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5G based Blockchain network for authentic and ethical keyword search engine

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Abstract

The evolution of 4G telecommunication propagated various resource-crunched clients to experience rate-effective resources at ease. However, it extends its underlying centralised architecture, which arouses various challenges correlated with network data availability, network information protection, and operational infrastructure charges. With the recent revolution of telecommunication, 5G networks promised to provide credible schemes like the high quality of service, ultra-low latency, and much security over the pre-existing architecture. However, the deployment of end-to-end 5G network cutting-edge systems in the present heterogeneous world limits its core idea of extensive data privacy, native interoperability, risk-free interference, and radio spectrum sharing. Perhaps, to achieve its true capability, improved versions of blockchain technology could be aligned to strengthen various real-time complex applications at a flourishing rate. One of the multiplexed real-time enterprise applications is a keyword search engine where the integrity of user data files and keyword searches are bound to come under cyber hackers. On the one hand, it was found that when a 5G-based blockchain emulated network gets deployed with intact encryption techniques, the entire system facilitates to give reliable, efficient, and risk-free keyword search over variegated 5G network data and its complex computational calculations. Consequently, the use of blockchain-based decentralised cloud orchestration scheme at various levels enabled the architecture to remain incorruptible and protects all the confidential files and keywords in a fully controlled file access environment. The results of the simulation kernel shows that proposed architecture which, when combined with blockchain-based decentralised cloud orchestration network system, justify all the essential characteristics and effectuates the optimal use of 5G network sharing by each network entity.

1 | INTRODUCTION

Every generation of cellular norms ceaselessly developed something which offered new evolution of services and highlighted advertised needs. But, in accordance with the telecommunication revolution, the 5th G cellular network targets at dynamicity for almost all aspects by using high-information rate administrations with credible QoS (quality of service). A low latency in the request for about 1 ms and less is delivered by 5G which is much required by real-time services like real-time gaming application, keyword search engine etc. It can promptly encourage such tough prerequisites when contrasted with past cellular advances (i.e. 2nd generation, 3rd generation, and 4th generation). With the exponential growth of technology across the world, 5G facilitates to provide all of its network capability using the network slicing method. Network slicing invokes making various virtual network based associations with a solitary network. Distribution of network resources among various virtual networks are made available in accordance with their particular necessities. For instance, sometimes a keyword search engine may require extremely quick and low latency associations for continuous activities as it generates a lot of bidirectional
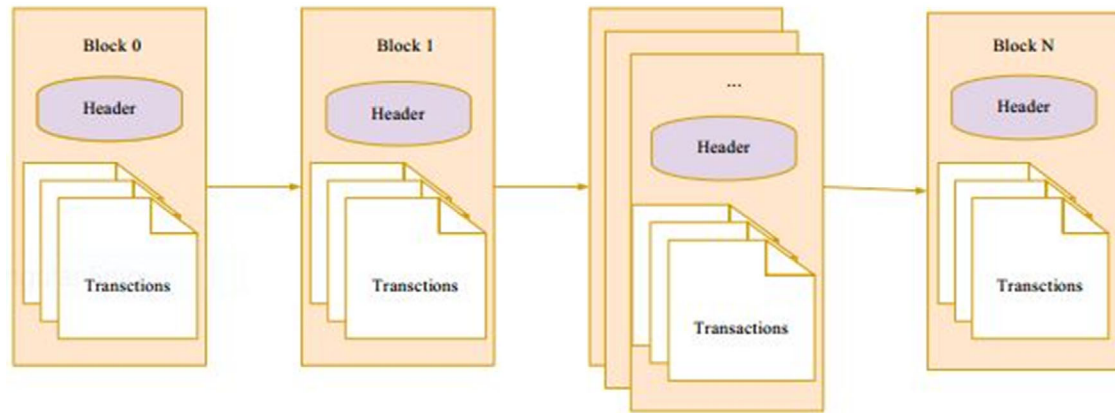
FIGURE 1   Basic structure of Blockchain

computational data than an IOT based sensing device which might require relatively less transmission capacity. Despite the accomplishments of 5G systems, few limitations like framework accessibility and limited spectrum are as yet significant constraining elements, which forestalls various CSPs and other administrators to deliver their upright potential appropriately.

In the current scenario, usage of 4G networks makes the technological ability to go backward. Irrespective of whether a data information requires a low or high latency, centralised mode of communication always hinders various autonomous activities. Limitation of spectrum in different segments of 4G networks also causes a ton of complexities. Owing to that, CSPs are compelled to put enormous measures of cash in their framework, so as to expand the overall resources by arranging the reuse of densification and reliable frequency across the whole area. The clouded side of such a pattern is that it turns out to be increasingly costly. In order to solve this impression, the idea of 5G based self-organising network (SON) has seemed to upgrade the governance of complex dense heterogeneous systems.

Moreover, the advent of cloud storage schemes have received massive recognition in the storage system because of advances in huge-scale digital programs. It has presented adaptable and ground-breaking figuring and capacity frameworks, which opened new open doors for more brilliant calculations. For the same reasons, 4G based network was initially equipped with centralised cloud to serve demands of keyword search engines at a higher rate but unfortunately over the years, use of this centralised architecture was found quite untrustworthy. It goes without saying that improved versions of BBD cloud systems with 5G based infrastructure will surely help in complex network data computation and analysis for preparing progressive insights.

Blockchain is computerised record innovation (CRI) which has gotten well known as of late because of its superior points of interest, for example, unchanging nature, security, directness and so on. Information that is put away in a blockchain does not get tampered much easily. Each block of the blockchain comprises data information, its hashed value, hash of the previous block, timestamp and an arbitrary nonce. The data blocks of the

blockchain system additionally have a unique hash value incentive to distinguish it and the entirety of its substance. The hash is determined when a block is made and will change if the data contents of that block gets altered. Figure 1 shows the basic structure of blockchain. For each change that is made in a data block at a given point of time, a new and unique hash value is generated which corresponds to that change [1]. In this manner if anytime, somebody attempts to use deceitful ways to alter the information present in a block, then predecessor and successor blocks discredit it because of a crisscross between two different hashes [2, 3]. Moreover, proof-of-work (POW) system in blockchain makes every miner to unravel some complex scientific riddle which in-turn enables the option to add an another approved block to the chain.

The utilisation of cryptocurrency in blockchain is effectively investigated in the telecommunication world. A few elements of blockchain can be coupled with cellular service providers (CSPs) to give a dispersed record of various CSPs to a network spectrum owner which makes the whole architecture quite secure. Smart agreements can empower sharing of blockchain framework via dealing with the exchange charges among various CSPs. These contracts are the self-computerised dynamic agreements that can be sent on the blockchain and can trigger diversely in various conditions with no human mediation [4]. The use of blockchain for CSPs can additionally be reached out to a structure that permits mapping of each and every different encrypted keyword belonging to various encrypted files to get stored within the decentralised hash table. This proposed protocol ensures that distinct users along with BBD storage schemes present in the network do not get an extra chance to examine someone's files and search contents. Figure 2 shows the architecture comparison between centralised and decentralised platform made in consilience with the proposed system. Besides, the user transparency and confidentiality of information is fully preserved with minimised network communication.

The contributions of this paper are as follow:

1. We endorse a framework that permits mapping of each and every network access node belonging to various network areas to get connected to permissioned blockchain.
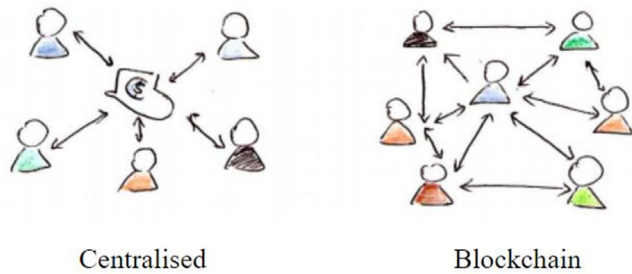
FIGURE 2 Overview of centralised versus decentralised architecture

This proposed protocol ensures that distinct users, along with decentralised scheme present in the network, gets a free chance to select the variability of latency and bandwidth through smart contract. Besides, the user transparency and confidentiality of information is fully preserved with minimised network communication.

2. The process of BBD cloud is utilised across the whole network, which allows every layer of data to get stored within the distributed hash table. This provides the crucial network data to stay near the user proximity, which in turn allows the encrypted keyword search engine to run at very low latency. Moreover, it facilitates to allocate the best possible search results with a risk-free environment.

3. The employment of equalised cryptocurrency to all CSPs, network function virtualisation and self-organising network creates a seamless and ultra-less network intervention ecosystem which makes the whole architecture to get scalable across various line streams of smooth-less 5G network sharing.

The remainder of the paper is organised as follows. In Section 2, we discussed the related work. Proposed system architecture is discussed in Section 3 followed by methodology in Section 4. Simulation results and performance evaluation are provided in Section 5 before we summarise our concluding remarks in Section 6.

2 | RELATED WORK

We started out with [5] which gave us the true idea of how the density of a network gets induced in different geographical areas and provided some techniques for the measurement of signal losses for both magnetic and electric fields. Then [6] stated the use of 5G tools to find how different areas of the network can get high transfer speed. Moreover, it highlighted the idea of using SINR and ray-tracing mechanisms to describe different scenarios of 5G networks. Further, the ideas proposed in [7] was taken into the account which examined the concept of realising the antenna based module for 5G beam steering [8] and explained the crucial parameters like 4 facet antenna-in-package and 16 facet antenna-on-display at millimetre-level [9] to systematically structure the network units in accordance with today's world.

To unravel the innovations in blockchain technology, [10] threw light upon a benchmarking structure for understanding the execution of private blockchains against information preparing outstanding burdens and led a far-reaching assessment of three noteworthy blockchain frameworks standards, to be specific Bitcoin, Hyperledger Fabric and Ethereum. The outcomes unavoidably showed a few exchange offs in the system space, and large execution loopholes among blockchain and database frameworks in accurate situations. To add more, [11] helped out in combining academia and industry to analyse problems extending from deploying newer cryptographic primitives to allowing use cases like preserving file storage privacy. Thus, it lighted out the fact of preserving the information in continuous immutable storage of blockchain in a safe and protected manner.

In the past few years, cloud computing technology has risen up tremendously and [12] presented out the qualities of distributed storage innovation and dissected the progressive structure and the information stockpiling structure of the distributed storage administration and finally, accentuated completely on adaptability and reliability of the distributed storage administration design attributes for upcoming future. In accordance with [13], clusters of honest nodes were considered with an objective to generate a shared secret key by means of a state-dependent wireless broadcasting channel. Also, development of a theoretical information to secure secret key agreement protocol is proposed which showed the optimality of this protocol [18] over a hybrid cloud service with respect to different calibrations of 5G network based scenarios.

The key idea of using a 5G based blockchain network is much emphasised on keyword search engine to which [14] extended their idea on storage of keywords presented inside encrypted files in cloud environment. It aids by adding a permission based token over the cloud to handle different types of keywords. With a need to improve the whole system, the articulated algorithm in [15] played a very essential role in meddling the recall results of the natural language processing (NLP) with features like term frequency distribution at an ease.

Moreover, [16] which explained about how a state-of-art blockchain-based network architecture should be coupled with 5G in order to organise the physical infrastructure like tower cells etc. in a meticulous way. Also, similarity results between various segments of underlying framework were considered to comprehend the cause and effect theory. Nonetheless, [17] was studied in the end in order to speculate the use of Blockchain and 5G telecommunication together to form a constrained based theory of the upcoming challenges in near future. It listed down the coverage of experimental analysis which helped us to find out the true sense of 5G networks [22-25].

3 | SYSTEM ARCHITECTURE

Figure 3 presents the system architecture of the 5G based blockchain network. The system starts with the native blockchain-based decentralised (BBD) user networks which encapsulates keyword search engines. Thereafter, BBD access
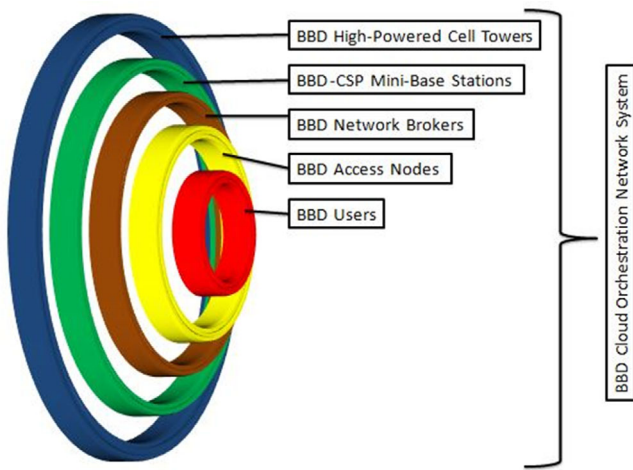
FIGURE 3 Proposed system architecture

nodes are dispersed around which further gets accompanied by various network slice brokers. The behaviour and topology of these network brokers are set into a decentralised blockchain scheme which facilitates direct access to various BBD-CSP mini-base stations. These stations are in conjugation with interconnected networks. Eventually at the top, the role of BBD high-powered interconnected cell towers comes into play which effectuates a globalised compliance, harmony and integrity to the entire system. Nonetheless, fair and optimised utilisation of BBD cloud orchestration network system is served to all network-based layers which contributes towards storage and statistical analysis of varied heterogeneous complex network data and hence, helps in eliminating various outliers present inside the system [26-29].

4 | METHODOLOGY

Our simulation kernel is written and developed using iPython Notebook and Sub-GHz radio's technology. Moreover, the architecture utilises the full potential of industrial, scientific and medical frequency bands in order to emphasise on network spectrum sharing across various CSP mini-base stations. Articulation of a 5G based network is emulated by assembling various line-of-sight and non-line-of-sight cluster areas along with 8 GHz in the Scientific band and 97 GHz in Echoless phased-array antenna [8]. Addition of permissioned blockchain structure and distribution of various decentralised cloud based orchestration units are established across various user points and hence, both of them work hand in hand. Further, addition of various BBD mini-base stations, network broker and access nodes are realised in order to make the system architecture immunised and equivalent to a pure decentralised system. The effectiveness of the architecture is made increase with the use of 5000 weighted badges, with the goal that range utilisation of all CSPs [19] should reach 100 percent. At last, the use of cryptocurrency at each and every node of blockchain structure is fostered to avoid any errors of interference at various levels. The workflow of the kernel has the following steps:

1. Importation of all necessary libraries is made available including psutil and NetworkX library. Instantiation of gazillions of BBD users with various attributes is made available in order to check the sturdiness of the whole architecture. Extensive use of blockchain systems gets effectuated at each user point to intact the level of transparency with other indispensable elements.

2. Empowerment of BBD access nodes is created and spanned across different parts of the calculated area. Maintenance of a diverse user network is handled by the decentralised ledgers which comes with the second use of blockchain mechanism.

3. Next, usage of a weighted voting system is embarked which allows various users to get assigned with a dedicated access node. The voting system encapsulates all information of requested smart contracts along with associated paid cryptocurrencies to allocate the best possible access node to each user.

4. Usage of network function virtualisation is then equipped with the system to generate BBD network slice brokers [20] to aid network sharing amongst different access nodes. This initiates the third use of permissioned blockchain which gets assisted by an tested cryptocurrency. Various smart contracts are made available to establish an intelligent handshake between various access nodes through a weighted voting system. Abundant mini-cells are spawned to induce and leverage the effect of low latency blockchain based networks.

5. Encrypted keyword search engine is provided to all users using a cascaded web-resource platform with varied choices. Combination of AES and DES standards are computed, added and made prevalent to provide encryption of user data files. Decentralised ledger details of the blockchain structure present at various network levels comes together into the effect to monitor and analyse each activity of user keyword search.

6. The dynamicity of bandwidth, latency and interference is inspected at each level by using machine learning statistics. For each requirement made by the user, an extra amount of cryptocurrency is charged and related interference is adjusted to ease the situation. The supervision of adjusted parameters were made continual to refrain from loss in network connectivity. A penalty of a certain amount is also charged up if a user is found to use malicious ways to enter into the blockchain consensus system.

7. Then, use of BBD-CSP mini-base stations gets acknowledged which targets various checkpoints of network data flow. It controls various network slice brokers [21] to accelerate their network flow plugin and that sanctions the use of blockchain technology for the fourth time. The mode of data transmission through the use of a weighted voting system allows various agreement based CSPs stations to enter into the emulated region. Creation of several macro-cells takes place to allow distribution of complex keyword based network information at an ease.

8. High-powered cell towers are the next network unit which provisions network spectrums across all CSPs stations to

complete the remaining circuit. These cell towers also come under BBD scheme which gets spread across the whole area but are much less than the rest of other network units. In accordance with almost zero interference, network spectrum sharing is the main rudiment of the whole network which gets authorised to each CSPs stations by the amount of cryptocurrency token they spent to continue a network event.

$$\alpha_j = \frac{T_{\mathrm{NB}}}{T_{\mathrm{CSP}}}, \quad j \in [1, \mathrm{CSPs}] \quad (1)$$

where α_j - network bandwidth distribution to each sanctioned CSP, T_{NB} - total accessible network spectrum.

9. Nonetheless, equal distribution of tokens amongst all CSPs stations is made mandatory at the beginning to disrupt the network intervention and hence, unbiased voting system gets incorporated which in turn accepts the concept of symmetricity amongst all cryptocurrency parameters.

$$ct_j = \frac{T_{\mathrm{C}}}{\mathrm{T}} T_{\mathrm{CSP}}, \quad j \in [1, \mathrm{CSPs}] \quad (2)$$

where ct_j - initiatory equal token distribution to each sanctioned CSP.

10. At last, the deployment of BBD cloud architecture [19] takes place within each and every network level which allows all network units to store complex keyword based network data at ease. Special security layer is implemented in the cloud architecture in order to store several private and public keys associated with users and CSPs stations. Moreover, all the operations of cloud are orchestrated in order to render risk-free flow of computational data across various network units.

11. Consequently, the core features of Self-organising network (SON) get invoked throughout the complete architecture to reduce the complex and dense effect of CAPEX and OPEX heterogeneous network infrastructure in a self-controlled manner.

Additionally, various options of adding any network unit through miners are made available at any given point. Also, storage and analysis of recent network based data items are made simultaneously accessible to each network cache to check upon various native services.

5 | RESULTS AND DISCUSSION

We started out by plotting a graph of network speed-wise keyword distribution in order to estimate the behaviour of the whole network. Figure 4 shows that as the user demands high network speed with an increase in number of keywords, the network responds and binds to act in accordance with agreement made between access node and that user. Thus, the use of smart contracts present in blockchain structure facilitates to disrupt fraudulent activities on unused net-
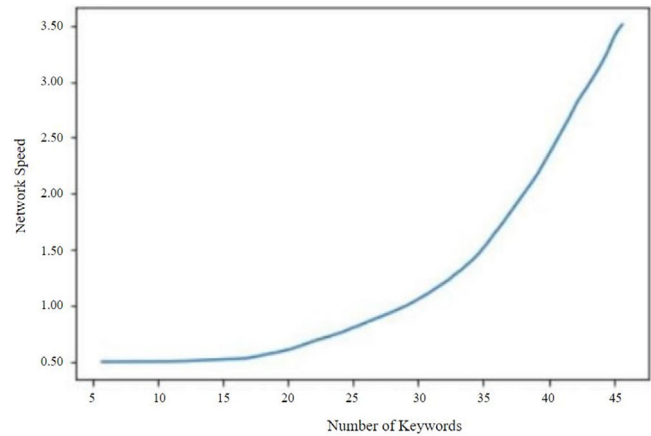

FIGURE 4 Network speed-wise keyword distribution
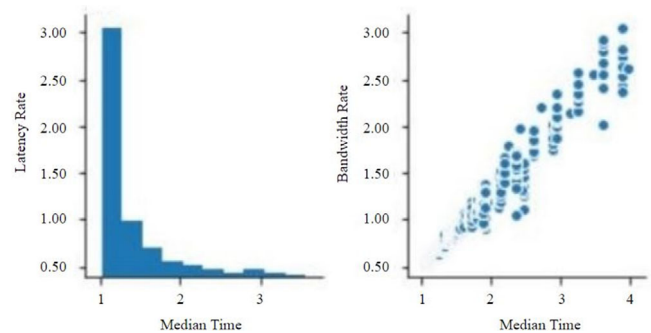

FIGURE 5 Relationship of latency and bandwidth with time

work bandwidth and hence integrity of the system gets preserved.

Next, we analysed a direct relation between latency and bandwidth with time to know the coherence of the entire architecture. According to Figure 5, we can easily find that as the time increases, the rate at which latency operates starts to decrease. Consequently, the bandwidth rate gets increased over the time which in-turn fulfills our idea of 5G network. Also, this empowered various clients to explore enormous amount of information through search engines without much delay.

Then, we analysed the processing power of the Blockchain structure present throughout the network as a function of time and in accordance with Figure 6, it is evidently seen that there is an increase in the processing power (hash rate) over the course of time. This helps to make our entire system susceptible to almost zero fraudulent cases as each time, the power and cascading of hashing gets stronger than the former.

Subsequently, we tried to analyse the stability of the system by implanting all users, access nodes (AN), mini-base stations (MBS) and high-powered cell towers with respect to time. Figure 7 shows that in the initial phase of the network development, the state of stability was low but as the system started to gain its full potential, the state-of-the-art 5G based blockchain network system reached its full equilibrium. This demonstrates the completeness and solidity of the whole architecture.
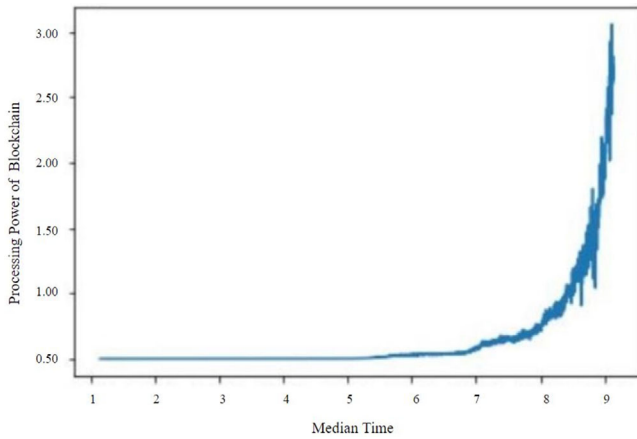
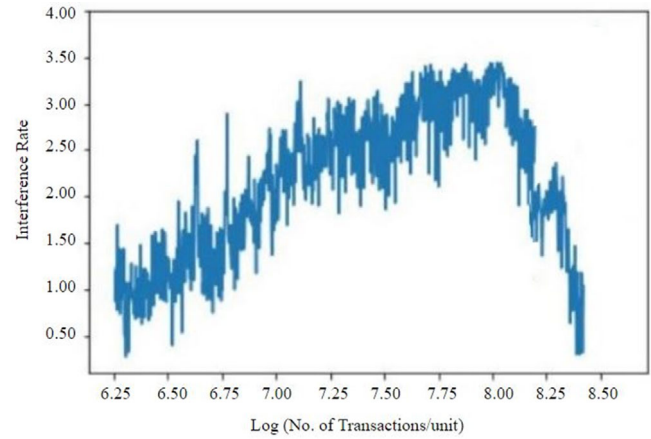**FIGURE 6**   Processing power of Blockchain versus time

FIGURE 8   Interference rate versus average no. of transactions
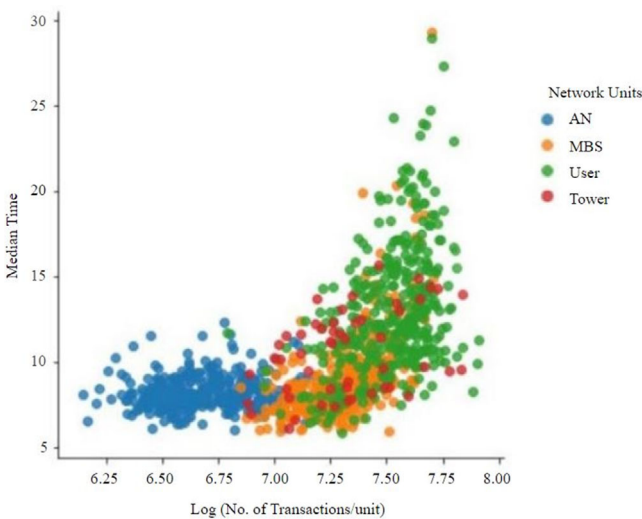

FIGURE 7   Median time versus stability of average transactions

At last, a corresponding Interference series was considered to deduce the rationality of Interference rate as the network grows up. From Figure 8, we can clearly notice that while there is an upward trend of Interference rate at the beginning, a sudden downfall can also be observed in the later stages which seemingly justifies the consonance of 5G based blockchain network throughout the entire architecture.

6 | CONCLUSION

In this paper, we were successfully able to carry out a proposed 5G based blockchain network architecture for encrypted keyword search engine. The suggested model permits to play out all connections amongst different users and mini-base stations through the use of diverse access nodes points and network brokers. It also helps to comprehend the complete application of blockchain technology wherein distribution of numerous digital ledgers and smart contracts were acknowledged between each network entity. Moreover, complete utilisation of cryp-

tocurrency is realised at essential points of the network layer to lessen the effect of interference rate and streamline the spectrum sharing when requested by the user. The results of the simulation kernel shows that proposed architecture which, when combined with BBD cloud orchestration network system, justify all the essential characteristics and effectuates the optimal use of 5G network sharing by each network entity.

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