintaining 6G's predicted huge network capacity in such as heterogeneous environment necessitates the shared exploitation of available spectrum resources through dynamic coordination across device and network, which can be accomplished by incorporating SDN into 6G networks. Due to the increased speeds and reliability of 6G networks, users may have to pay more for energy, to overcome these issues, In this paper, a novel proposed a 6G HetNet spectrum management system based on HSA and Smart Contracts. HSA harmonizes network operation by spreading local decision-making and network-wide policy-making processes between BS and the SDN controller, correspondingly, to relieve any possible controller scalability and latency difficulties. And, to tackle the intricacies of service-level agreements, leverage blockchain's smart contract technology, which allows for automation and trustworthy, transparent radio spectrum negotiation among several parties. This proposed solution is dependable, scalable, and implementable, as seen by the results.

Index Terms – 6G, Spectrum Management, Harmonized SDN-Enabled Approach, Blockchain, Smart Contracts, Software-Defined Networking.

1. INTRODUCTION

6G is the current Internet of Everything (IoE) technology, and it's driving Industry 4.0 and smart city applications. Services allocation for Industry 4.0 applications necessitates industrial standardization, with recently specified 6G frequency bands and existing 5G channels expected to be deployed in tandem to fulfil rising demand [1].To meet the needs of new services

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RESEARCH ARTICLE

and applications, 6G networks must surpass previous generations in terms of multigiga bit speed, reliability, sub-1 millisecond latency, and wide adoption of the Internet of Things [2].Due to the paucity of spectrum resources, effective management of resources and sharing are essential to meeting all of these lofty goals. Only by successfully sharing existing spectrum and avoiding spectrum underutilization will the increased demand for cellular services be addressed. The spectrum bands presently used for 4G&5G are still accessible in several countries for future 6G networks [3]. Figure 1 shows the 6G architecture.

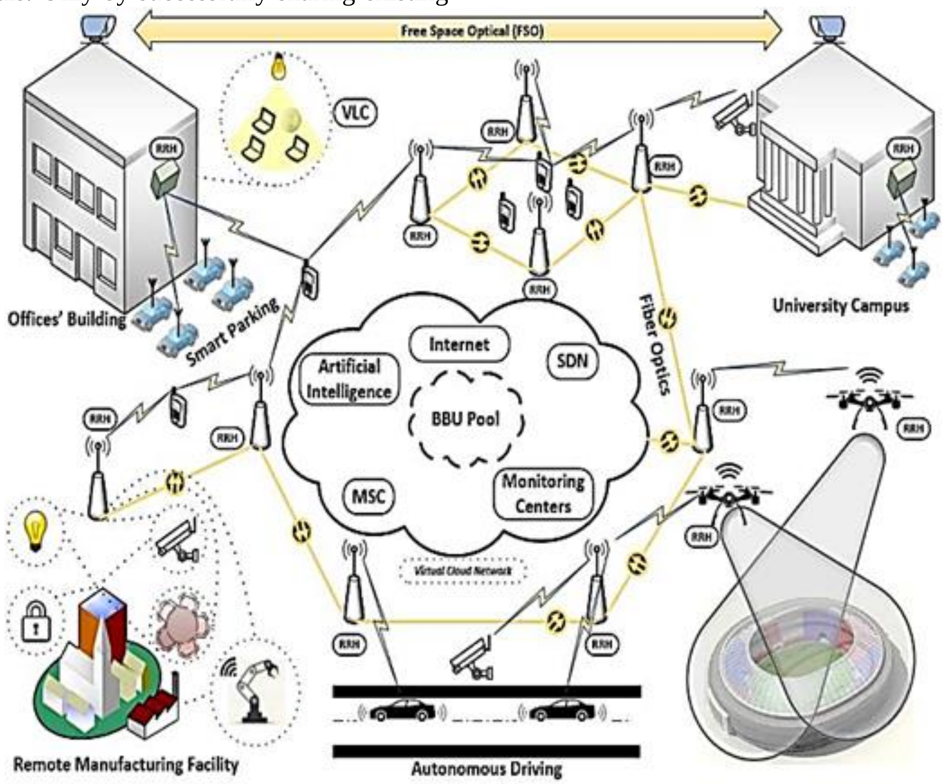

Figure 1 6G Architecture

Regulators' spectrum management [4, 5] decisions are aimed at making effective use of a limited natural resource while guaranteeing equality among the various parties that wish to use the radio spectrum. Spectrum sharing has the potential to significantly boost the efficiency of the available spectrum. Mobile networks can utilize different unlicensed band, such as the industrial, scientific, and medical (ISM) band, by sharing spectrum [6]. It can be used to combine licensed and unlicensed band channels, allowing high-bandwidth applications to attain data rates in the gigabit range in 6G.A spectrum management strategy often requires decision-making despite divergent stakeholder opinions in light of the fact that most of the optimal frequency bands have already been licensed by specific wireless service providers. As spectrum demand grows, it becomes increasingly challenging for regulators to define the norms and guidelines for spectrum usage [7].

The heterogeneous nature of 6G is mostly owing to network densification, which is unavoidable in the pursuit of high capacity, and the use of a multi-tier design to provide universal coverage [8]. As a result, for 6G to achieve considerably enhanced network capacity, efficient spectrum management systems must be developed. As a result, supporting 6G's anticipated huge networks capacity in such diverse environment necessitates the shared exploitation of available spectral resources via dynamic coordination among devices and networks, which can be achieved by incorporating SDN [9] into 6G networks.

Harmonized SDN-enabled approach (HSA) uses the notion of centralized administration with dispersed inputs to make spectrum sharing easier. By balancing workload distribution amongst the controller and the BSs, HSA harmonizes network operation. To that aim, the controller is solely liable for controlling network rules and regulations through the establishment of fine-grained operational policies, whilst the BSs are answerable for all localised decision-making based on the controller's framework [10]. It's only logical for the BSs at the access network's edge to make local decisions because they have the most up-to-date knowledge about the frequently changing wireless channel condition. More spectrum can be

RESEARCH ARTICLE

used more efficiently using database-assisted spectrum management.

Smart contracts [11] are computer programs that include statutory clauses and are executed mechanically once the imposing or activating circumstances are met. Because the smart contract's source code is publicly viewable, the blockchain [12] platform on which it sits ensures immutability, ensuring that all participants to the smart contract may rest certain that any questionable conduct will be investigated. Once the transactions have been validated as genuine, using a hash value, they are attached to the chain as a block [13].Following that, each node saves a copy of the most recent BN update. The major contribution of the work has been followed by:

- In this paper, a novel proposed an HSA and Smart contracts-based Spectrum Management for 6G HetNet.
- HSA harmonises network operation by spreading local decision-making and network-wide policy-making processes across base stations and the SDN controller, respectively, to reduce potential controller scalability and latency difficulties.
- They use blockchain's smart contract technology to handle the complexities of service-level agreements, allowing for automation and reliable, transparent radio spectrum negotiation across several parties.

1.1. Problem Statement

Spectrum management is the art and science of controlling the use of the radio spectrum in order to reduce interference and guarantee that the radio spectrum is utilized to the greatest degree possible and for the greatest benefit to the public. The USDOT is concerned with promoting safe, efficient, and cost-effective transportation. Low latency, low energy consumption, huge capacity and large quality of experience, huge connection, and dependable connectivity are the primary problems of a 6G networking system.

The rest of the paper is organized as follows: In section 2 represents the existing methods is given. In section 3 represents the proposed methodology is discussed. In section 4 results and analysis of the suggested method is discussed. Finally, in section 5, the paper's conclusion has been made.

2. RELATED WORK

In general, spectrum management is a well-studied problem, particularly in the context of CR networks. After over a decade of study, CR-based spectrum sharing strategies have yet to be widely deployed. As a result, recent research has focused on developing solutions that incentivise network operators to control spectrum. Recent research has looked into the concept of network share among small cell network operators, as well as how Blockchain could be utilized to properly manage network resources.

Basu, D., et al. [13] proposed a dynamic Control plane load balancing method in a SDN-enabled dense heterogeneous network. The C/U plane split supported by SDN and NFV expands the potential of small scale very dense BS installations beneath macro BS. To lower the service burden on the corresponding macro controller, our integer linear optimization ILP model dynamically distributes tiny BS to the appropriate macro cell.

Hao Xu et al [14] assessed the blockchain's potential for management and sharing of resources in 6G. Future use cases based on this envisioned architecture are projected to include 6G enabled blockchain resource management, energy trading and sharing of spectrum.

Xin Fan et al [15] developed a broad architecture for license-free spectrum management using blockchain technology and smart contracts, in CPSSs. The management structure was mostly used for non-real-time data edge computing. The Blockchain-KM protocol was used to allocate spectrum and record transactions in a network. They would investigate different lightweight consensus techniques to apply to their system, given the downside of PoW using resources. For spectrums or other trading, they introduced Xcoin, a virtual currency.

Jagannath, J., et al. [16] offered a thorough assessment of the cross-layer protocol stack literature with emphasis on their maturity scale. After that, we will swiftly walk through the process of converting a COTS, low SWaP embedded SDR (e-SDR) into a standalone, fieldable transceiver. To support our claims, we offer results from extensive outdoor over-the-air experiments in a variety of settings with up to 10-node network topologies. The field trial results show great dependability, throughput, and dynamic routing capability.

Ye, J., et al. [17] presented a privacy protection mechanism is to secure sensors' real-time geo-location information while sensing information is uploaded to the BN. Two smart contracts are intended to automate the entire operation. The simulation findings show that the PoT consensus algorithm's predicted computing cost for trustworthy sensing nodes is low, and cooperative sensing performance is increased with the aid of the trust value assessment mechanism.

Tooba Faisal et al. [18] introduced "BEAT," a blockchain-based, end-to-end architecture for network sharing that is automated, transparent, and responsible. It concentrated on Permissioned Distributed Ledger (PDL), a type of blockchain that allows for industry-compliant SLAs and strict governance due to its permissioned nature. It was implemented with the least amount of hardware changes and overhead.

RESEARCH ARTICLE

Hossain, M.A., et al. [19] proposed a layer-based HetNet system that optimally distributes tasks associated with various Machine learning techniques all over link layer and entities; such a HetNet involves multiple access schemes as well as device-to-device (D2D) communications to enhance energy savings through collaborative learning and communications.

Du, J., Jiang, C., et al. [20] suggested a SDN-based spectrum sharing and traffic offloading method to realise cooperation and competition between cellular network ground BSs and STCom beam groups. The simulations confirm the efficacy of the proposed traffic offloading system, revealing that there exists a unique optimal offloading threshold for the MNO to obtain the highest predicted benefit.

Yuan, S., [21] proposed SISTN architecture. The proposal's hierarchical architecture is defined in detail, and a distributed deployment plan for SISTNs controllers is presented in order to achieve flexible and effective network administration and control. In addition, three SISTN application scenarios are explored. Meanwhile, essential methodologies and their associated solutions are described, followed by a discussion of various unresolved difficulties in SISTNs, such as compatibility with existing networks, the tradeoff between network flexibility and performance, and so on.

Al Razib, M., [22] suggested a DL driven SDN enabled IDS to address rising cyber threats in IoT. Our suggested approach DNNLSTM can deal with a wide range of typical and uncommon cyber threats in IoT communications. The proposed design has outperformed the current literature, achieving 99.55% acc, 99.36% pre, 99.44% recall, and 99.42% F1-score.

These methods outperform those previously developed but they have some drawbacks such as Next-generation architecture, spectrum, and services; next-generation networking; IoT wireless location and sensing; and deep learning applications in 6G networks and enhanced speeds and dependability of 6G networks would need more energy, perhaps resulting in greater energy prices for consumers. To overcome these drawbacks, Spectrum Management in 6G HetNet based on Smart Contracts and Harmonized software-defined networking -enabled Approach has been proposed.

3. PORPOSED MODELLING

In this paper, a novel proposed a 6G HetNet spectrum management system based on HSA and Smart Contracts. The Harmonized SDN-enabled approach (HSA) [23] utilises the notion of centralized administration with distributed inputs to facilitate spectrum sharing. HSA balances workload allocation between the controller and the BSs to optimise network performance. Smart contracts are used in our system to handle the difficulties of service-level agreements, allowing for automation and reliable, transparent radio spectrum negotiation across several parties. Figure 2 illustrates the HSA-Smart Contract Framework for 6G HetNet.

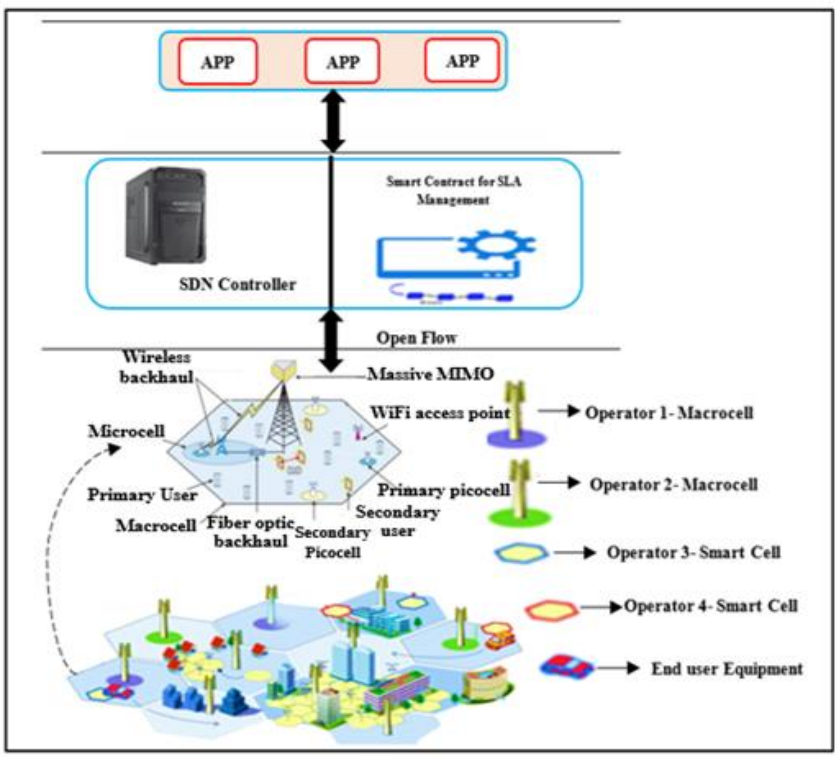

Figure 2 HSA-Smart Contract Framework for 6G HetNet

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RESEARCH ARTICLE

3.1. Harmonized SDN-Enabled Approach (HSA)

It features a multi-layered architecture that comprises licensed-spectrum macrocells, small cells, and picocells, as well as unlicensed-spectrum WiFi access points. Offloading of traffic, spectrum sharing, multihop, and D2D communications as well as huge multiple-input multiple-output communications (MIMO), are all supported by the HetNet. A centralized SDN controller manages a cluster of macrocell BSs, As illustrated in the picture, it links to the BSs through huge-capacity fibre optic connections and manages the data plane using the Open Flow protocol. In addition, if the data plane devices have an SNMP agent, the SNMP plugin enables the controller and associated application to control and manage them. To address scalability issues, HSA limits the controllers to only managing a cluster of macrocell BSs. The BS of the tiny cells in the HetNet often communicate with the macrocell about their load conditions through a wireless or fiber-optic backhaul link.The controller establishes rules for different access network capabilities, such as resource allocation, handovers, and transmit power allocation, among others. Within the context of HSA, and this feature comprises the radio access network's control plane. The data plane of the network is made up of base stations, which carry out the controller's policies.

The dispersed inputs are provided by secondary users (SUs), who detect the spectrum and send their search to the nearby BS. The macrocell BSs and SDN controller are in charge of centralized management. As previously stated, task sharing among the BS and the controller reduces the load on the centralized SDN controller while also harmonizing overall network operation. HSA limits the BSs' use of the SUs' inputs to side information only, in order to reduce their reliance on spectrum sensing. The contents of a LDB stored at each BS are used to make spectrum sharing choices, which are based on policies specified by a centralized SDN controller. When a PU or SU joins or departs the network, the LDB is updated.

3.1.1. Base Station of Macrocell

An LDB and an application module are included in each macrocell BS. The LDB provides the BS with a picture of the cell load circumstances and facilitates local decision-making. It is made up of a Primary User (PU) section and an SU section, both of which provide information on the cell's users. As the associated PU or SU enters or quits the spectrum slot, each of these portions changes. The LDB has additional modules for subscriber information as well as network rules and regulations. The first module deals with subscriber information including cellular network provider, device kind, subscriber type, and recent use. In addition to packet processing and charging, resource management, mobility management, routing, the update module, and admission control, the network rules and regulations module contains policies for the application module's numerous functions. The centralized SDN controller is used by the operator to maintain and enforce these regulations. The BSs make all local decisions in accordance with the centralized controller's directives. The Macrocell is shown in Figure 3.

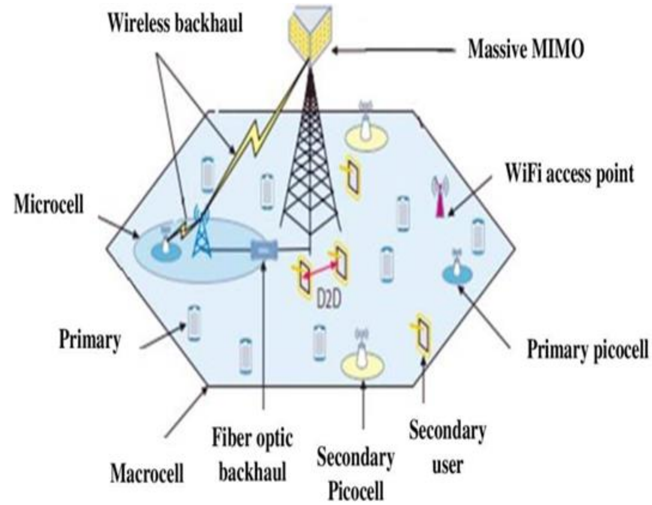

Figure 3 Macrocell

3.1.2. SDN Controller

A GDB is a network policy making module are included in the SDN controller. The GDB stores data on all cluster users and is kept up to date by the BSs. The GDB is used by the controller to update policies relevant to the network's numerous operations. Because all changes or update to network rules and regulations must be done at a single control point, the SDN controller gives network administrators more control. The network policies are either proactively or reactively updated by the controller.

3.1.3. Spectrum Management using HSA

The BSs establish a communication link with the SUs. When the SUs require spectrum access, they communicate with the BS through a low-complexity multiple access method such as CSMA. PUs, on the other hand, have a higher priority inside the network and are granted access using the typical multiple access processes used by cellular networks. The BS would first wait for consumers to seek spectrum access. When a request for spectrum access is received, the BS first evaluates if it is from a PU or an SU. According to the PU, there are a variety of options or the asking user's SU status, whichever is the case a plan of action is implemented.

3.1.4. Spectrum Access Request by Secondary Users

The spectrum is first sensed by each SU for detecting the presence of PUs. The SUs send their searches to the BS, along with a request for spectrum access, after completing the spectrum sensing procedure. The BS combines input from several SUs and uses them to determine if the LDB's contents

RESEARCH ARTICLE

are up to current. If there is a mismatch, the BS verifies the accuracy of the inputs obtained from the SUs by interacting with the respective spectrum users. Only if the SUs' inputs are verified to be correct is the LDB updated. For security concerns, the BSs can additionally label the SUs as trustworthy or untrustworthy devices depending on how frequently each SU's input is true/false. After completing the above operation successfully, the BS predicts the position of each secondary source-destination pair and assigns an appropriate spectrum band to each SU. A number of parameters, including source-destination locations, PU locations, the specific frequencies currently utilised by PUs and SUs, and so on, are used to establish the optimal spectrum allocation.

The LDB has access to all of this information. The distance between the origin and the destination, for example, might have an impact on the selection. If the two are close enough together, the BS might assign mm Wave frequencies, for example. Lower frequencies should be assigned if the distance between both the source and the destination is substantial. The BS considers the amount of interference created by the SUs on the primary network, as well as the distance between the source and the destination. The BS updates the LDB after the spectral resource has been assigned. If the cell becomes totally full following this RA, the BS sends a GDB update as well as a message to the SDN controller seeking additional spectral resources.

The SDN controller examines the GDB to see if the cluster has any lightly loaded cells.If such a cell exists, the controller reallocates some of the controller's previously allotted frequencies to the severely laden cells. If such cells are not available, the controller checks if any traffic may be offloaded to another network, such as WiFi or TVWS. Finally, the SDN controller sends the BS its final judgement and supporting instructions through the backhaul network. If no fresh resources are granted, the BS frees up spectrum by eliminating SUs that have been utilising it for the longest time. Frame Work for Spectrum Management Process at the BS is depicted in Figure 4.

3.1.5. Spectrum Access Request by Primary Users

If a PU wishes to use the spectrum, the BS must first determine the principal source and destination locations. The appropriate frequency for the corresponding principal transmissions is then calculated. The BS evaluates the appropriate transmit frequency for the PU first, then examines its impact on the SUs, because the PUs have the highest priority. If an SU is in close proximity to the PU and utilizes the same frequency as the PU, the BS modifies the SU's transmission settings and assigns the PU the frequency that is deemed most appropriate. After that, the LDB is updated, the rest is similar to the process above.

3.2. Smart Contract for SLA Management

The blockchain network (BN) [24] sits on top of the SDN architecture and allows for distributed network authorization to verify network operations. The BN communicates with the SDN controller via the northbound bound interface using APIs. In transferring information with the BN, the SDN controller signs transactions with its private key, which is accessible on the BN through the accompanying public key. The BN receiver employs the same hash function as the sender to generate the transaction's hash value in order to authenticate the sender's digital key. Which it compares to the hash obtained by decrypting the sender's digital signature using the matching public key.Smart contracts are used to record these transactions on the blockchain. BlockChain Formation is shown in Figure 5.

The following is a basic overview of the smart contract's elements:

ID of the device: This is a number that is assigned to devices and is used to uniquely identify them.

Location of the device:The geographic position of the network's nodes is given.

Billing and Subscription information: This is where subscribers or users service profiles on the network are saved. The category and class of services to which the UE has subscribed, the charge rate, the billing cycle and the validity duration of those services are all examples of such information.

Participating MNOs: This list demonstrates which MNOs are partaking in the contract and have reached contracts with their peers.

Operating frequency: For the sake of spectrum accountability, keeps track of the frequency bands that each MNO is currently using to offer services to its customers.

QoS parameters: QoS parameters define the performance metrics based onwhich MNO services are evaluated and assessed.

Contract Clause Breach: This document contains visibly stated criteria that must be met, as well as the repercussions that will occur if those thresholds are not met. The guilty party is immediately removed from the smart contract if the contract is breached after a certain number of billing cycles.

Transaction history: The blockchain stores all transaction history information, which may be accessed using smart contracts. Account reconciliation and billing settlements can both benefit from the information presented therein.

Smart contracts in an incorporated HSA and blockchain architecture would provide for a dispersed consistent record of SDN data across all blockchain nodes, allowing for more

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effective network resource management. Furthermore, separating all control of the network from any single node reduces the threats of multi-vendor device isolation and single point failure, resulting in improved fault recovery. Information in Smart Contract is shown in Figure 6.

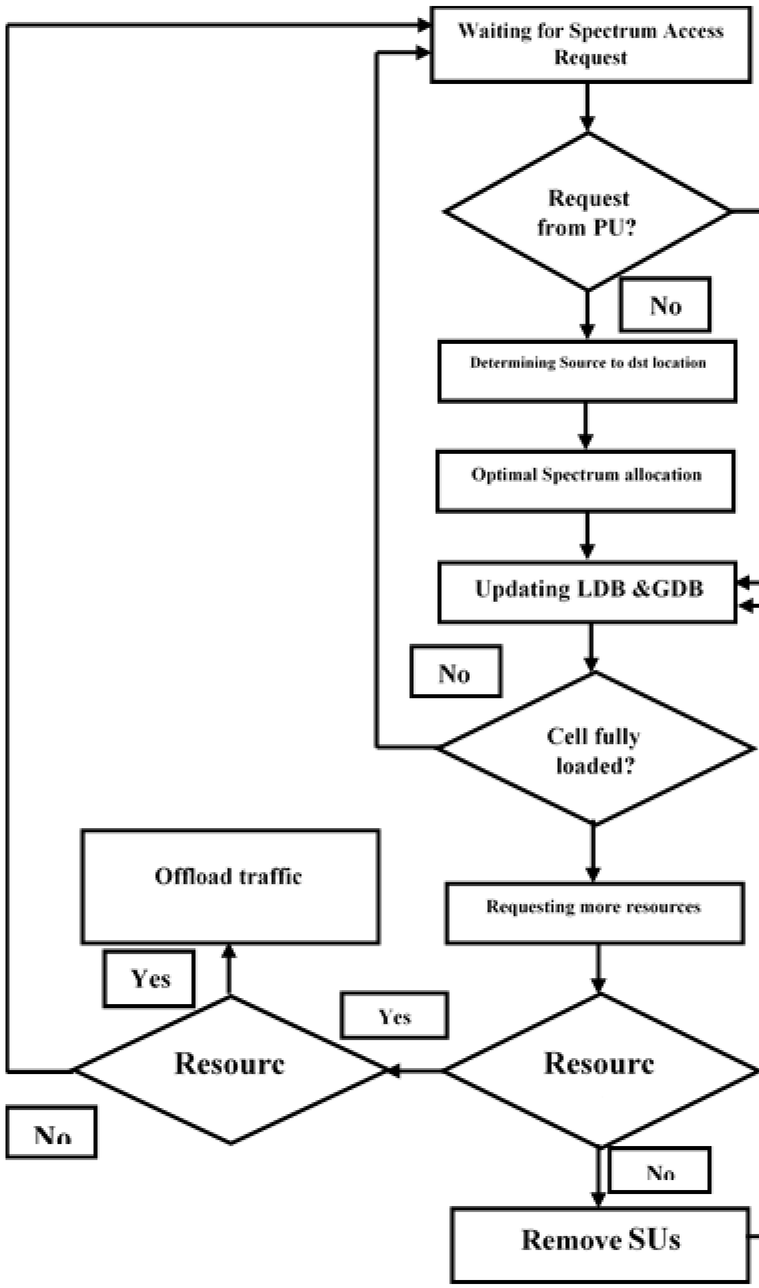

Figure 4 Frame Work for Spectrum Management Process at the BS

3.2.1. HSA-Smart Contract Architecture

The combined HSA and Smart Contract architecture [25, 26] facilitates MNO business agreements while at the same time controlling radio access in a shared network environment. For both MNOs, the Blockchain Network administers registration of users and a shared billing system, together with an SLA manager built in the BN via a smart contract. By means of this setup, the smart contract is in charge of arranging and delivering invoice settlements and agreed-upon service levels to subscribers. The BN communicates with the SDN

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controller via the northbound bound interface using APIs. In (sender) signs transactions with its private key, which is accessible on the BN through the accompanying public key. The BNs receiver employs the same hash function as the transferring information with the BN, the SDN controller sender to generate the transaction's hash value in order to authenticate the sender's digital key. Figure 7 depicts the operational architecture of HSA-smart contract framework.

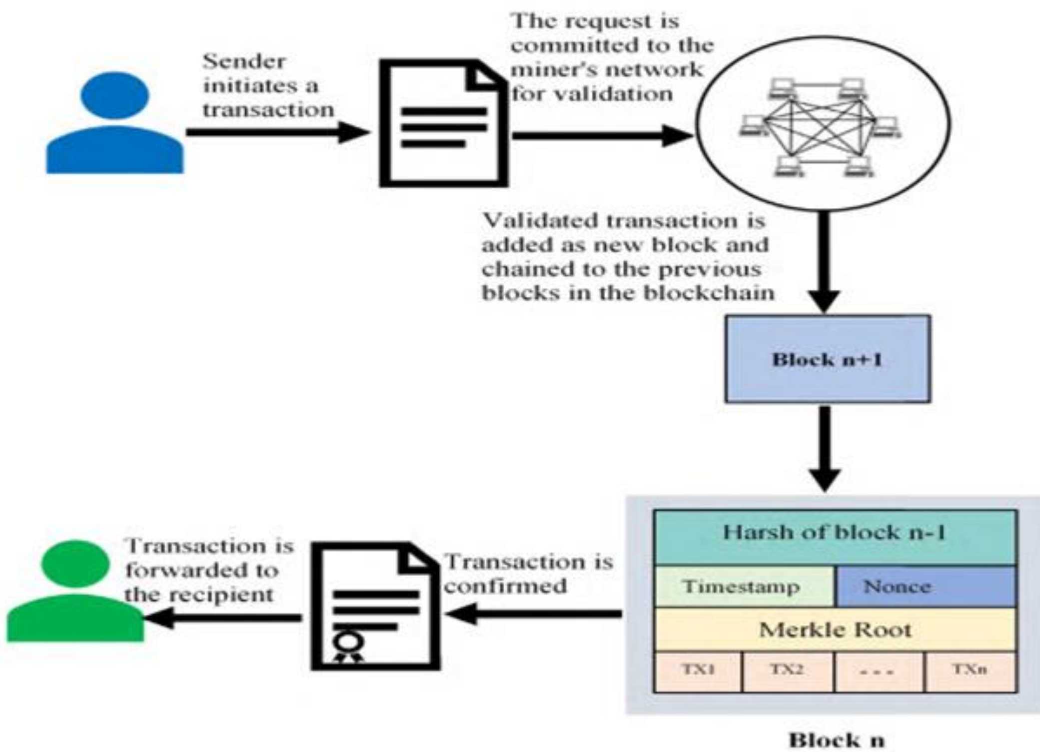

Figure 5 BlockChain Formation

Smart Contract Information

- Device ID
- Device location
- Subscription and billing information
- Participating MNOs
- Frequency band of operation
- QoS Parameters (Throughput, Delay, Packet loss rate, bandwidth, etc.)
- Breach of contract clause
- Payment intervals
- Transaction history

Figure 6 Information in Smart Contract

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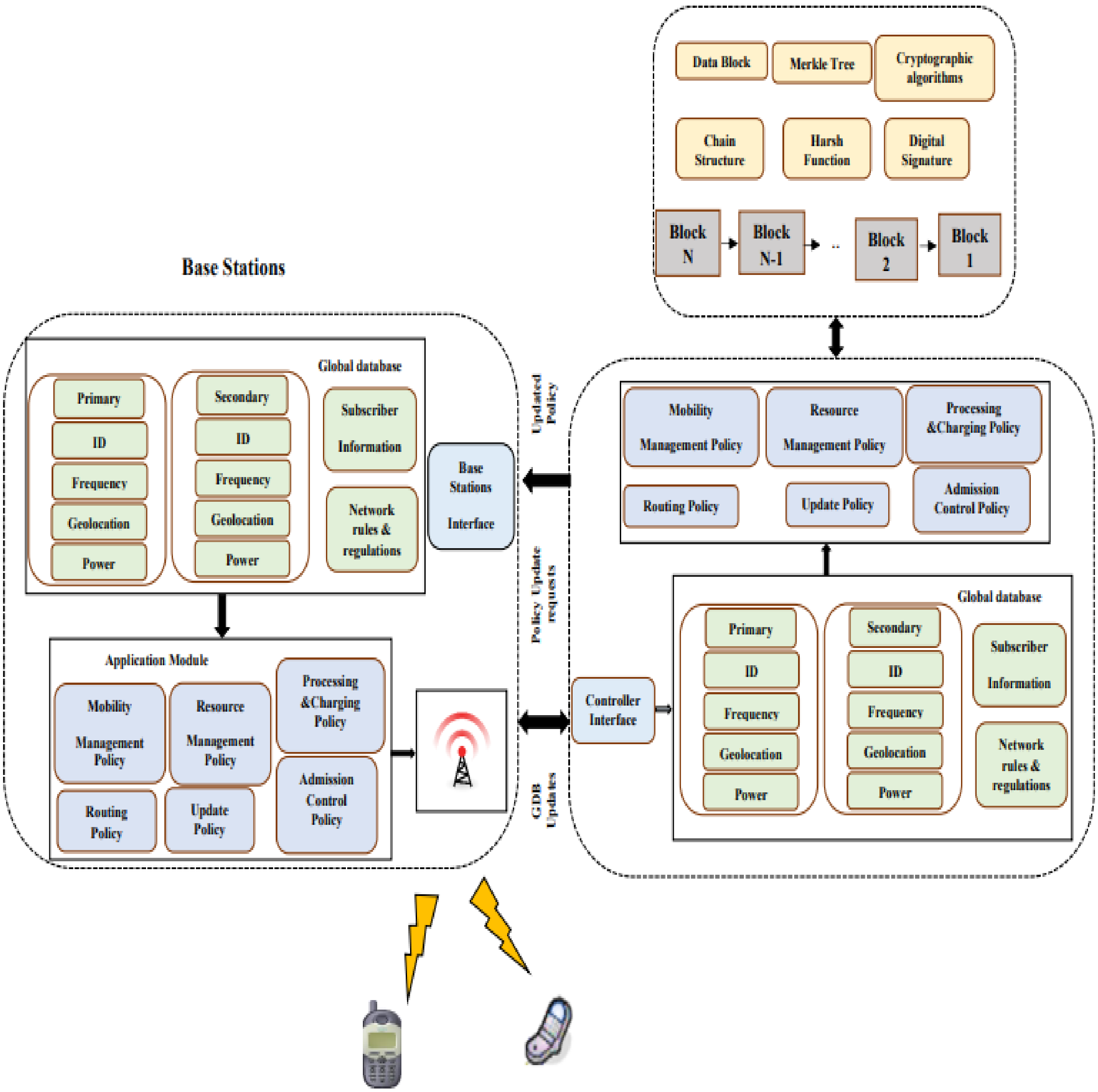

Figure 7 Operational Architecture of HSA-Smart Contract Framework

4. RESULTS AND DISCUSSIONS

The experimental arrangement of the proposed Spectrum Management in 6G HetNet based on Smart Contracts and Harmonized software-defined networking -enabled Approach was implemented using MATLAB. RADAR, Average PU are the different metrics used to evaluate it.Within a single cell of radius 1 km, Figureures 8 and 9Analyze the performance of sensing-based spectrum access as well as the planned HSA centralized spectrum access solutions. The two strategies are evaluated in terms of both the interference imposed on the PUs and the percentage of refused access requests (RADAR).

$$RADAR=\frac{Denied\ Secondary\ Spectrum\ Access\ requests}{total\ requests\ generated} \quad (1)$$

Three primary users (PU1, PU2, and PU3) were supposed to communicate over frequencies of 900 MHz, 1800 MHz, and 2.4 GHz.This conFigureuration is similar to a HetNets situation, in which a macrocell, microcell, and/or picocell operate at distinct frequencies.

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RESEARCH ARTICLE

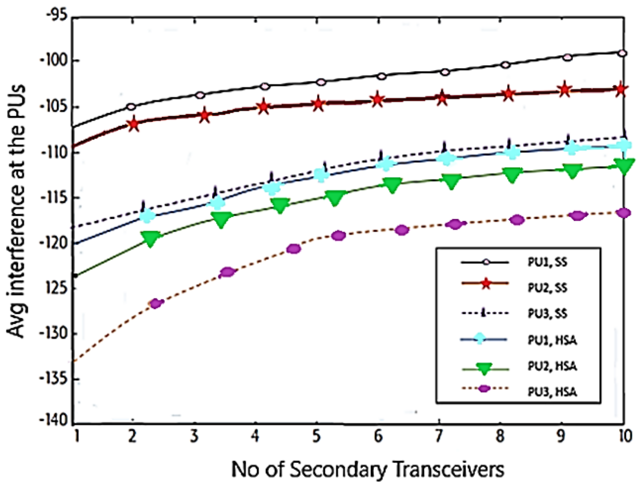


Figure 8 Average PU Interference as a Function of the Network's Secondary Transceivers

Figure 8 HSA outperforms spectrum-sensing-based resource management methods, as seen in the graph. The SUs used the energy detection technique with a modest level of complexity for sensing the spectrum with the help of spectrum-sensing (SS) based access, and if the obtained primary signal level was below the predefined threshold, the spectrum was declared idle. The proposed technique (HSA), on the other hand, used the SUs' and PUs' geolocation information to estimate the interference imposed on the PUs in various frequency bands. If the cumulative amount of the interference at the PU enforced by the SU transmissions stayed below a predetermined threshold, the requested spectrum was assigned to a SU. The proposed spectrum management method optimizes spectrum usage by supporting a higher number of secondary users, as seen in the Figure 8.

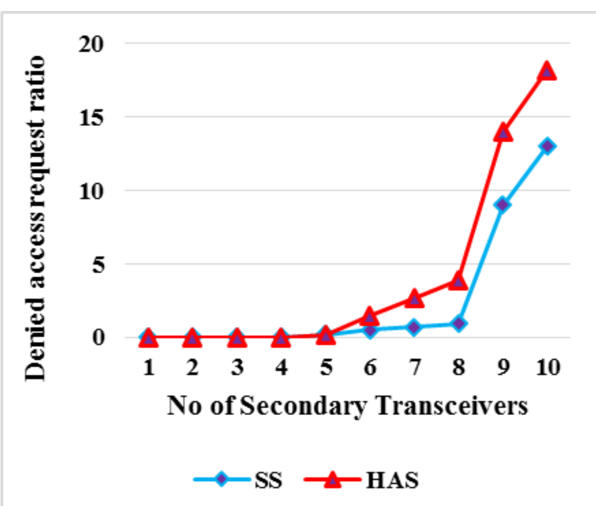


Figure 9 Number of Refused Spectrum Access Requests as a Function of the Network's Secondary Transceivers

To acquire insight into the frequency of transactions between multiple users, Ethereum virtual machines (VM) are utilized to replicate blockchain transactions. The performance of the blockchain was assessed across numerous instances with 5, 10, 15, and 20 (Figure 9) users dynamically interacting with the smart contract for 600 seconds each. For distinct groups of users, the number of transactions grows with time, whereas the amount of transactions mined declines as the number of users grows. This is due to the rising number of blocks that miners must process, which raises the difficulty level and slows consensus.

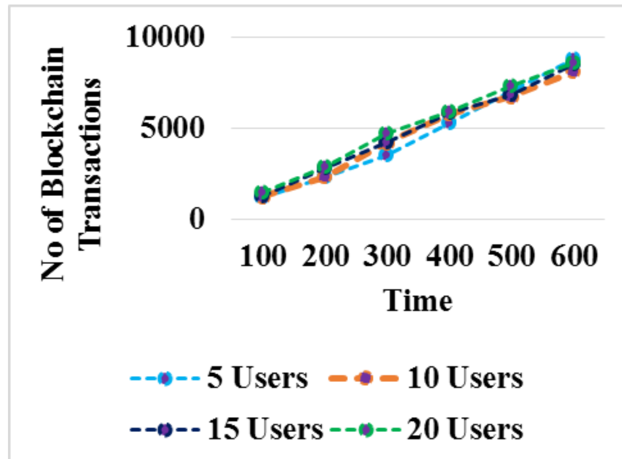
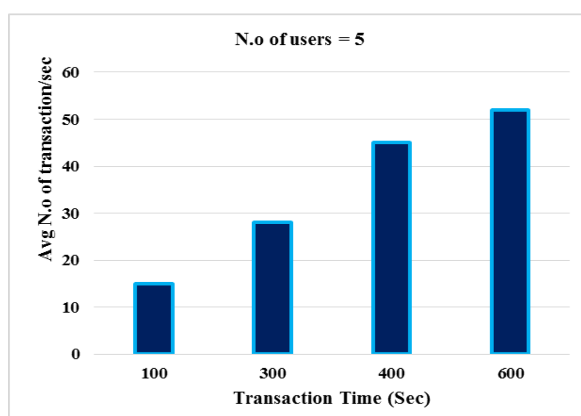
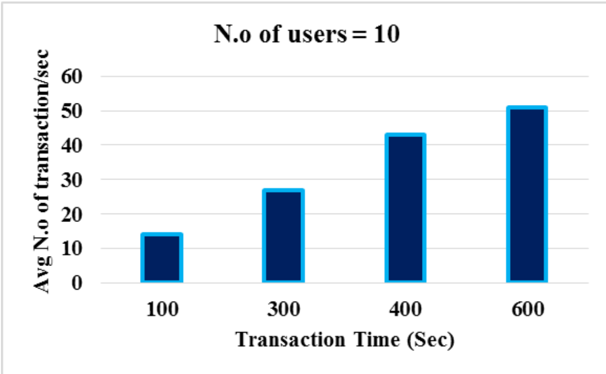


Figure 10 No of Transactions across Different no of Users

The blockchain's ability to record every single transaction leads in greater latency and scalability. To address latency and scalability concerns, our solution employs the technique of off-chaining the majority of transactional data, only the latest transaction is stored on the blockchain. In a Merkle tree, all transactions are hashed, but only the root is included in the block's hash, to permit this without violating the block's integrity. In this finding in Figure 10, which provide a study of the number of transactions/secs at various cases of the simulation with a growing number of users, support this.



(a)



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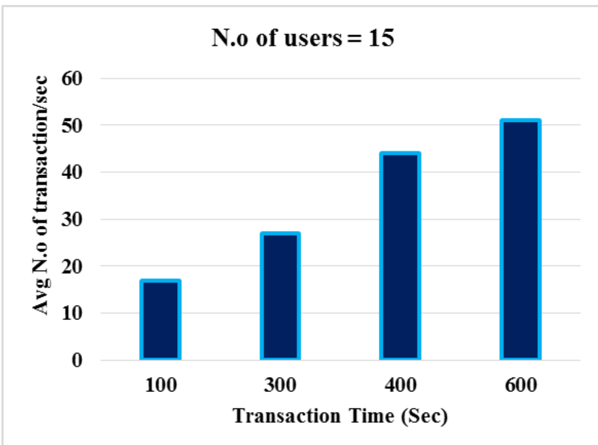
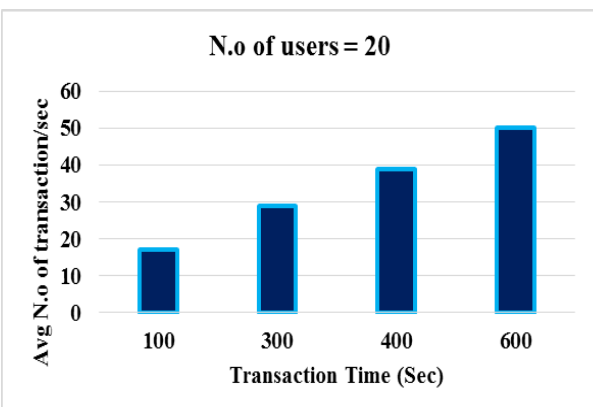


(c)



(d)

Figure 11: Avg no of Transaction/sec When no of Users = 5, 10, 15, and 20

For each set of users, the amount of transactions handled at each simulation instance (100 s, 300 s, 400 s, 600 s) (Figure 11) is fairly constant and only marginally decreases as the number of users enhance. Despite a rise in the number of users, a substantial number of successful transactions were reported, as shown in the simulation results, clearly proves the scalability of our system. Table 1 illustrates the performance comparison in ablation study of with and without HAS

Table 1 Performance Comparison in Ablation Study of with and Without HAS

Transactions	With HSA	Without HSA
10	18 (denied access ratio)	15
50	47	32
100	88	73

Initially, we have evaluated the effectiveness of the proposed Spectrum Management in 6G HetNet based on Smart Contracts and Harmonized software-defined networking -enabled Approach and the ablation study is performed with and without HSA method in terms of different transactions. There is a possibility that the model without HSA had lowest denied access ratio in classification. The proposed Spectrum Management in 6G HetNet based on Smart Contracts and Harmonized software-defined networking -enabled Approach model with HSA method had the denied access ratio is classifying different transaction.

5. CONCLUSION

In this paper, a novel proposed a 6G HetNet spectrum management system based on HSA and Smart Contracts. HSA used the notion of centralized administration with dispersed inputs to make spectrum sharing easier. By balancing workload distribution between the controller and the BSs, HSA harmonized network operation. Also used blockchain's smart contract technology to address the complexities of service-level agreements, which enables for automation and trustworthy, transparent radio spectrum negotiation across several parties. The BN communicates with the SDN controller via APIs (Python or C++) via the northbound bound interface. In a shared network environment, the integrated HSA and Smart Contract architecture supported MNO business agreements while simultaneously controlling spectrum management. This technique was more efficient and automatic when it comes to negotiating SLAs for infrastructure sharing in terms of time and money. Our proposed solution is dependable, scalable, and implementable, as seen by the outcomes.

REFERENCES

[1] Zhang, Z., Xiao, Y., Ma, Z., Xiao, M., Ding, Z., Lei, X., Karagiannidis, G.K. and Fan, P., 2019. 6G wireless networks: Vision, requirements, architecture, and key technologies. IEEE Vehicular Technology Magazine, 14(3), pp.28-41.

RESEARCH ARTICLE

[2] Qamar, F., Siddiqui, M.U.A., Hindia, M.H.D., Hassan, R. and Nguyen, Q.N., 2020. Issues, challenges, and research trends in spectrum management: A comprehensive overview and new vision for designing 6G networks. Electronics, 9(9), p.1416.

[3] Agrawal, R., 2022. Comparison of Different Mobile Wireless Technology (From 0G to 6G). ECS Transactions, 107(1), p.4799.

[4] Zheng, S., Han, T., Jiang, Y. and Ge, X., 2020. Smart contract-based spectrum sharing transactions for multi-operators wireless communication networks. IEEE Access, 8, pp.88547-88557

[5] Ye, J., Kang, X., Liang, Y.C. and Sun, S., 2021. A Trust-Centric Privacy-Preserving Blockchain for Dynamic Spectrum Management in IoT Networks. arXiv preprint arXiv:2106.13958.

[6] Ibrahim, M.M. and Azzuhri, S.R., 2022. Coexistence of Wi-Fi 6e with Lte-U/Laa in the 5 Ghz Frequency Band (No. 9242). EasyChair.

[7] Venugopalan, K. and Sumathy, V., 2021. Interference mitigation with spectrum sharing and aggregation for SDN based cognitive networks. Journal of Ambient Intelligence and Humanized Computing, pp.1-11.

[8] Cicioğlu, M., Cicioğlu, S. and Çalhan, A., 2020. SDN-enabled Cognitive Radio Network Architecture. IET Communications, 14(18), pp.3153-3160.

[9] Abbas, K., Afaq, M., Ahmed Khan, T., Rafiq, A., Iqbal, J., Ul Islam, I. and Song, W.C., 2020. An efficient SDN-based LTE-WiFi spectrum aggregation system for heterogeneous 5G networks. Transactions on Emerging Telecommunications Technologies, p.e3943.

[10] Liang, Y., Lu, C., Zhao, Y. and Sun, C., 2021. Interference-based consensus and transaction validation mechanisms for blockchain-based spectrum management. IEEE Access, 9, pp.90757-90766.

[11] Xie, J., Zhang, K., Lu, Y. and Zhang, Y., 2021. Resource-efficient DAG Blockchain with Sharding for 6G Networks. IEEE Network.

[12] Maksymyuk, T., Gazda, J., Volosin, M., Bugar, G., Horvath, D., Klymash, M. and Dohler, M., 2020. Blockchain-empowered framework for decentralized network management in 6G. IEEE Communications Magazine, 58(9), pp.86-92.

[13] Basu, D., Jain, A., Rao, A.S., Ghosh, U. and Datta, R., 2022, January. Multi-cluster dynamic load balancing in vsdn-enabled 5g heterogeneous network for smart cyber-physical systems. In 2022 14th International Conference on COMmunication Systems & NETworkS (COMSNETS) (pp. 871-876). IEEE.

[14] Xu, H., Klaine, P.V., Onireti, O., Cao, B., Imran, M. and Zhang, L., 2020. Blockchain-enabled resource management and sharing for 6G communications. Digital Communications and Networks, 6(3), pp.261-269.

[15] Fan, X. and Huo, Y., 2020. Blockchain based dynamic spectrum access of non-real-time data in cyber-physical-social systems. IEEE Access, 8, pp.64486-64498.

[16] Jagannath, J., Jagannath, A., Henney, J., Gwin, T., Kane, Z., Biswas, N. and Drozd, A., 2022. Design of fieldable cross-layer optimized network using embedded software defined radios: Survey and novel architecture with field trials. Computer Networks, 209, p.108917.

[17] Ye, J., Kang, X., Liang, Y.C. and Sun, S., 2022. A trust-centric privacy-preserving blockchain for dynamic spectrum management in IoT networks. IEEE Internet of Things Journal, 9(15), pp.13263-13278.

[18] Faisal, T., Dohler, M., Mangiante, S. and Lopez, D.R., 2021. BEAT: Blockchain-Enabled Accountable and Transparent Network Sharing in 6G. arXiv preprint arXiv:2107.04328.

[19] Hossain, M.A., Hossain, A.R. and Ansari, N., 2022. AI in 6G: Energy-Efficient Distributed Machine Learning for Multilayer Heterogeneous Networks. IEEE Network, 36(6), pp.84-91.

[20] Du, J., Jiang, C., Zhang, H., Ren, Y. and Guizani, M., 2018. Auction design and analysis for SDN-based traffic offloading in hybrid satellite-terrestrial networks. IEEE Journal on Selected Areas in Communications, 36(10), pp.2202-2217.

[21] Yuan, S., Peng, M., Sun, Y. and Liu, X., 2022. Software defined intelligent satellite-terrestrial integrated networks: Insights and challenges. Digital Communications and Networks.

[22] Al Razib, M., Javeed, D., Khan, M.T., Alkanhel, R. and Muthanna, M.S.A., 2022. Cyber threats detection in smart environments using SDN-enabled DNN-LSTM hybrid framework. IEEE Access, 10, pp.53015-53026.

[23] Salahdine, F., Han, T. and Zhang, N., 2023. Security in 5G and beyond recent advances and future challenges. Security and Privacy, 6(1), p.e271.

[24] Okon, A.A., Sholiyi, O.S., Elmirghani, J.M. and Munasighe, K., 2021. Blockchain for Spectrum Management in 6G Networks. Wireless Blockchain: Principles, Technologies and Applications, pp.137-159.

[25] Okon, A.A., Elgendi, I., Sholiyi, O.S., Elmirghani, J.M., Jamalipour, A. and Munasinghe, K., 2020. Blockchain and SDN Architecture for Spectrum Management in Cellular Networks. IEEE Access, 8, pp.94415-94428.

[26] Zhang, H., Leng, S., Wei, Y. and He, J., 2022. A blockchain enhanced coexistence of heterogeneous networks on unlicensed spectrum. IEEE Transactions on Vehicular Technology, 71(7), pp.7613-7624.

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RESEARCH ARTICLE

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